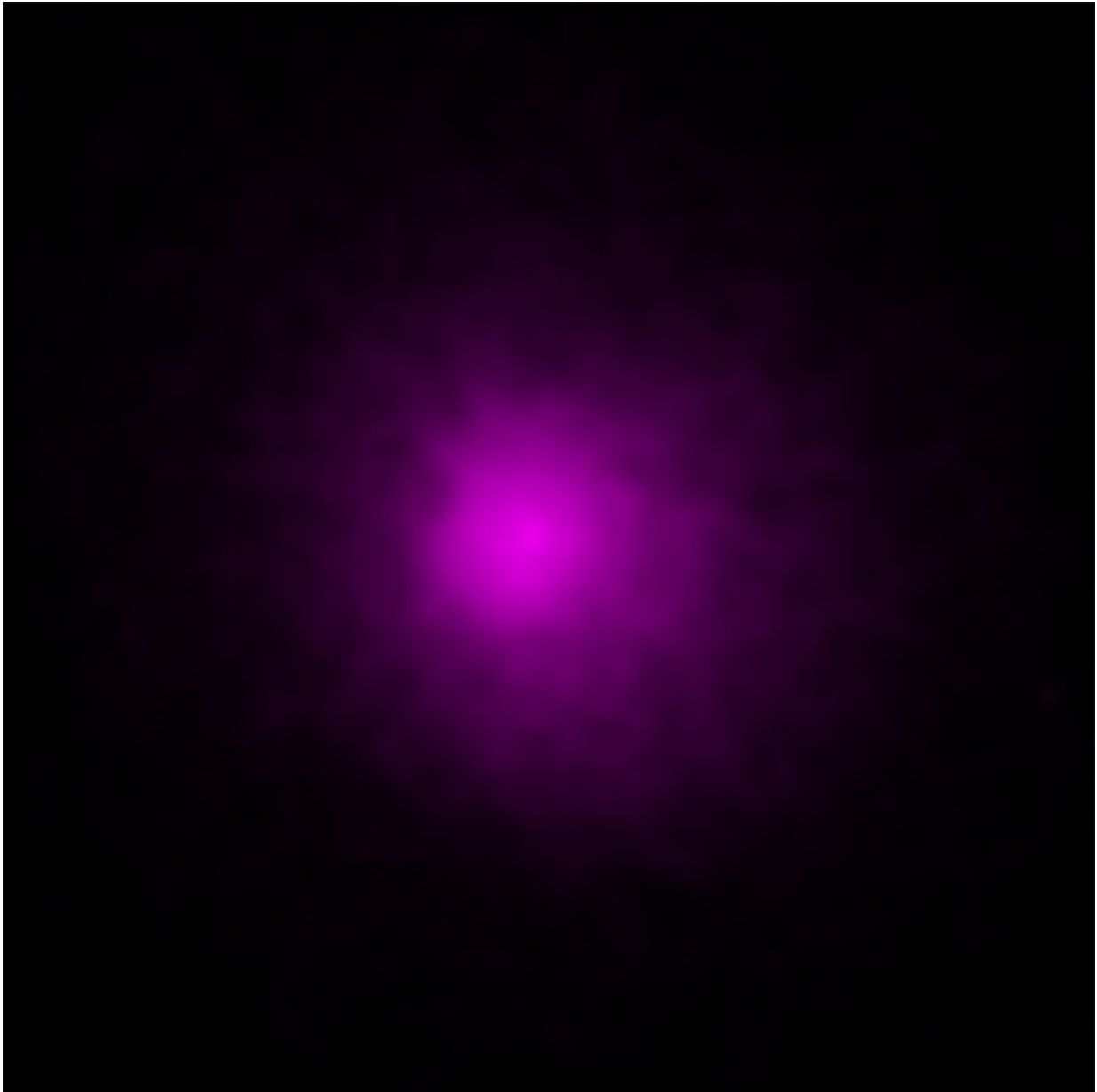


# On the hunt for a missing giant black hole

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Credit: X-ray: NASA/CXC/Univ of Michigan/K. Gültekin ; Optical:

NASA/STScI and NAOJ/Subaru; Infrared: NSF/NOAO/KPNO; Radio: NSF/NOAO/VLA

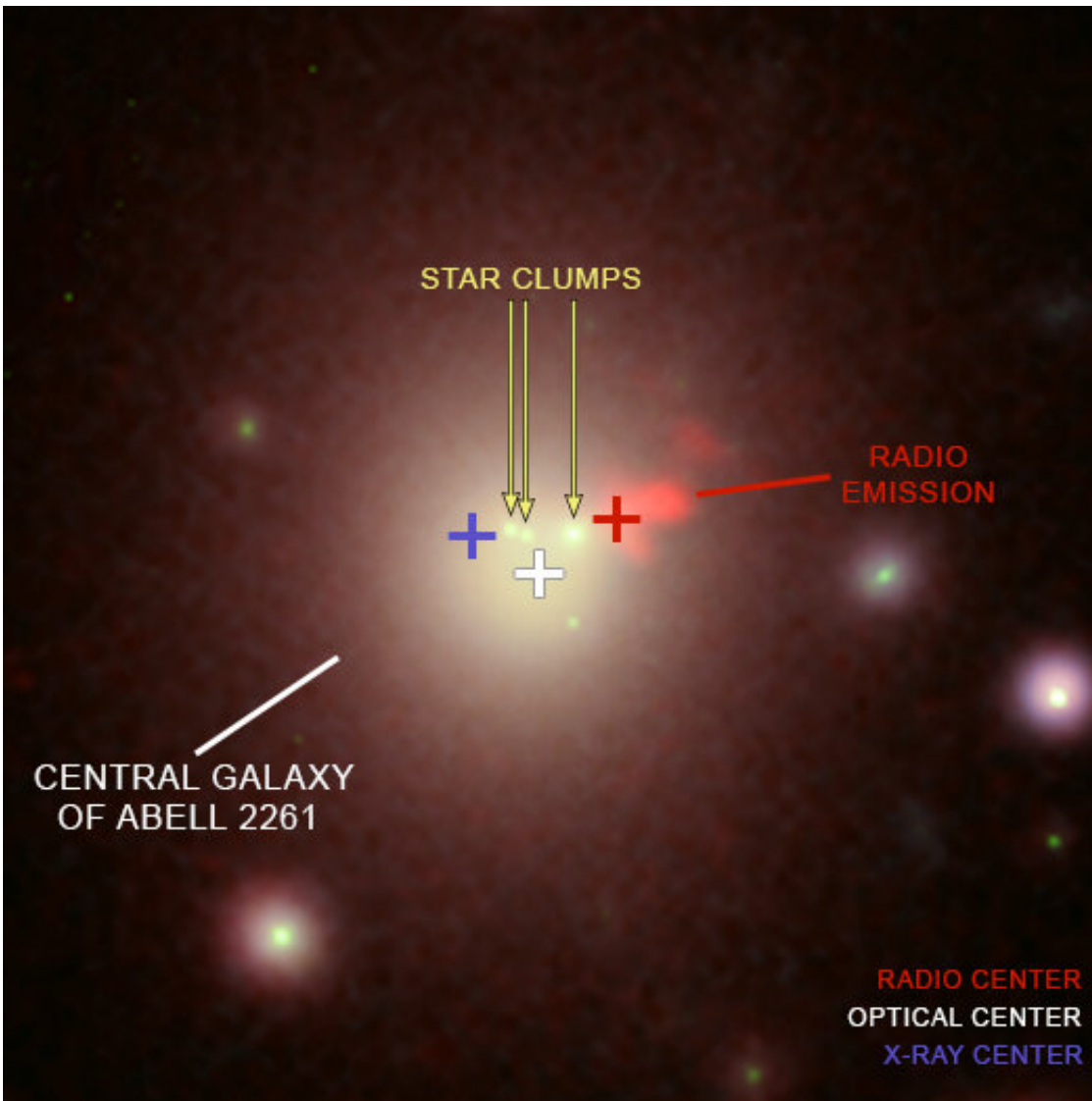
The mystery surrounding the whereabouts of a supermassive black hole has deepened.

Despite searching with NASA's Chandra X-ray Observatory and Hubble Space Telescope, astronomers have no evidence that a distant black hole estimated to weigh between 3 billion and 100 billion times the mass of the Sun is anywhere to be found.

This missing black hole should be in the enormous galaxy in the center of the galaxy cluster Abell 2261, which is located about 2.7 billion light years from Earth. This composite image of Abell 2261 contains [optical data](#) from Hubble and the Subaru Telescope showing galaxies in the cluster and in the background, and Chandra X-ray data showing hot gas (colored pink) pervading the cluster. The middle of the image shows the large elliptical galaxy in the center of the cluster.

Nearly every large galaxy in the Universe contains a [supermassive black hole](#) in their center, with a mass that is millions or billions of times that of the Sun. Since the mass of a central black hole usually tracks with the mass of the galaxy itself, astronomers expect the galaxy in the center of Abell 2261 to contain a supermassive black hole that rivals the heft of some of the largest known black holes in the Universe.

Using Chandra data obtained in 1999 and 2004 astronomers had already searched the center of Abell 2261's large central galaxy for signs of a supermassive black hole. They looked for material that has been superheated as it fell towards the black hole and produced X-rays, but did not detect such a source.



Credit: NASA/CXC, NASA/STScI, NAOJ/Subaru, NSF/NRAO/VLA

Now, with new, longer Chandra observations obtained in 2018, a team led by Kayhan Gültekin from the University of Michigan in Ann Arbor conducted a deeper search for the black hole in the center of the galaxy. They also considered an alternative explanation, in which the black hole was ejected from the host galaxy's center. This violent event may have resulted from two [galaxies](#) merging to form the observed galaxy,

accompanied by the central black hole in each galaxy merging to form one enormous black hole.

When black holes merge, they produce ripples in spacetime called gravitational waves. If the huge amount of gravitational waves generated by such an event were stronger in one direction than another, the theory predicts that the new, even more massive black hole would have been sent careening away from the center of the galaxy in the opposite direction. This is called a recoiling black hole.

Astronomers have not found definitive evidence for recoiling black holes and it is not known whether supermassive black holes even get close enough to each other to produce gravitational waves and merge; so far, astronomers have only verified the mergers of much smaller black holes. The detection of recoiling supermassive black holes would embolden scientists using and developing observatories to look for [gravitational waves](#) from merging supermassive black holes.

The galaxy at the center of Abell 2261 is an excellent cluster to search for a recoiling black hole because there are two indirect signs that a merger between two massive black holes might have taken place. First, data from the Hubble and Subaru optical observations reveal a galactic core—the central region where the number of stars in the galaxy in a given patch of the galaxy is at or close to the maximum value—that is much larger than expected for a galaxy of its size. The second sign is that the densest concentration of stars in the galaxy is over 2,000 light years away from the center of the galaxy, which is strikingly distant.

These features were first identified by Marc Postman from Space Telescope Science Institute (STScI) and collaborators in their earlier Hubble and Subaru images, and led them to suggest the idea of a merged black hole in Abell 2261. During a merger, the supermassive black hole in each galaxy sinks toward the center of the newly coalesced galaxy. If

they become bound to each other by gravity and their orbit begins to shrink, the black holes are expected to interact with surrounding stars and eject them from the center of the galaxy. This would explain Abell 2261's large core. The off-center concentration of stars may also have been caused by a violent event such as the merger of two supermassive [black holes](#) and subsequent recoil of single, larger black hole that results.

Even though there are clues that a black hole merger took place, neither Chandra nor Hubble data showed evidence for the black hole itself. Gültekin and most of his co-authors, led by Sarah Burke-Spolaor from West Virginia University, had previously used Hubble to look for a clump of stars that might have been carried off by a recoiling black hole. They studied three clumps near the center of the galaxy, and examined whether the motions of stars in these clumps are high enough to suggest they contain a ten billion solar mass black hole. No clear evidence for a black hole was found in two of the clumps and the stars in the other one were too faint to produce useful conclusions.

They also previously studied observations of Abell 2261 with the NSF's Karl G. Jansky Very Large Array. Radio emission detected near the center of the galaxy showed evidence that supermassive black hole activity had occurred there 50 million years ago, but does not indicate that the center of the galaxy currently contains such a black hole.

They then turned to Chandra to look for material that had been superheated and produced X-rays as it fell towards the black hole. While the Chandra data did reveal that the densest hot gas was not in the center of the galaxy, they did not reveal any possible X-ray signatures of a growing supermassive black hole—no X-ray source was found in the center of the cluster, or in any of the clumps of stars, or at the site of the radio emission.

The authors concluded that either there is no black hole at any of these

locations, or that it is pulling material in too slowly to produce a detectable X-ray signal.

The mystery of this gigantic black hole's location therefore continues. Although the search was unsuccessful, hope remains for astronomers looking for this supermassive black hole in the future. Once launched, the James Webb Space Telescope may be able to reveal the presence of a supermassive black hole in the center of the galaxy or one of the clumps of stars. If Webb is unable to find the black hole, then the best explanation is that the black hole has recoiled well out of the center of the galaxy.

A paper describing these results has been accepted for publication in a journal of the American Astronomical Society, and is also available online at [arxiv.org/abs/2010.13980](https://arxiv.org/abs/2010.13980) .

**More information:** Kayhan Gultekin et al. Chandra Observations of Abell 2261 Brightest Cluster Galaxy, a Candidate Host to a Recoiling Black Hole. arXiv:2010.13980 [astro-ph.HE]. [arxiv.org/abs/2010.13980](https://arxiv.org/abs/2010.13980)

Provided by Chandra X-ray Center

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