# Cookie cutter in the sky: Seeing the shape of material around black holes for first time 

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This is a visualization of material swirling around a black hole. Credit: Chris Reynolds

Black holes can now be thought of as donut holes. The shape of material around black holes has been seen for the first time: an analysis of over 200 active galactic nuclei-cores of galaxies powered by disks of hot material feeding a super-massive black hole-shows that all have a consistent, ordered physical structure that seems to be independent of the black hole's size.
"This should be a very messy and complicated environment, but the stuff flowing onto different black holes looks the same, no matter how massive the black hole is," says Barry McKernan, a Research Associate in Astrophysics at the American Museum of Natural History and a professor at the Borough of Manhattan Community College, City University of New York. "This observed shape should constrain all our ideas as to how the glow around black holes is produced, and if we can
handle the stuff around black holes, we can begin to study black holes themselves."

Although black holes cannot be seen directly, the hot material swirling around super-massive black holes can be observed. In this paper, McKernan and colleagues tested a hypothesis about the relationship between two extremes of radiation coming from around super-massive black holes: X-rays should come from very hot material close to the black hole, and infrared light should come from warm material much further from the hole. This pattern allowed them to tell if matter around the black hole was being observed face-on (looking directly down onto the black hole ringed by X -rays and infrared light) or edge-on (seeing only the side of the donut of material). Some of the infrared light should also come from part of the donut that has been fried by X-ray bombardment. By comparing the proportion of X-rays to infrared light coming from around a black hole, it is possible to indirectly figure out how material may be distributed around the black hole.

McKernan and colleagues looked at a large sample size of 245 active galactic nuclei containing black holes between 1 million and 100 million times heavier than the sun. All of these active galactic nuclei have been described, and data is available through the NASA/IPAC Extragalactic Database. After partitioning the systems into those observed edge-on and those observed face-on, the team found that $90 \%$ of the active galactic nuclei observable face-on had basically the same proportion of X-rays to infrared light.
"Because the data points in the infrared range are from the old Infrared Astronomical Satellite, we can say this is not a infrared-biased sample because the satellite looked at all of the sky," says coauthor K.E. Saavik Ford, also a Research Associate in Astrophysics at AMNH and a professor at BMCC, CUNY. "It is interesting to learn something about black holes as a class."

McKernan agrees. "Now we know they all look like donuts, and the same kind of donut too. The lack of variety would disappoint Homer Simpson."

The research is published in Monthly Notices of the Royal Astronomical Society.

## Source: American Museum of Natural History

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