A NICE *Ring* TO IT

By Robert Perkins

We now know what the supermassive black hole at the heart of our galaxy looks like thanks to Caltech researchers and their colleagues.

A multi-institution collaboration that includes a Caltech-led imaging team has generated the first image of the supermassive black hole at the center of the Milky Way galaxy. This result provides conclusive evidence that the body, known as Sagittarius A* (Sgr A*) is indeed a black hole and yields valuable clues about the workings of such massive objects, which are thought to reside at the center of most galaxies.

The Sgr A* image was produced by an international research team, called the Event Horizon Telescope (EHT) Collaboration, which includes more than 300 researchers from 80 institutions around the world. The result includes key contributions from an imaging team led by Caltech's Katie Bouman together with Kazunori Akiyama of MIT Haystack Observatory and José L. Gómez of The Institute of Astrophysics of Andalusia in Spain. Joining Bouman, who is an assistant professor of computing and mathematical sciences, electrical engineering and astronomy; a Rosenberg Scholar; and an investigator with the Heritage Medical Research Institute, were former Caltech postdoctoral researcher He Sun and current postdoctoral researchers Aviad Levis and Junhan Kim.

This is the second-ever image taken of a black hole. In 2019, the EHT collaboration released an image of a black hole named M87*, found at the center of the more distant Messier 87 galaxy.

Taking an image of Sgr A* at 27,000 light-years away from Earth is akin to taking a photo of a single grain of salt in New York City using a camera in Los Angeles. To accomplish this, EHT collected data from eight radio observatories scattered across the globe to form a single "Earth-sized" virtual telescope.

"This image from the Event Horizon Telescope required more than just snapping a picture from telescopes on high mountaintops. It is the product of both technically challenging telescope observations and innovative computational algorithms," Bouman said at a press conference announcing the new image. "Taking this picture of our black hole proved even more challenging than imaging the M87* black hole."

Although the black hole itself is completely dark, we can see a telltale ring of glowing gas surrounding a dark central region called a "shadow." The size of the shadow observed, which theory says depends primarily on the black hole mass, precisely matched the mass estimated by prior observations. The new view captures light bent by the powerful gravity of the black hole, which is 4 million times more massive than our sun. The team collected entire nights' worth of data over the course of multiple days, a bit like a traditional camera with a long exposure time. Members of the EHT went to the ends of the earth to collect these measurements; Caltech's Kim, for example, helped prepare a telescope near the South Pole.

Because the data came from only a small number of telescopes peering at an object far away, the EHT team was left with incomplete data to use to construct the image of Sgr A*. To reconstruct an image, they developed computational imaging algorithms that could make inferences to fill in the blanks.

"Through literally years of exhaustive tests on both real and synthetic data we are now confident that there is compelling evidence that the true underlying source has a ring structure," Bouman says.