UC SANTA BARBARA

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Three-Telescope Interferometry Allows Astrophysicists to Observe How Black Holes are Fueled

By combining the light of three powerful infrared telescopes, an international research team has observed the active accretion phase of a supermassive black hole in the center of a galaxy tens of millions of light years away, a method that has yielded an unprecedented amount of data for such observations. The resolution at which they were able to observe this highly luminescent active galactic nucleus (AGN) has given them direct confirmation of how mass accretes onto black holes in centers of galaxies.

"This three-telescope interferometry is a major milestone toward directly imaging the growth phase of supermassive black holes," said Sebastian Hoenig, a postdoctoral researcher at the UC Santa Barbara Department of Physics, and one of the astrophysicists who utilized this technique to observe the AGN at the center of galaxy NGC 3783. The observation was led by Gerd Weigelt, a director of the Max Planck Institute for Radio Astronomy in Bonn, Germany.

Hoenig described their findings as a ring of hot dust that marks the transition from a more-distant mixture of gas and dust in a toroidal (doughnut-shaped) structure, to a gaseous disk closer to the black hole. The dusty part, he said, is interesting because it dominates the infrared emission of active galactic nuclei and can be easily observed.

However, observing the ring of hot dust in NGC 3783 was a challenge for the astrophysicists. Not only is the ring distant and faint, but the ability of individual infrared telescopes to resolve distances between actively accreting objects is also highly limited. Even the largest optical/infrared telescopes in the world, the Keck telescopes, were not powerful enough, though they can show objects in the infrared comparable to about the size of a football field at the distance of the moon.

"In order to spatially resolve the accretion process onto supermassive black holes in nearby galaxies, we have to be at least a factor of ten better," said Hoenig. To achieve that angular resolution in a single telescope, it would have to be 130 meters in diameter.

However, by using the AMBER interferometry instrument to simultaneously combine the light from three 8-meter telescopes at the Very Large Telescope Interferometer (VLTI) at the Paranal Observatory in Chile, the research team was able to achieve the angular resolution needed to observe the hot dust ring. The Paranal Observatory is operated by the European Southern Observatories (ESO).

The combination of the light from the three telescopes was no small feat, as the tiny differences in the arrival of light in the individual telescopes have to undergo constant correction with an accuracy of a few micrometers – roughly ten times smaller than the thickness of a hair, according to Hoenig.

"The ESO VLTI provides us with a unique opportunity to improve our understanding of active galactic nuclei," said lead researcher Weigelt. "It allows us to study fascinating physical processes with unprecedented resolution over a wide range of infrared wavelengths. This is needed to derive physical properties of these sources."

Up next for the research team, which also includes astrophysicists from the universities of Florence, Grenoble, and Nice, will be the continued accumulation of information from additional observations toward a highly detailed image of the active galactic nucleus at galaxy NGC 3783.

"Our main interest is to learn how supermassive black holes in the centers of galaxies are fueled, so that they grow to the enormous million to billion solar mass objects we see today," said Hoenig.

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† Top image: Artist's view of a dust torus surrounding the accretion disk and the central black hole in active galactic nuclei.

Credit: NASA E/PO - Sonoma State University, Aurore Simonnet (http://epo.sonoma.edu/)

†† Bottom image: Very Large Telescope Interferometer at the ESO/Paranal Observatory in Chile.

Credit: Sebastian Hoenig

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