Monster black holes grow after galactic mergers

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An analysis of the Hubble Space Telescope's deepest view of the universe offers compelling evidence that monster black holes in the centers of galaxies were not born big but grew over time through repeated galactic mergers.

"By studying distant galaxies in the Hubble Ultra Deep Field (HUDF), we have the first statistical evidence that supermassive black-hole growth is linked to the process of galaxy assembly," said Arizona State University astronomer Rogier Windhorst, who is a member of the two teams that conducted the analysis. "Black holes grow by drawing in stars, gas and dust. These morsels come more plentifully within their reach when galaxies merge."

The two teams will present their results in a press conference on Jan. 10 at the 207th meeting of the American Astronomical Society in Washington, D.C.

The HUDF studies also confirm the predictions of recent computer simulations by Lars Hernquist, Philip Hopkins, Tiziana di Matteo and Volker Springel of the Harvard Smithsonian Center for Astrophysics in Cambridge, Mass., that newly merging galaxies are enshrouded in so much dust that astronomers cannot see the black-hole feeding frenzy. The computer simulations, as supported by Hubble, suggest that it takes hundreds of millions to a billion years before enough dust clears so that astronomers can see the black holes feasting on stars and gas from the merger. The telltale sign that black holes are dining is seeing light from

galaxies that vary with time.

The two HUDF teams believe they are seeing two distinct phases in galaxy evolution: the first phase -- the tadpole stage -- representing the early-merging systems where central black holes are still enshrouded in dust, and a much later "variable-object phase," in which the merged system has cleared out enough gas for the inner accretion disk around the black hole to become visible.

"The fact that these phases were almost entirely separate was a surprise, because it is commonly believed that galaxy mergers and central black-hole activity are closely related," Windhorst explained. "Our nearby universe, including the Milky Way galaxy in which we live, has mature galaxies, but in order to understand how they formed and evolved, we must study them over time. HUDF provides an actual look back in time to see snapshots of early galaxies so that we can study them when they were young."

A link between the growth of galaxies through mergers and the feeding of the central black holes has long been suspected. The evidence, however, has been inconclusive for many years.

"The HUDF has provided very high-quality information," said Seth Cohen of Arizona State University and leader of one of the teams. "It is the first data we could use to test this theory, since it allowed us to study about 5,000 distant galaxies over a period of four months."

The HUDF observations have now shed light on how the growth of monster black holes kept pace with that of galaxies. A team of astronomers, led by Amber Straughn of Arizona State University, searched the HUDF for "tadpole galaxies," so-called because they have bright knots and tails caused by mergers. These features are produced when the galaxies lose their gravitational grip on their stars, spewing

some of those stars into space. The team found about 165 tadpole galaxies, representing about 6 percent of the 2,700 galaxies in the tadpole galaxy study.

"To our surprise, however, these tadpole objects did not show any fluctuation in brightness," Straughn said. "The flickering light -- when it is present -- comes from the material swirling around an accretion disk surrounding a black hole. The material is heated and begins to glow. As it spirals down toward the black hole, it can rapidly change in brightness. This study of tadpole galaxies suggests that black holes in newly merging galaxies are enshrouded in dust, and therefore, we cannot see them accreting material."

Cohen's team studied the brightness of about 4,600 HUDF objects over several weeks to many months. The Hubble team found that about 45 (non-tadpole) objects, representing 1 percent of the faint galaxies in the study, fluctuated significantly in brightness over time. This result indicates that the galaxies probably contain supermassive black holes that are feeding on stars or gas.

"A black hole's typical mealtime lasts at least a few dozen million years," Windhorst said. "This is equivalent to black holes spending no more than 15 minutes per day eating all their food -- a veritable fast food diet."

The HUDF analysis also reinforces previous Hubble telescope studies of monster black holes in the centers of nearby, massive galaxies. Those studies showed a close relationship between the mass of a galaxy's "central bulge" of stars and that of the central black hole. Galaxies today have central black holes with masses ranging from a few million to a few billion solar masses.

Source: Arizona State University

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