

# First black holes born starving (w/ Video)

August 10 2009

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This computer-simulated image shows gas (blue) interacting with one of the first black holes (white) in the early universe, approximately 200 million years after the Big Bang. Credit: Image courtesy of Marcelo Alvarez (KIPAC), Tom Abel (KIPAC) and John H. Wise (NASA).

The first black holes in the universe had dramatic effects on their surroundings despite the fact that they were small and grew very slowly, according to recent supercomputer simulations carried out by astrophysicists Marcelo Alvarez and Tom Abel of the Kavli Institute for Particle Astrophysics and Cosmology, jointly located at the Department of Energy's SLAC National Accelerator Laboratory and Stanford University, and John Wise, formerly of KIPAC and now of NASA Goddard Space Flight Center.

Several popular theories posit that the first black holes gorged themselves on gas clouds and dust in the [early universe](#), growing into the

supersized black holes that lurk in the centers of galaxies today. However, the new results, published in *The [Astrophysical Journal Letters](#)*, point to a much more complex role for the first black holes.

"I'm thrilled that we now can do calculations that start to capture the most relevant physics, and we can show which ideas work and which don't," said Abel. "In the next decade, using calculations like this one, we will settle some of the most important issues related to the role of black holes in the universe."

To make their discovery, the researchers created the most detailed simulations to date of the first black holes in the universe that formed from the collapse of stars. The simulations started with data taken from observations of the cosmic background radiation—the earliest view of the structure of the universe. The researchers then applied the basic laws that govern the interaction of matter, allowing the early universe in their simulation to evolve as it did in reality.

In the simulation, clouds of gas left over from the Big Bang slowly coalesced under the force of [gravity](#), and eventually formed the first stars. These massive, hot stars burned bright for a short time, emitting so much energy in the form of starlight that they pushed nearby gas clouds far away. Yet these stars could not sustain such a fiery existence for long, and they soon exhausted their internal fuel. This caused one of the stars in the simulation to collapse under its own weight, forming a black hole located in a pocket of emptiness. With very little matter in the near vicinity, this black hole was essentially "starved" of food on which to grow.

"Quasars [extremely strong sources of radiation] powered by black holes a billion times more massive than our sun have been observed in the early universe, and we have to explain how these behemoths could have grown so big so fast," said Alvarez. "Their origin remains among the

most fundamental unanswered questions in astrophysics."

One explanation for the existence of supermassive black holes in the early universe postulates that the first black holes were 'seeds' that grew into much larger black holes by gravitationally attracting and then swallowing matter. But in their simulation, Alvarez, Abel and Wise found that such growth was negligible, with the black hole in the simulation growing by less than one percent of its original mass over the course of a hundred million years.

Although the simulations do not yet completely rule out the theory, this makes it less likely that these first black holes could have grown directly into the supermassive black holes observed to have existed less than a billion years later, Alvarez said.

## **An Alternative Theory**

Although the early stars pushed away nearby clouds of gas, delaying significant growth of the black holes the stars later became, wisps of gas sometimes found their way to the black holes. As this matter was sucked into the black hole in the researchers' simulation, it accelerated and released enough X-ray radiation to heat gas as much as a hundred light years away to several thousand degrees. The additional heat from the X-rays caused the gas to expand away from the black hole, helping to keep the snack from turning into a feast.

Heating due to the X-rays was also enough to effectively prevent nearby gas from collapsing to form stars for tens and maybe even hundreds of millions of years. As a result, the researchers hypothesize, significantly larger than usual gas clouds may have had the opportunity to form without creating stars. Such enormous [gas clouds](#) may have eventually collapsed under their own weight, creating a supermassive black hole.

"While X-rays from matter falling onto the first black holes hindered their further growth, that very same radiation may have later cleared the way for direct formation of supermassive black holes by suppressing star formation," said Alvarez. "However, a lot of work remains to be done to test whether this idea will actually pan out; this is really just the tip of the iceberg in terms of realistic simulations of black holes in the early universe."

"This work will likely make people rethink how the radiation from these black holes affected the surrounding environment," added Wise. "[Black holes](#) are not just dead pieces of matter; they actually affect other parts of the galaxy."

Source: SLAC National Accelerator Laboratory ([news](#) : [web](#))

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