Scientists discover how first quasars in universe formed

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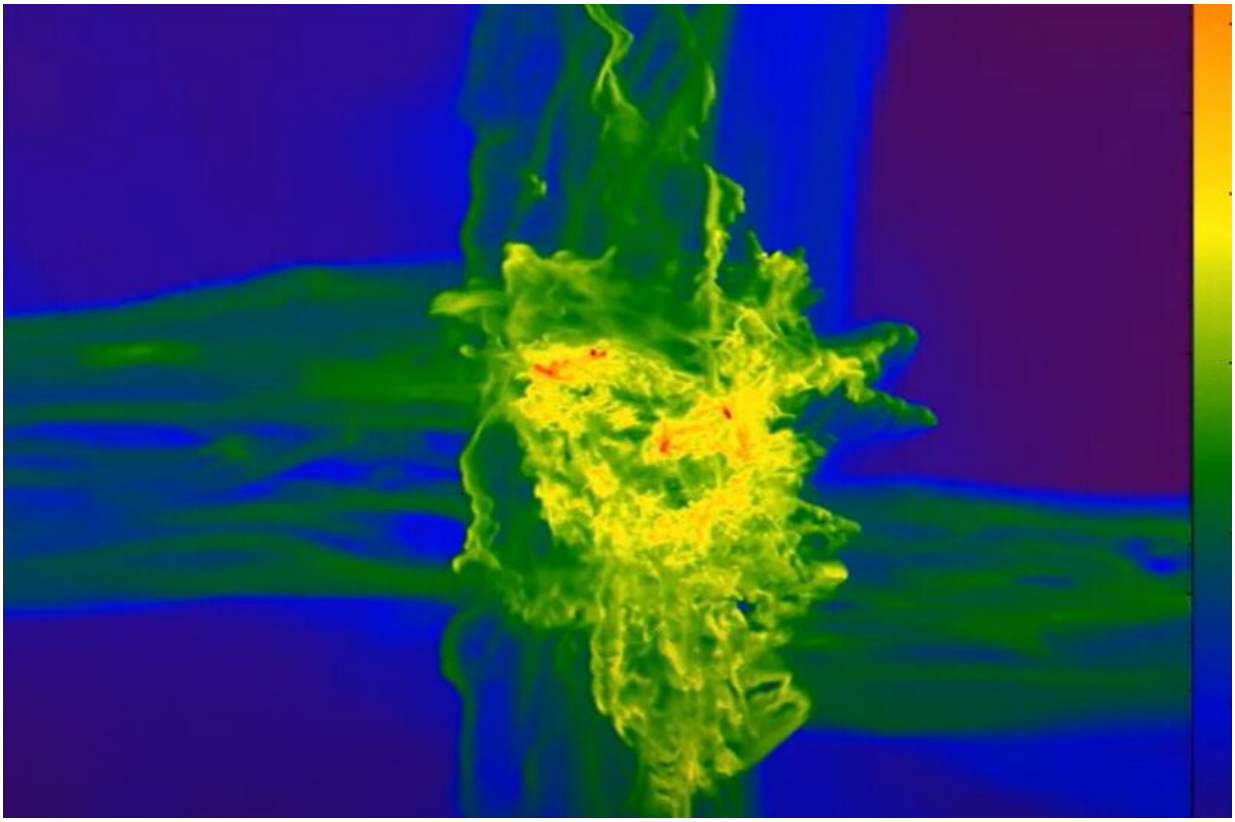

Credit: University of Portsmouth

The mystery of how the first quasars in the universe formed—something that has baffled scientists for nearly 20 years—has now been solved by a team of astrophysicists whose findings are published in *Nature*.

The existence of more than 200 quasars powered by supermassive black holes less than a billion years after the Big Bang had remained one of the outstanding problems in astrophysics because it was never fully understood how they formed so early.

The team of experts led by Dr. Daniel Whalen from the University of Portsmouth have found that the first quasars naturally formed in the violent, turbulent conditions of rare reservoirs of gas in the early universe.

Dr. Whalen, from the University's Institute of Cosmology and Gravitation, said: "This discovery is particularly exciting because it has overturned 20 years of thought on the origin of the first supermassive black holes in the universe.

"We find supermassive black holes at the centers of most massive galaxies today, which can be millions or billions of times the mass of the sun. But back in 2003 we began finding quasars—highly luminous, actively-accreting supermassive black holes that are like cosmic lighthouses in the early universe—that existed less than a billion years after the Big Bang. And no one understood how they formed by such early times."

A few years ago, supercomputer simulations showed that early quasars could form at the junctions of rare, cold, powerful streams of gas. Only a dozen of these existed in a volume of space a billion light-years across, but the black hole had to be 100,000 solar masses at birth. Black holes today form when massive stars run out of fuel and collapse, but they are usually only 10–100 solar masses.

Astrophysicists had long theorized that 10,000–100,000 solar-mass stars formed in the early universe but only in exotic, finely-tuned environments like strong ultraviolet backgrounds or supersonic flows

between gas and dark matter that had no resemblance to the turbulent clouds in which the first quasars formed.

Dr. Whalen said: "We think of these stars as a bit like dinosaurs on earth, they were enormous and primitive. And they had short lives, living for just a quarter of a million years before collapsing to black holes.

"Our supercomputer models went back to very early times and found that the cold, dense streams of gas capable of growing a billion solar-mass black hole in just a few hundred million years created their own supermassive stars without any need for unusual environments. The cold streams drove turbulence in the cloud that prevented normal stars from forming until the cloud became so massive it collapsed catastrophically under its own weight, forming two gigantic primordial stars—one which was 30,000 solar masses and another which was 40,000.

"Consequently, the only primordial clouds that could form a quasar just after cosmic dawn -when the first stars in the universe formed—also conveniently created their own massive seeds. This simple, beautiful result not only explains the origin of the first quasars but also their demographics—their numbers at early times.

"The first supermassive black holes were simply a natural consequence of structure formation in cold dark matter cosmologies—children of the cosmic web."

The paper "The Turbulent Origins of the First Quasars" is published in *Nature*.

More information: Daniel Whalen, Turbulent cold flows gave birth to the first quasars, *Nature* (2022). DOI: 10.1038/s41586-022-04813-y. www.nature.com/articles/s41586-022-04813-y

Daniel Whalen et al, Revealing the origin of the first supermassive black holes, *Nature* (2022). DOI: 10.1038/d41586-022-01560-y , www.nature.com/articles/d41586-022-01560-y