
"Long before it's in the papers"

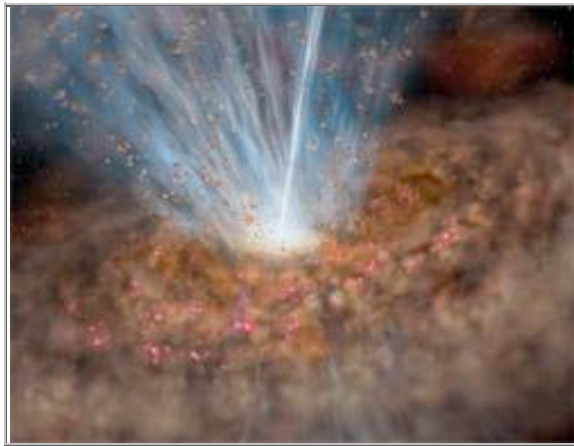
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Explosion shutting down a galactic party: physicists

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Courtesy of the Gemini Observatory
and World Science staff

An immense black hole in a galaxy far, far away seems to be causing an explosion that will change that galaxy forever, scientists say.

Blasts of its type, never reported in detail before, will snuff out a galactic party, they predict: like a suddenly enraged father who at a holiday feast yanks the tablecloth high into the air, the black hole is in a sense tossing its own meals out of the galaxy. And everyone else's, too, because some of this same material is expected to have been nourishing a flurry of new star formation elsewhere in the galaxy, which will now stop.



Artist's conceptual of the environment around the supermassive black hole at the center of Mrk 231. The broad outflow seen in the Gemini data is shown as the fan-shaped wedge at the top of the accretion disk around the black hole. This side-view is not what is seen from the Earth where we see it 'looking down the throat' of the outflow. A similar outflow is probably present under the disk as well and is hinted at in this illustration. The total amount of material entrained in the broad flow is at least 400 times the mass of the Sun per year. Note that a more localized, narrower jet is shown, this jet was known prior to the Gemini discovery of the broader outflow featured here. (Courtesy of Gemini Observatory, artwork by Lynette Cook)

“This is really a last gasp of this galaxy. The black hole is belching its next meals into oblivion!” said Sylvain Veilleux of the University of Maryland, one of the authors of the research. The report is to appear in the March 10 issue of *The Astrophysical Journal Letters*.

A black hole is an object with an enormous weight packed into such a small space that it develops an invincible gravitational force in its immediate surroundings. Anything that gets too close, even beams of light, gets sucked in.

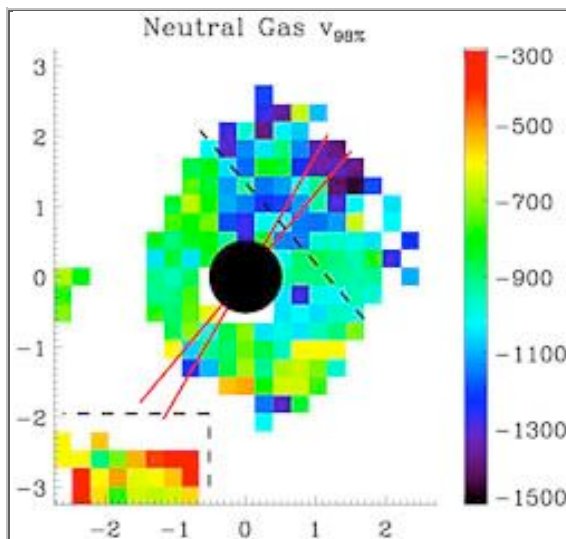
Giant, or “supermassive,” black holes sit at the centers of most galaxies like anchors, helping to keep their stars tied to the system. All the while, physicists say, these black holes eat whatever strays nearby—sometimes just nibbling, other times feasting, in a violent process that also releases heat and light.

The situation can change when the galaxy finds itself merging with another one, according to researchers. Then waves of new material, including gas and dust, wash into the galaxy. This spurs the formation of new stars and also provides fresh fodder for the central black hole, drastically boosting its intake.

But these events prove their own undoing, physicists say. The voracious consumption process starts to create so much heat that it generates a fierce light. This light in turn pushes outward against the gas and dust surrounding the black hole—its food. Turn up the heat enough, and the light blows the whole dinner away. Not only is the black hole’s meal disrupted, but star formation throughout the galaxy, also nourished by this material, grinds to a near-halt.

Previous studies have observed a common variant of this process: rather than the whole galactic supper being disrupted, beams of light called collimated jets merely punch small holes through the material around the black hole. But a full-on blowout, scientists say, is new to our observations.

In the galaxy that they describe, they add, both processes are in play, the cocoon being pushed outward at the same time as holes are punched straight through it. While this may be hard to picture, it is easier when we consider that such large-scale explosions appear to happen very slowly from our perspective, owing to the vastness of the spaces involved. The exploding material moves inconceivably fast, but due to the huge amounts of space that it has to fill, it looks slow from Earth.



Though this chart is less impressive than the artwork, it is part of the actual telescope data that reflects the same type of event, scientists say. It is a cross-section of a three-dimensional "data cube" showing information from throughout the galaxy, in particular the large-scale, fast outflow of neutral sodium gas, detectable because it absorbs yellow light. The viewer is looking down onto the material that moves toward us relative to the galaxy. The large black circle marks the location of the black hole, and red lines show the location of a radio-wave jet. In addition to the quasar outflow, the jet pushes the material at the top right, resulting in even greater speeds. Part of the starburst is located at the position of the box at the lower left, and it is likely responsible for the gas motion in this region, researchers say. (Courtesy of Gemini Observatory)

Veilleux and David Rupke of Rhodes College in Tennessee used a telescope at the Gemini Observatory in Mauna Kea, Hawaii, to study what they said were events in a galaxy known as Markarian 231. "This object is arguably the closest and best example that we know of a big galaxy in the final stages of a violent merger and in the process of shedding its cocoon and revealing a very energetic central quasar," another term for a highly active black hole, Veilleux said.

As extreme as Markarian 231's eating habits seem, Veilleux said they're probably not unique. "When we look deep into space and back in time, quasars like this one are seen in large numbers, and all of them may have gone through shedding events like the one we are witnessing."

Markarian 231 is well known for its collimated jets, but the new study also revealed a broad "outflow" extending in all directions around the galaxy's core, the two scientists said. The gas is estimated to be moving at over 1,000 kilometers (600 miles) per second. At this speed, the gas could go from New York to Los Angeles in about four seconds. The energy to power the massive outflow can only come from the black hole, because stars don't have enough energy to drive such a process, they added.

"The fireworks of new star formation and black hole feeding are coming to an end, most likely as a result of this outflow," Rupke said.

The environment around such a black hole is commonly known as an active galactic nucleus. Merging galaxies help to feed the central black hole and also shroud it in gas. But eventually, bereft of fuel, the active galactic nucleus goes "extinct," scientists say. Without gas to form new stars, the host galaxy also starves, turning into a collection of aging stars. Ultimately, these old stars will make the galaxy appear redder, giving these galaxies the moniker "red and dead."

Numerical astrophysicist Philip Hopkins of the University of California at Berkeley said processes unique to fast-growing black holes probably help propel the winds observed by Gemini. These extend an estimated 8,000 light years outward, a light year being the distance that light travels in a year. "At its peak, the quasar shines with such intensity that the light itself is 'trapped' by a cocoon of gas and dust," Hopkins explained. This light pushes "on material with a force that can easily overcome the gravitational pull of the black hole."

Hopkins adds that the bath of X-rays and gamma rays known to be generated by quasars could also heat up the gas in the galaxy's center until it reaches a temperature where it "boils over" and causes a bomb-like explosion. "But until now, we haven't been able to catch a system 'in the act.'" Part of the problem, according to Hopkins, has been that the most visible outflows are those 'collimated jets' already

known in Markarian 231. These jets are trapped into narrow beams, probably by magnetic fields, whereas material falls into the black hole from all directions.

Markarian 231 lies an estimated 600 million light-years away in the direction of the constellation of Ursa Major. Some estimates indicate that the galaxy has a weight in stars of about three times that of our Milky Way galaxy, while its central black hole is estimated to weigh the equivalent of about 10 million of our suns, or also about three times the supermassive black holes in our own galaxy.