The mysterious black behemoths controlling our galaxies

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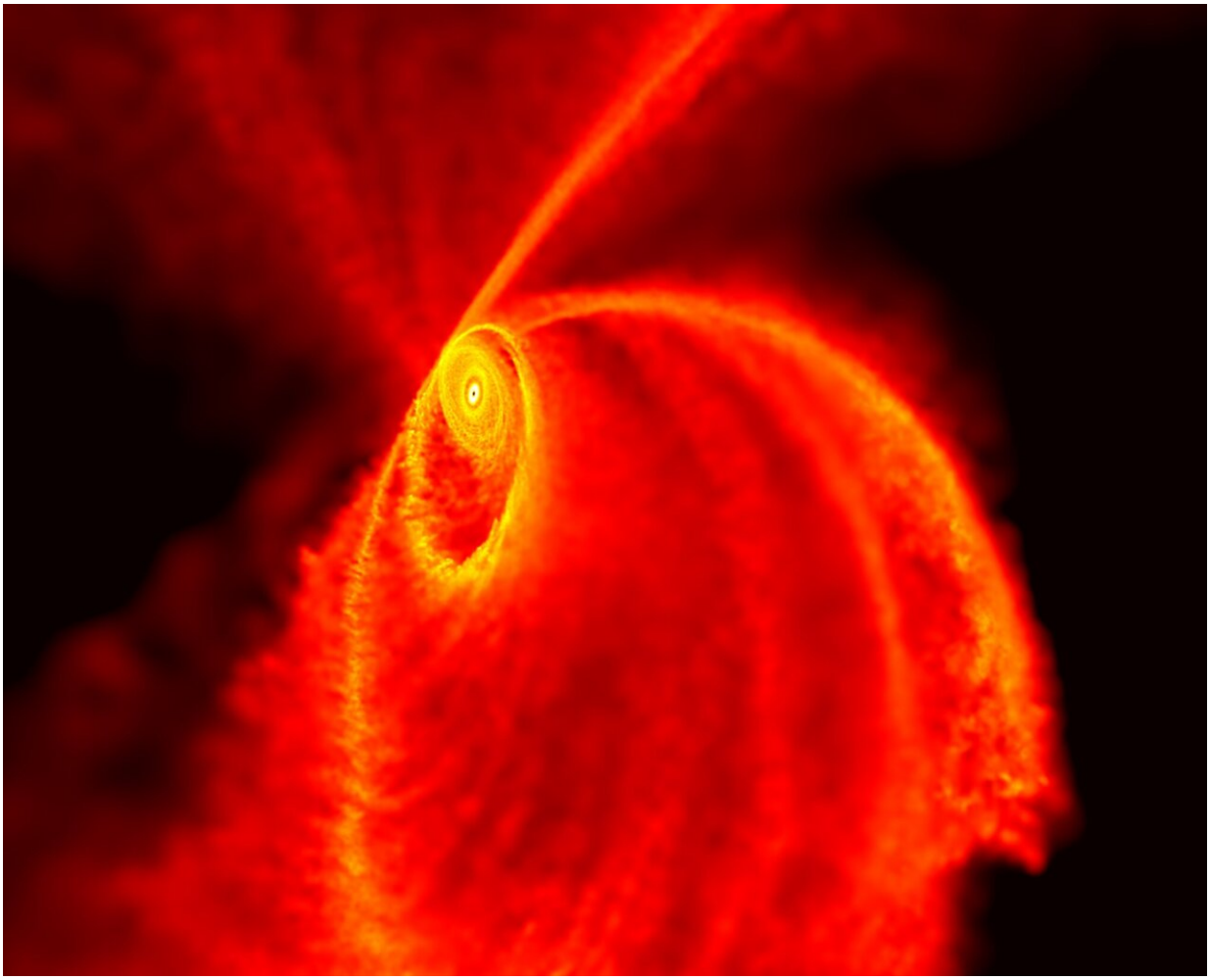

The innermost rim of this gas disc is accreting onto a massive black hole. Credit: © Michela Mapelli

Scientists try to unravel the birth, growth and power of black holes, some of the most forceful yet difficult-to-detect objects in our universe.

It was only last year that astronomers were finally able to unveil the first pictures of the supermassive black hole at the center of our Milky Way galaxy. But you couldn't actually see the black hole itself, not directly. That's because it is so dense that its gravitational pull prevents even light from escaping.

But the image of Sagittarius A, as our galaxy's black hole is known, revealed a glowing halo of gas around the object—an object that we now know has a million times more mass than our sun.

Recent discoveries like that, as well as many others, have astonished astronomers.

"Over the last few years, everything we thought we knew about black holes now comes with a question mark," said Professor Michela Mapelli, an astrophysicist at the University of Padua in Italy.

Everyone has heard of black holes. Few people, though, realize just how much these weird objects continue to vex astronomers.

One black hole announced itself to astronomers last year when it shredded and then swallowed a star that had wandered too close. Another was described as the fastest-growing black hole ever observed, devouring the equivalent mass of one Earth every second. As a result, it's already 3 billion times more massive than our sun.

Cosmic minnows

Mapelli studies stellar black holes, which form when a large, fast-burning star collapses in on itself. Compared to the supermassive ones,

these black holes are cosmic minnows.

Astronomers had expected such black holes to possess between five to 10 times the mass of our sun.

But the truth is that these types of black hole come in a much wider range of sizes. In recent years, some have been discovered that are up to about 100 solar masses, as well as one as small as 2.6.

"We have discovered features and a mass range of black holes that we could not even imagine before the recent observations," Mapelli said.

One system that intrigues her is known as binary black holes—where two orbit one another. This can happen when two stars that orbit each other both end their life as black holes.

Then again, there could be many other ways to form binary black holes and this is something that Mapelli studies in her DEMOBLACK project.

"Seven years ago, most people were skeptical about the existence of binary black holes," she said. "Even theorists were not convinced about their existence."

Now, Mapelli said, almost 100 of them have been discovered. They spew out gravitational waves, ripples in space-time that can be snagged by sophisticated detectors at the Laser Interferometer Gravitational-Wave Observatory in the US and Italy's Virgo interferometer.

Most astrophysicists, according to Mapelli, doubted that two black holes could get intimate enough to merge, but then gravitational waves began signaling the collision of black holes. One peculiar merger event in 2019 happened between black holes 60 and 80 solar masses.

Whether these black holes formed directly from stars isn't known. This is because the assumption that stellar-born black holes were between five and 10 solar masses has now been sunk.

"There is a really big question mark over whether the maximum mass of a stellar black hole is just 60 solar masses, or could it be 90, or even 300?" said Mapelli. "I feel guilty about this large uncertainty because I personally helped cause this situation."

Galactic monsters

The biggest beasts lie at the center of almost every galaxy. Nearly all are active, with gravity-sucking hot gas inside them. Some of these black holes have masses up to 10 billion times the mass of our sun.

"These are real monsters," said Professor Christopher Reynolds at the University of Cambridge in the U.K. "Their influence in a galaxy can extend 100, even 200, light years out."

Even at those astronomical distances, stars and galaxies still feel the gravitational tug of these black holes. But their energy blasts as they consume matter can be felt even farther out, as far as 100,000 light years or more.

In the DISKtoHALO project, Reynolds is investigating how these supermassive black holes grow, suck hot gas inside them and generate explosions of energy outwards.

"We know these black holes produce jets of energy, sending shocks outwards," he said.

One thing that astrophysicists haven't been able to figure out yet is why gas in the core of some galaxies can be so hot—up to 10 to 100 million

°C—yet the systems are billions of years old and therefore should have had plenty of time to cool down.

How the black holes interact with their immediate surroundings and distant parts of their galaxy is an extremely taxing conundrum. Computer models struggle to help because this requires insight into relatively small scales as well as ginormous scales measured in light years.

"You are talking about something the size of a tennis ball regulating something that is Earth's size," Reynolds said.

One way to study these supermassive black holes at the center of galaxy clusters is to examine the hot gases in their vicinity. It is impossible to see these gases with a telescope, but their energy is observable via the X-rays they send out because they are so hot.

Again, it remains unknown why the hot gas doesn't cool down and coalesce into stars.

"You need a heater to send out energy in the middle of the cluster and the only heater powerful enough are supermassive black holes," Reynolds said.

How precisely this heater works continues to mystify him and his colleagues. It is clear, however, that supermassive black holes do not live tranquility.

"These black holes are not even spherical, but they spin themselves into a disk that is rife with instabilities," Reynolds said.

Despite new insights into these strange galactic creatures, the true nature of black holes remains obscure. Past assumptions have been shaken.

What we can be sure of is that black holes will continue to puzzle the brightest minds in astronomy.

More information: DEMOBLACK
DISKtoHALO
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