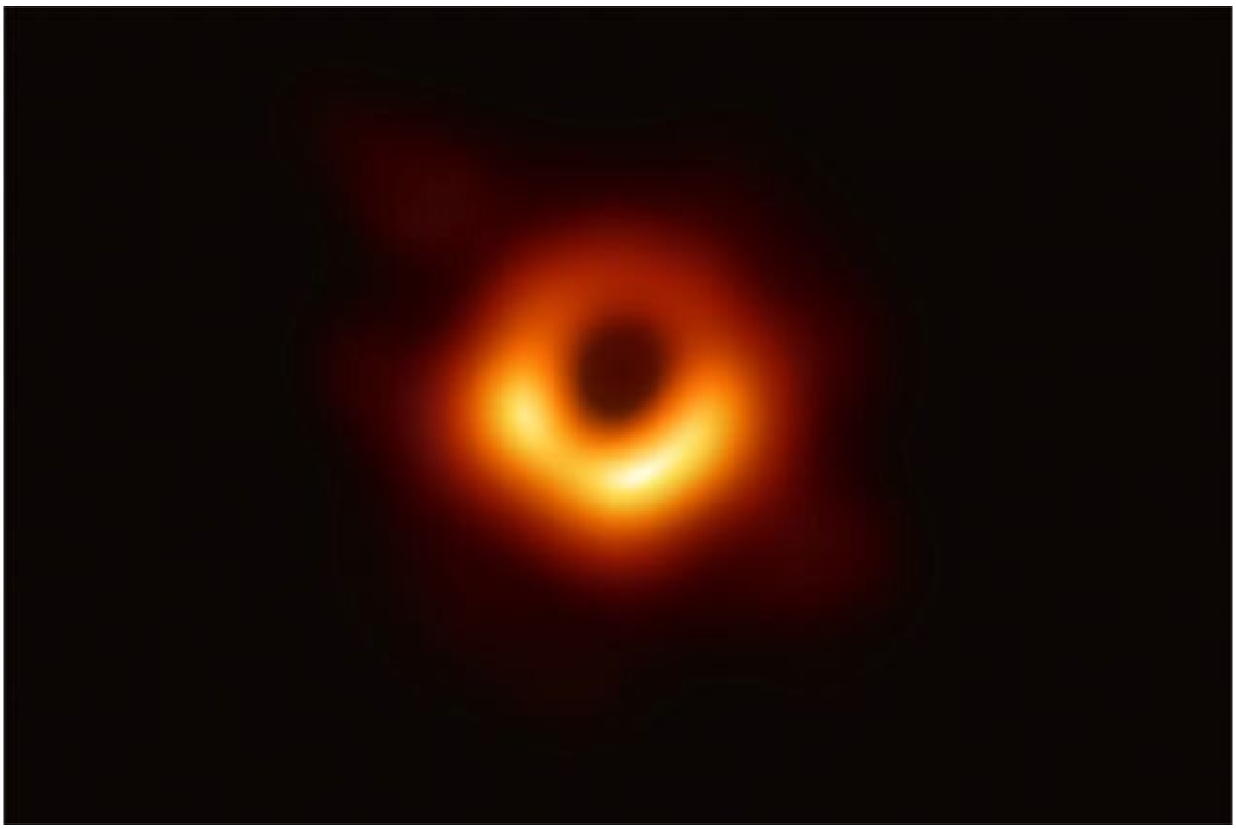
Explainer: A theoretical cosmologist describes how large black holes really are, and the 'point of no return'

June 30 2020, by Angela Nelson



The first photo of a black hole, taken in 2019, shows light bending around a black hole that is 6.5 billion times larger than the sun. Credit: Event Horizon Telescope Collaboration

Black holes are among the most fascinating phenomena of outer space, and we're learning more about them all the time. Just last week, a group of astronomers published a paper documenting a rare visible collision of black holes, which produced a flash of light that allowed scientists to see the event from Earth.

From Star Trek to Doctor Who to The Orville, science fiction often incorporates black holes into story lines, in large part because there's still so much we don't know. But Alexander Vilenkin isn't daunted at all by this vast and complex subject. The Leonard and Jane Holmes Bernstein Professor in Evolutionary Science in the Department of Physics and Astronomy at Tufts, he has studied theoretical cosmology, including dark energy, cosmic strings, and the multiverse, for decades. If anyone can help unravel some of the mystery around black holes, it's him.

Vilenkin recently gave Tufts Now a crash course to make these cosmic giants a bit more accessible. Here are three facts about black holes to wrap your head around.

Black holes can be incomprehensibly huge

Black holes are measured by their size and mass, or the amount of matter they have. A medium-sized black hole may have a mass twenty times greater than the Sun. However, the pull of gravity inside a black hole is so strong that it condenses all that mass into a ball with a diameter of only about twenty miles.

Supermassive black holes are the largest black holes. Vilenkin said these behemoths can have a mass of one billion suns with a diameter about the size of our solar system.

Every large galaxy, including the Milky Way, has at least one supermassive black hole at its center. "As far as supermassive black holes go, ours is pretty small. It's only about a few million solar masses," he said.

The smallest black hole recorded is practically petite: It's barely four times the mass of our sun.

Black holes can merge

Black holes that are near each other tend to drift closer together, said Vilenkin. "What happens is that these black holes attach to one another, gravitationally, and start rotating about one another. They form a binary system, and as they rotate, they gradually will lose their energy by gravitational radiation. They get closer and closer together and rotate around each other faster and faster. Eventually they merge," he said.

So far, collisions of supermassive black holes have not been observed, but astronomers have observed collisions of much smaller black holes, said Vilenkin.

We can't see such a collision through a telescope, no matter how high-powered it is, because no light can escape from a black hole. However, using very sensitive—and very large—instruments called gravitational wave detectors, scientists can detect and measure gravitational waves emitted by black holes. The waves are like ripples in spacetime (more on that in a bit), and the data collected tells the story of what's happening millions or billions of light years away.

"The gravitational waves emitted while black holes are just orbiting in their binary systems are typically too weak to be detected. But this final dose of radiation when the black holes are about to merge, and when they eventually do merge to form a bigger black hole, has been observed many times," he said.

The bursts of gravitational radiation last a very short time, but they come in a certain pattern. When astronomers see this pattern, Vilenkin said, they can identify it as a collision of black holes and figure out their masses and how far away they are. In September 2019, NASA announced that astronomers spotted three supermassive black holes on a collision course in a system about a billion light years from Earth.

Black holes have a point of no return

Black holes have what's called an event horizon. Think of this of as the surface of the black hole. Nothing can escape from under the surface, including light. So what happens when, for example, a spaceship, crosses the event horizon?

"Let's say the spaceship sends light pulses to us as it approaches the black hole. As the spaceship approaches the event horizon, the pulses will become weaker and weaker, and the intervals between them become longer and longer," said Vilenkin. "As the spaceship gets very close to the event horizon, we see it as if it's frozen. We will never see the spaceship actually go under the event horizon because light cannot escape from under there."

What about the travelers in the spaceship? Vilenkin said as the spaceship approaches the event horizon, they wouldn't notice anything particular, and they would still see us. However, once they cross the event horizon, this is a point of no return. You cannot turn around and get out. You can only move towards the center of the black hole, he said.

Gravity will get stronger and stronger, and since gravity stretches things in one direction, the spaceship will get spaghettified. "Eventually this spaceship will hit the central point, which is called the singularity. The singularity is, mathematically, where the gravity becomes infinitely strong, so the curvature of spacetime becomes infinite. We cannot really tell what exactly happens in singularity, but the spaceship and everything inside will be destroyed well before the ship reaches the singularity," Vilenkin said.

Provided by Tufts University

Citation: Explainer: A theoretical cosmologist describes how large black holes really are, and the 'point of no return' (2020, June 30) retrieved 6 May 2024 from
https://phys.org/news/2020-06-theoretical-cosmologist-large-black-holes.html