Video: How do black holes evaporate?

April 14 2015, by Fraser Cain

Artist's illustration of black holes.

Nothing lasts forever, not even black holes. According to Stephen Hawking, black holes will evaporate over vast periods of time. But how, exactly, does this happen?

The actor Stephen Hawking is best known for his cameo appearances in Futurama and Star Trek, you might surprised to learn that he's also a theoretical astrophysicist. Is there anything that guy can't do?

One of the most fascinating theories he came up with is that black holes, the universe's swiffer, can actually evaporate over vast periods of time.

Quantum theory suggests there are virtual particles popping in and out of existence all the time. When this happens, a particle and its antiparticle appear, and then they recombine and disappear again.

When this takes place near an event horizon, strange things can happen. Instead of the two particles existing for a moment and then annihilating each other, one particle can fall into the black hole, and the other particle can fly off into space. Over vast periods of time, the theory says that this trickle of escaping particles causes the black hole to evaporate.

Wait, if these virtual particles are falling into the black hole, shouldn't that make it grow more massive? How does that cause it to evaporate? If I add pebbles to a rock pile, doesn't my rock pile just get bigger?

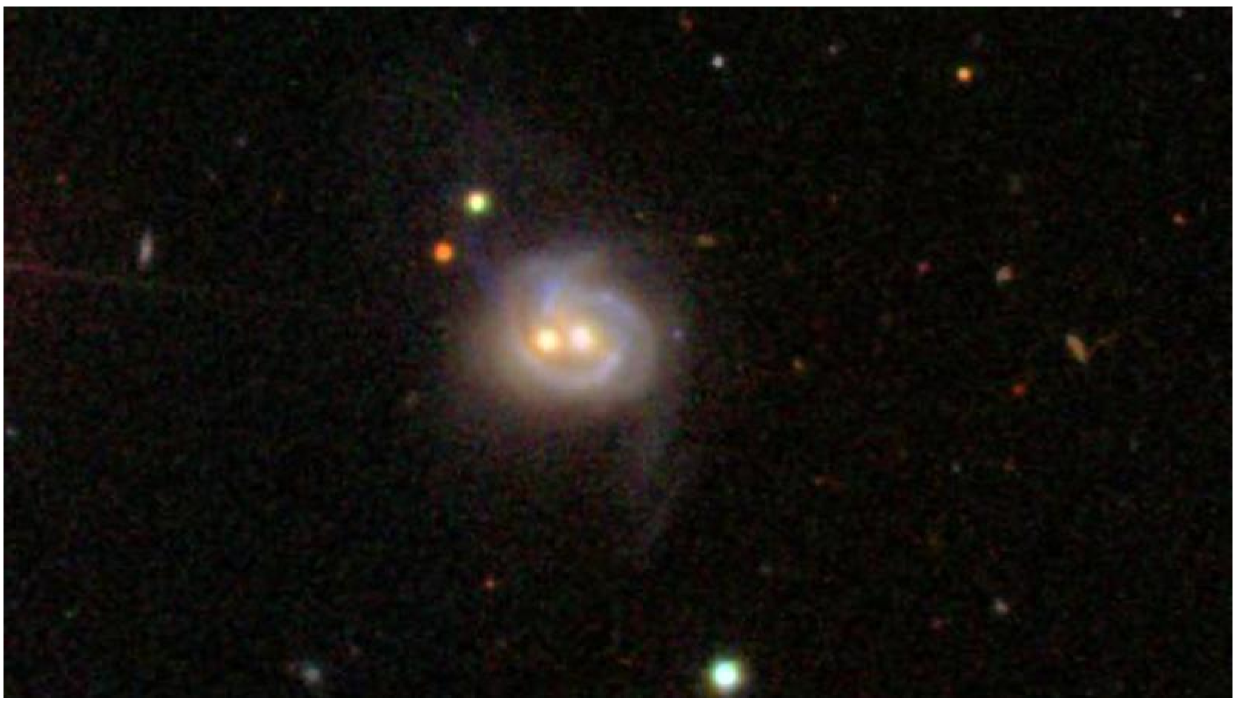
It comes down to perspective. From an outside observer watching the black hole's event horizon, it appears as if there's a glow of radiation coming from the black hole. If that was all that was happening, it would violate the law of thermodynamics, as energy can neither be created nor destroyed. Since the black hole is now emitting energy, it needs to have given up a little bit of its mass to provide it.

Let's try another way to think about this. A black hole has a temperature. The more massive it is, the lower its temperature, although it's still not zero.

From now and until far off into the future, the temperature of the largest black holes will be colder than the background temperature of the universe itself. Light from the cosmic microwave background radiation will fall in, increasing its mass.

Now, fast forward to when the background temperature of the universe drops below even the coolest black holes. Then they'll slowly radiate heat away, which must come from the black hole converting its mass into energy.

The rate that this happens depends on the mass. For stellar mass black holes, it might take 10^67 years to evaporate completely.



Viewed in visible light, Markarian 739 resembles a smiling face. Inside are two supermassive black holes, separated by about 11,000 light-years. The galaxy is 425 million light-years away from Earth. Credit: Sloan Digital Sky Survey

For the big daddy supermassive ones at the cores of galaxies, you're looking at 10^100. That's a one, followed by 100 zero years. That's huge number, but just like any gigantic and finite number, it's still less than infinity. So over an incomprehensible amount of time, even the longest living objects in the universe – our mighty black holes – will fade away into energy.

One last thing, the Large Hadron Collider might be capable of generating microscopic black holes, which would last for a fraction of a second and disappear in a burst of Hawking radiation. If they find them, then Hawking might want to the acting on hold and focus on physics.

Nothing is eternal, not even black holes. Over the longest time frames we're pretty sure they'll evaporate away into nothing. The only way to find out is to sit back and watch, well maybe it's not the only way.

The LHC. Credit: CERN

Source: Universe Today