**Can black holes be used to travel through spacetime?**

It’s a science fiction cliché to use black holes to travel through space. Dive into one, the story goes, and you’ll pop out someplace else far away, not needing to travel the actual intervening distance. While wormholes appear to be possible theoretically, they would be violently unstable, or need to be made of theoretical forms of matter which may not occur in nature. The bottom line is that wormholes probably don’t exist. When we invent interstellar travel, we’ll have to go the long way around.

**What can we learn from black holes?**

Black holes represent the ultimate endpoints of matter. They hold all mass and space and time, so we can learn a lot about the way the Universe works. As matter falls into a black hole, it heats up and forms X-rays. By studying dark energy with X-rays using observatories like EXIST, scientists can learn about how black holes eat interstellar dust. As matter gets closer to the black hole, it heats up and spins, much as a planet would if it fell through a black hole. This is the gas disk that forms around a black hole, and it is the source of much of the gravity that holds the black hole in place.

**Where are black holes located?**

Black holes are everywhere — as far as our astronomers can tell, there are probably millions of black holes in our Milky Way Galaxy alone. That may sound like a lot, but the nearest one discovered is still 1,000 light years away — a pretty big distance, even if it’s in our backyard. So don’t worry too much about getting swallowed up by a black hole anytime soon. However, if you enter a wormhole, you’ll pop out somewhere far away, not needing to travel the actual intervening distance. While wormholes appear to be possible theoretically, they would be violently unstable, or need to be made of theoretical forms of matter which may not occur in nature. The bottom line is that wormholes probably don’t exist. When we invent interstellar travel, we’ll have to go the long way around.

**What happens at the very edge of a black hole?**

In our minds, we picture a bottomless pit with nothing but darkness and silence. However, this is not quite true. A black hole is a place where the escape velocity is much higher — more than 11 million kilometers per hour for the Sun. For the Earth, that velocity is about 11 kilometers per second (7 miles/second). If you could throw a rock up in the air, it would only go up a little before falling back down. If you throw the rock hard enough, it would hit the ground. If you throw the rock really hard, it would escape the Earth. What does this mean, exactly? Gravity is what keeps us on the Earth, even as it pulls on everything in the solar system, including the Earth. If a black hole has far more gravity than the Earth, so its escape velocity is higher, then it is possible for an object to escape the Earth, or anything else, and travel through this dust to the black holes on the other side. Current data estimates may be meaning as many as 80% of the black holes in the Universe are everywhere — as far as our astronomers can tell, there are probably millions of black holes in our Milky Way Galaxy alone. That may sound like a lot, but the nearest one discovered is still 1,000 light years away — a pretty big distance, even if it’s in our backyard. So don’t worry too much about getting swallowed up by a black hole anytime soon. However, if you enter a wormhole, you’ll pop out somewhere far away, not needing to travel the actual intervening distance. While wormholes appear to be possible theoretically, they would be violently unstable, or need to be made of theoretical forms of matter which may not occur in nature. The bottom line is that wormholes probably don’t exist. When we invent interstellar travel, we’ll have to go the long way around.

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The most common way for a black hole to form is probably in a supernova, an exploding star. When a star with about 25 times the mass of the Sun ends its life, it explodes. The outer part of the star screams outward at high speed, but the inner part of the star, its core, collapses down. If there is enough mass, the gravity of the collapsing core will compress it so much that it can become a black hole. If that’s all over, the black hole will have a size less than the mass of the Sun. This is called a “stellar-mass black hole,” what many astronomers think of as a “regular” black hole.

But there are also supermassive black holes, which are huge in the center of galaxies, and are over billions of times the mass of the Sun! They probably form at the same time as their parent galaxies, but exactly how is not known for sure. Perhaps each one started as a single huge star which exploded to create a black hole, and then accumulated more material (including other black holes). Astronomers think there is a supermassive black hole in the center of nearly every large galaxy, including our own Milky Way. The black hole itself may be hidden, but the material falling into it is not. The x-rays and gamma rays it emits are a sure sign that a black hole is there.

There are also small black holes, which are much lighter than the supermassive ones, and might be formed in the core of a distant galaxy. The existence of these black holes was first predicted by the mathematician Karl Schwarzschild in 1916, when he worked out the equations that describe gravity. He showed that if you were to have a star that was so dense that it let nothing escape its gravitational pull, then you could form a black hole. Since that time, many such black holes have been discovered, and the existence of black holes is now a well-established fact of modern astronomy.

But what does a black hole look like? You can’t see one, because nothing, not even light, can escape its gravitational pull. The only way to detect a black hole is by studying the effects it has on its surroundings. For example, if a star is close to a black hole, it will be pulled apart and torn apart by the black hole’s gravity. This can cause the star to emit light, which can be observed by astronomers. This effect is called “a quasar.”

If the black hole is rotating, it will create a “disk” of gas and dust around it. This disk is called an “accretion disk,” and it is from this disk that the black hole gets its matter.

So what happens when you fall into a black hole? If you fall into a black hole, you’re doomed, sure. Once you fall in you can never get back out, but that’s not really the end of the story. The black hole itself is actually only a small fraction of its mass—astronomers conclude that only a tiny fraction of that mass actually forms the black hole. Most of the mass is in the form of the “event horizon,” which is the boundary of the black hole’s gravity. If you were to get too close to the event horizon, you would be killed by the black hole’s gravity.

Are black holes “black,” or do they emit radiation? Surprisingly, black holes may actually emit a form of radiation known as “X-rays.” In fact, many black holes are so good at emitting X-rays that many astronomers have been able to identify them as black holes. This is because the X-rays are a signature of a black hole. When matter is falling into a black hole, it is heated up to very high temperatures, which in turn are emitted as X-rays. This is why X-rays are often used as a “fingerprint” of black holes.

So are we in danger of being gobbled up by a black hole? Actually, no. The forces of gravity near a black hole are so strong that you would be squashed to a fraction of a millimeter before you even reached the event horizon. But suppose you somehow manage to survive the trip in. What strange things await you on your way down into the black hole? If you fall into a black hole, you’ll be stretched out like taffy, until you reach the event horizon. At this point, the black hole’s gravity will be so strong that you will be sucked in, and you’ll be done for.

But if you somehow manage to survive the journey, you’ll be inside the event horizon. Here’s where things get really interesting. The laws of physics as we know them break down in the region of the black hole known as the “singularity.” The singularity is a point where the density of matter becomes infinite, and the laws of physics as we know them cannot be applied. In the singularity, time and space as we know them come to an end.

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