Why it Matters

Black Holes

A black hole is an object that is so massive that nothing, not even light, can escape the pull of its gravity. In 1916, Karl Schwarzschild was the first person to suggest the existence of black holes. He used his solutions to Einstein's general-relativity equations to explain the properties of black holes. In 1967, the physicist John Wheeler coined the term "*black hole*" to describe these objects.

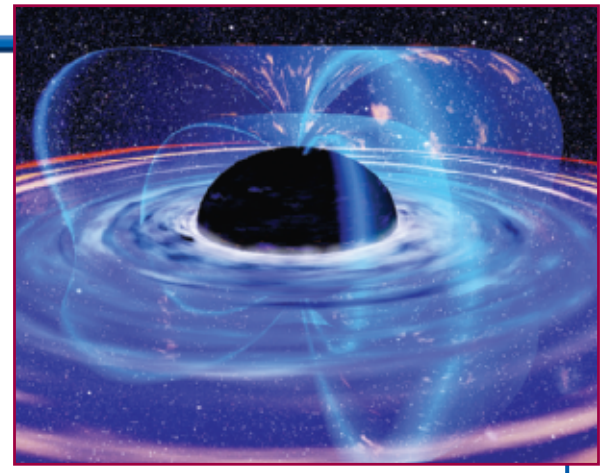
In order for an object to escape the gravitational pull of a planet, such as Earth, the object must be moving away from the planet faster than a certain threshold speed, which is called the *escape velocity*. The escape velocity at the surface of Earth is about 1.1×10^4 m/s, or about 25 000 mi/h.

The escape velocity for a black hole is greater than the speed of light. And, according to Einstein's special theory of relativity, no object can move at a speed equal to or greater than the speed of light. Thus, no object that is within a certain distance of a black hole can move fast enough to escape the gravitational pull of the black hole. That distance, called the *Schwarzschild radius,* defines the edge, or *horizon,* of a black hole.

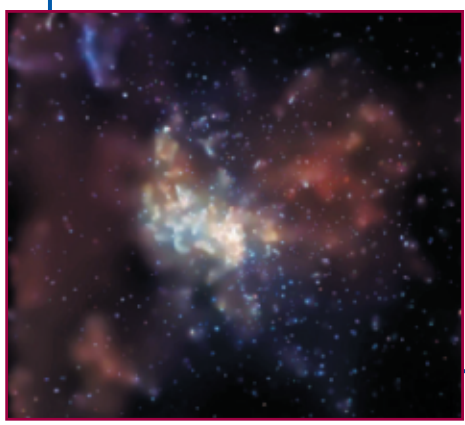
Newton's laws say that only objects with mass can be subject to forces. How can a black hole trap light if light has no mass? According to Einstein's general theory of relativity, any object with mass bends the fabric of space and time itself. When an object that has mass or even when a ray of light passes near another object, the path of the moving object or ray curves because space-time itself is curved. The curvature is so great inside a black hole that the path of any light that might be emitted from the black hole bends back toward the black hole and remains trapped inside the horizon.

Because black holes trap light, they cannot be observed directly. Instead, astronomers must look for indirect evidence of black holes. For example, astronomers have observed stars orbiting very rapidly around the centers of some galaxies. By measuring the speed of the orbits, astronomers can calculate the mass of the dark object—the black hole—that must be at the galaxy's center. Black holes at the centers of galaxies typically have masses millions or billions of times the mass of the sun.

The figure above shows a disk of material orbiting a black hole. Material that orbits a black hole can move at such high speeds and have so much energy that the material emits X rays. From observations of the X rays coming from such disks, scientists have discovered several black holes within our own galaxy.



This artist's conception shows a disk of material orbiting a black hole. Such disks provide indirect evidence of black holes within our own galaxy.



This image from NASA's *Chandra X-ray Observatory* is of Sagittarius A*, which is a supermassive black hole at the center of our galaxy. Astronomers are studying the image to learn more about Sagittarius A* and about black holes in the centers of other galaxies.