BLACK HOLES EXPLAINED

(1) Black holes are often featured in science fiction movies, but few people actually know what they are. They seem scary, but do we really have that much to fear from them? The concept of a black hole can be difficult to understand because it can't be seen and no human has actually experienced going into one or even being near one. A black hole is a region in space-time that has an extremely high gravitational attraction due to its mass and density. Let's break apart that statement so that we can understand black holes better.

(2) "A black hole is a region in space-time..." Space-time (or the space-time continuum) is four dimensions rolled into one. There are three dimensions of space: one is height, one is width and another is depth. This gives us the sense of three dimensional space. The fourth dimension is time. Albert Einstein came up with a theory called the Theory of Relativity and in this theory, he proposed that the three dimensions of space and the one dimension of time are linked and cannot be separated. Einstein suggested that they exist as one thing called the space-time continuum.

(3) Often people think of gravity as a "pulling effect" of one object on another. The object with more mass "pulls" the object with the lesser mass towards it. However, when we consider space-time, gravity becomes something very different. Gravity is actually the curving of space-time due to the presence of an object with a lot of mass. When an object has a lot of mass, our Sun for example, the mass of the object causes space-time to curve towards the Sun and this curve is called gravity.

(4) Here is an analogy to help you visualize the curvature of space-time. Imagine if you have a piece of fabric stretched out flat by four friends who each holds one corner of the fabric at waist height. This fabric represents space-time. Imagine that there is a fifth friend and she throws a ping pong ball to the center of the fabric. The ping pong ball has very little mass so the fabric stays nicely stretched between the four friends. If, however, the fifth friend throws a bowling ball to the center of the fabric, the heavy mass of the bowling ball causes the fabric to sag and dip underneath the mass of the ball. This causes the sides of the fabric to slope downwards towards the bowling ball even if the four friends hold on tightly to the fabric. If the fifth friend now releases a ping pong ball at one corner of the fabric, the ping pong ball would roll down the sloped side of the fabric to join the bowling ball at the bottom of the fabric.

(5) In the above example, the bowling ball represents a massive object, like a black hole, and the ping pong ball represents an object of lesser mass nearby, like a star. Since the black hole's mass curves space-time (the fabric), the star seems like it gets "pulled" or "sucked" towards the black hole. In reality, it's just moving along the curve in space-time created by the presence of the black hole. The mass of the star will add to the mass of the black hole making it even more massive and causing it to curve space-time even more.

(6) All things with mass curve space-time, but a black hole contains so much mass squeezed into such a small volume that the curvature of space-time is extreme. A black hole's gravitational attraction is so strong that not even light can escape it. However, you have to be close enough to a black hole to get "sucked" in. How close is too close? There is a spherical region around a black hole and the outermost border of this region is called the event horizon. If anything moves within the boundary of the event horizon, it will not be able to escape being drawn into the black hole. Anything travelling fast enough outside of the event horizon has a chance of escaping. In the middle of the black hole is the region where all the mass of the black hole is concentrated and this is called the singularity.

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(7) Since you can't see a black hole, as it doesn't emit or reflect light, the only way to know it's there is to see its effects on the matter and energy around it. If you see stars or gases swirling around an invisible center, that's a good indication that there might be a black hole in the middle. Stars that come too close to a black hole can start to get ripped apart and bright clouds of gases can be seen being stripped from the star and swirling into the black hole.

(8) There are different types of black holes that differ in their size and origins. Miniature black holes have the mass of Mount Everest but compacted into the space of an atom. They are thought to have formed when the universe was first created. A stellar black hole is formed by a star with a mass that is 3-20 times that of our Sun. It forms when a huge star explodes in what is called a supernova. What remains after the supernova is the stellar black hole. Hundreds of millions to billions of these may exist in our Milky Way galaxy. Supermassive black holes are thought to be in the centers of galaxies. Each one is millions of times the mass of our Sun. Supermassive black holes may have formed by the joining of several black holes and they get bigger and more massive as they attract more matter and energy to them.

Article Questions

1) The gravitational attraction of black holes are so strong that not even _____, which is the fastest known thing in the universe, can escape it. _____ black holes are thought to have formed when the universe first formed. _____ developed the Theory of _____. _____ is the curvature of space-time.

2) What is a black hole?

3) What is space-time?

4) What is the event horizon?

5) What is a singularity?

6) If a black hole is invisible, how can we determine when one is present?

7) What is one major difference between a stellar black hole and a supermassive black hole?