The Science Behind Black Holes

Black holes are one of the most destructive forces in the universe. Nothing, not even light, can escape their grasp. Despite this, black holes may yet hide some of the universe's most amazing secrets.

PRACTICAL SCIENCE WITH PHIL FREDA

What is a black hole?

If you remember my article a few months back on the red giant star Betelgeuse, I wrote briefly about the topic of black holes.
Our sun is a relatively average, main-sequence star. In about five billion years or so, our star will run out of hydrogen fuel and expand to a brief "red giant" phase before shrinking into a small, pale white dwarf.
There are much bigger stars out there, however.
Stars with a mass greater than 20 times that of our sun will go through a massive explosion before they die called a supernova.
For most of a star's life, it is in a constant tug-of-war between gravity pushing down and nuclear energy pushing out.

When all of the star's energy is depleted, gravity wins out the war.
For massive stars, the amount of gravity is so great that it compresses the core of the star to a point at which it occupies no volume but is infinitely dense.

This point is referred to as the singularity, and we now have ourselves a black hole.
A black hole distorts the fabric of space-time so much that its gravitational pull is immense and can suck in anything that gets near it.

How powerful is a black hole's gravitational pull?

Every planet, moon and star has something called an escape velocity.
An escape velocity is defined as the minimum speed required to break the celestial body's gravity and travel into space.

The larger the celestial body's size and mass, the faster the speed needed to escape.

According the UC Berkeley's Cosmology site, the escape velocity for the Earth is 25,000 mph.
This is how fast the space rockets must travel in order to achieve orbit.

A black hole's gravitational pull is so intense that the escape velocity exceeds the speed of light!
Remember, the speed of light is 186,000 miles per second!
If you recall one of my previous articles on the relativity of time, nothing can travel faster than light.
From a black hole, there is no escape. Light itself cannot even escape.

What makes up a black hole?

Aside from the singularity, there is another major point of the black hole called the event horizon.
Just for clarification, the 1997 movie *Event Horizon*, starting Laurence Fishburne and Sam Neill, got its name from referencing black holes, not the other way around.
The event horizon is the spherical boundary of the black hole. Tidal forces of the black hole get more powerful the closer you get to them.

As you move closer and closer, the escape velocity also begins to increase exponentially.

Once you cross the event horizon, the escape velocity exceeds the speed of light, and escape is no longer an option.

Some black holes sport whats called an accretion disk. This is another feature that may or may not be visible on a black hole.
An accretion disk is essentially matter swirling around and being sucked into the event horizon and ultimately the singularity.

Another interesting event sometimes observed in rotating black holes are super-heated columns of radiation called jets.
It is unclear what the origin and function of these jets are, but there are some interesting theories out there that we will cover later.

What would it be like to be sucked into a black hole?

According to UC Berkeley's Cosmology site and Amazing-Space, falling through a black hole would be a very strange experience.
First, you wouldn't feel any gravitational force because your body will be pulled equally and you would be in free-fall.

As you get closer and closer, however, you will start to feel tidal forces.

Let's say your feet are a little closer to the black hole than your head. Eventually, your feet will feel more of a gravitational pull than your head.

This will increase the closer you get to the center until you are ultimately stretched and ripped apart.
Sounds fun!

If you took one look back toward the part of space you came from before falling in, you would sill be able to see it, but it may seem a bit distorted. Remember, this is because light can still enter the black hole, but it can't escape.

To an observer, however, things would look very odd.

Say you were able to watch an object being sucked in from a safe distance.

As this object gets closer and closer to the event horizon, the object will appear to be moving slower and slower to the observer.

This happens because the light emitted from the object has a harder time reaching you, as the object gets closer to the black hole's event horizon.

Finally, after you see the object hit the event horizon, the object will appear to be frozen in time because the light it is emitting can no longer escape.

You could stay at that safe distance forever, and the object will appear to never cross the threshold.

This is merely an optical illusion however, because it has already fallen into the black hole.

Are we in danger?

There are no black holes that we know of that are close enough to our planet to pose any threat at all.

According to the Black Hole Encyclopedia, the closest black holes are on the order of thousands of light years away.

How do we know they exist?

This is a great question.

Black holes cannot be viewed directly because they emit no light, but rather, trap it.

The best way to detect black holes is the effect they have on the matter around them.

According to Amazing-Space, as matter swirls faster and faster around a black hole radiation is emitted that can be detected.
Procedures like this have led scientists to point to the center of galaxies as possible areas for immense, super-massive black holes that are billions of times more massive than our sun.

It is currently theorized that there is a behemoth of a black hole in the center of our home galaxy, the Milky Way.

Another way to detect black holes is to measure the mass of an area where a black hole is thought to exist.

According to UC Berkeley, if the mass is very large, but the volume is small and no light is being emitted, there's a good chance you've found one.

What can black holes teach us?

There is a lot of science fiction out there that paints black holes as doorways to another universe or a way to traverse time.
These ideas are fascinating and fun to think about, but they are highly speculative.

There is so much we do not know about black holes, and there is no evidence that points to black holes being wormholes or gateways of any sort.
On the other hand, there are many contemporary "real-science" ideas concerning black holes.

Some scientists have observed large amounts of charged particles and radiation being emitted from rotating black holes from their powerful jets.

This points to the possibility that black holes are not merely cosmic vacuums, but rather "recycling bins" that help reshape and "seed" regions of space.

The immense power of the jets is thought to help spread star-making gases around space to make new stellar nurseries.

It may be true that black holes are integral to the life cycles of stars, solar systems, and galaxies.

This area is still wide-open with many more spectacular discoveries that are possible in the future.

Since we know close to nothing about black holes, many more interesting theories will soon come to pass.

Think about it!

If interested in black holes, I highly recommend checking out the work of Stephen Hawking.
Don't forget to check out the embedded video links, too!

Have you thought about it, yet? Tell us in the comments.