BACK TO THE FUTURE OF PHYSICS: Black Holes

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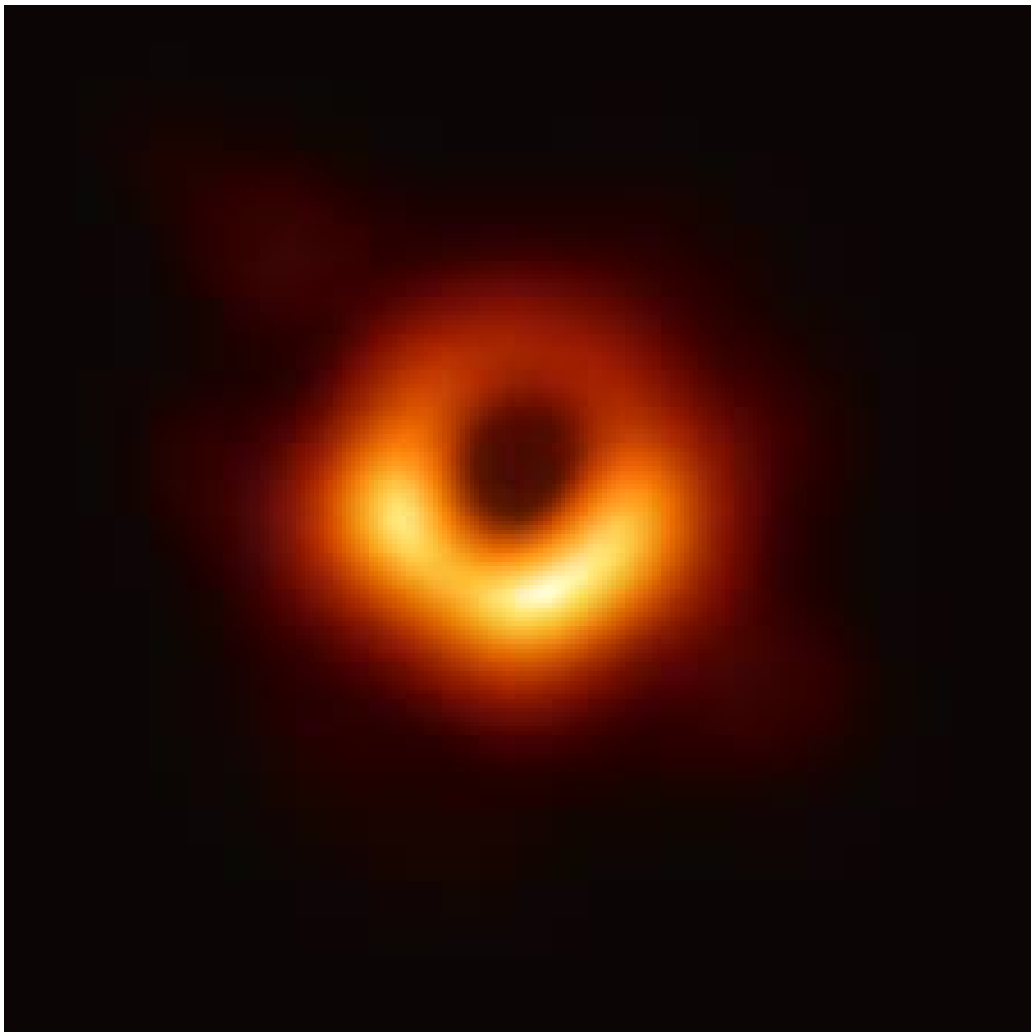
Etwinning project between De Bron Tielt and Liceo Lugo



First picture of a black hole, made by the Event Horizon Telescope on 10 april 2019

For this report, we want to get to know more about black holes and we're going to do that by asking ourselves several questions. We'll explain what black holes are, how they are formed, what types there are, what the future of them is and much more.

What is a black hole?

So far, astronomers have identified three types of black holes: stellar black holes, supermassive black holes and intermediate black holes.

A black hole is a place in space where gravity pulls so much that even light can not get out. The gravity is so strong, because matter has been squeezed into a tiny space. This can happen when a star is dying.
Light can't get out, consequently people can't see black holes just using their eyes. Space telescopes with special tools are used in order to detect the presence of black holes. The special tools can see how stars, close to black holes, behave.

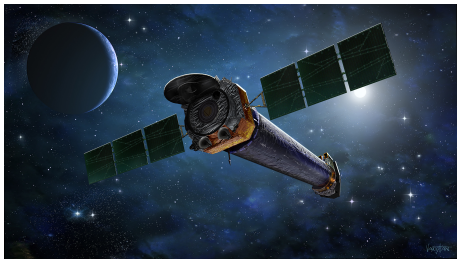
The largest black holes are called "supermassive." The masses of these types of black holes are bigger than 1 million suns put together. Scientists discovered that every large galaxy contains a supermassive black hole at its center. The supermassive black hole at the center of the Milky Way galaxy is called Sagittarius A. It has a mass equal to about 4 million suns and would fit inside a very large sphere that could hold a few million Earths

Black holes can be big or small. Scientists think the smallest black holes are as small as just one atom. Scientists are able to observe them through special equipment such as telescopes. The telescopes that are used are able to detect x-rays, light and all the other forms of electromagnetic radiation. Mainly, they observe the influence that black holes have on whatever is around them, like for example stars or other celestial bodies.

These black holes are very little, nevertheless they have the mass of a large mountain. The smallest black hole ever discovered is 3,3 times the mass of the sun.
Around its horizon, a rotating black hole creates a region called the Ergosphere.

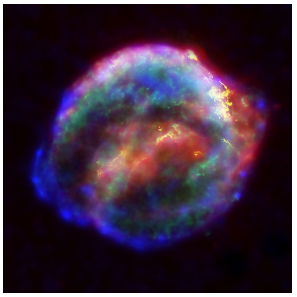
How are black holes created and how do we see them?

They are generated in space and we know that black holes have a great influence on the matter around them. Black holes are born when the center of a star collapses on itself.
This so-called implosion can also cause a supernova or an exploding star that throws pieces of the star into space.
Scientists think supermassive black holes were formed at the same time as the galaxy they are in. The size of the supermassive black hole is related to the size and mass of the galaxy it is in.



By observing the effects of the strong gravity of a black hole on tha stars and gases around it, physicists are able to analyze a star's motion in order to find out if they are influenced by a nearby black hole.

What's the difference between a supernova and a black hole?



To fully understand the formation of a black hole as we explained in the previous segment, you must know the difference between a black hole and a supernova.
Actually, they don't have much in common apart from their formation. You need a supernova to form a stellar black hole. The last one is created when the core of a supernova collapses. When this happens, there is a leftover. This can either be a neutron star or a stellar black hole.
As you know, a black hole is a large amount of mass squished in a tiny space, while a supernova is the explosion of a star. After the explosion, you have remnants in the form of an expanding ball of gas and that is the main difference.
The figure you see here shows what a supernova looks like.

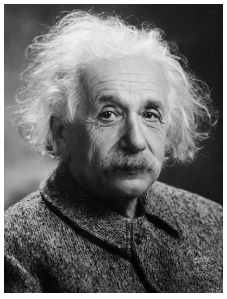
Could black holes destroy Earth?

Black holes do not wander around the universe. They follow the laws of gravity just like other objects in space. The orbit of a black hole would have to be very close to the solar system to affect Earth, but none of them is close enough to our planet to do so.

If a black hole with the same mass as the sun would replace the sun, Earth would not fall in. The black hole would keep the same gravity as the sun. The planets would still orbit the black hole as they orbit- the sun now.

The sun, the closest star to our planet, won't become a black hole because it doesn't have enough mass to collapse into a black hole. When the sun reaches the end of its life, it will become a red giant star. Finally, at the end it will be a white dwarf star.
This means that we don't have to worry about our sun capturing the Earth. By the time the sun changes into a red giant, there will no longer be life on this planet anyways.

When did we discover Black Holes?



Albert Einstein predicted the existence of them in 1916, with his general theory of relativity. The term "black hole" was coined many years later in 1967 by the American astronomer John Wheeler. After many years of theories, the first physical black hole ever discovered was spotted in 1971. Then, in 2019 the Event Horizon Telescope collaboration took the first image ever recorded of a black hole. The EHT saw the black hole in the center of galaxy M87 while the telescope was examining the event horizon, the area past which nothing can escape from a black hole. It also opens up a

whole new area of research in black holes, now that astronomers know what a black hole looks like. In 2020, the Nobel Prize for Physics went to three scientists, ,Roger Penrose, Reinhard Genzel and Andrea Ghez, that proved Einstein's theory of relativity and proved that there was a superheavy ‘object’ in the center of the Milky Way. This proves that black holes are still topical.

What is the etymology of black holes?

John Michell used the term "dark star" to describe the phenomenon, and in the early 20th century, physicists used the term "gravitationally collapsed object". In the early 1960s they reportedly even compared the phenomenon to the Black Hole of Calcutta, a notorious prison where people entered but never left alive.

The term "black hole" was used in print by Life and Science News magazines in 1963 (this is the first time the word “Black Hole” was used in print). In December 1967, a student reportedly suggested the phrase "black hole" at a lecture by John Wheeler; Wheeler adopted the term for its brevity and "advertising value", and it quickly caught on, leading some to credit Wheeler with coining the phrase.

How did scientists take a picture of a black hole?

In April 2019, scientists managed to take the first ever picture of a black hole. It was located in the galaxy M87 which is about 53 billion light years away from Earth. In this case, we speak of a supermassive black hole.
Actually, we don’t see the black hole in the picture because they absorb everything, even light as we already mentioned. What we actually see in the pictures are the photons that are circling around the black hole and the shade that is created by them. Einstein already predicted this in his theory.
Scientists could capture this image because they already knew that there was a black hole situated right there. They could find out where it was using radio waves. The only thing they then still had to do was to take the picture.

First, you should know that all we can see of a black hole are the things that flew around it right before it arose. That’s because time stands still inside of a black hole. These flying particles also emit radio waves, and by using eight radio telescopes placed all over the world, they could eventually make this photograph. All these telescopes together are called the EHT or Event Horizon Telescope, which you see in the figure on this page. In 2017, these telescopes were directed to the same location in M87 for a few nights. The waves of all the things that circulated around the black hole were intercepted. These contained lots of information which was stored on hard disk drives with a storage of multiple petabytes. One petabyte is equivalent to 1000 terabytes. After analyzing all of this data with complex algorithms on so-called supercomputers , less than 0.0001% of it was needed for the final result.

How will black hole images change and become better in the future?

April 2020 marked the first anniversary of the image of the environment directly surrounding the black hole of the M87 galaxy as already mentioned earlier. This image was captured by the EHT or Event Horizon Telescope and researchers haven't rested ever since. Several teams have been working on this topic extensively, trying to make even better pictures of these natural phenomena.

A team led by scientists at the Center for Astrophysics, Harvard and Smithsonian have published a study that promises an improvement in the imaging of black holes, but also in the amount of information that can be derived from them. They have calculated that an intricate substructure within these images could be revealed by gravitational lensing, this is a phenomena where objects with great mass cause the curvature of space around them, and thus bend the path of the light traveling through it. The scientists conducted their study by examining the golden ring that dominates the image of M87. The ring is impossible to notice in this image. Through the use of Einstein's theory of general relativity, they found out that the image of a black hole actually contains a series of rings as you can see on the picture on the right. These rings have the same diameter, but become sharper and sharper because their light has orbited the black hole more times before reaching the observer. With this EHT image, they think they've just caught a glimpse of the full complexity of the image of a black hole. As you see in the figure above, we know some of the 'layers' of the black hole, but scientists don't know what lies deep inside of them.

The scientists of this study say it's an exciting time to be thinking about the physics of black holes. The special image of the EHT, mentioned earlier, has changed black hole research from purely theoretical field to experimental science. This is because Einstein's predictions for certain types of observation, based on his theory of relativity, are finally coming within reach due to our developing systems and technology. This theory of relativity is the basic idea that instead of being a force that attracts objects to one another, gravity is a curving or warping of space. The more massive an object, the more it warps the space around it. The results of the previous study were also roughly the same as Einstein's theories, making his other ideas even more plausible and proving some of his hypotheses. Not only for black holes but also for other universal predictions of general relativity these results are very promising.

What is the closest black hole to Earth?

The closest black hole to Earth discovered is 1000 light years away. It was discovered by the MPG/ESO 2.2-metre telescope at ESO's La Silla Observatory in Chile. The black hole forms a part of a triple system that can be seen with the naked eye. The hidden black hole in the system, HR 6819 is important because it is one of the very first stellar-mass black holes found that do not interact violently with their environment and, therefore, appear truly black. The discovery of this silent, invisible black hole can be important: it provides clues about where the many hidden black holes in the Milky Way might be. Studying these systems can give astronomy more information about the formation and evolution of the stars, who begin their life with a mass that is more than 8 times the sun and ends in a supernova explosion that leaves behind a blackhole.

Conclusion

By now, we know quite a lot about black holes. We know what they are, how they are formed and what types there are and we already know a few things about future research, but only time will tell. Unless you're trapped inside a black hole of course because as you know, time stands still in there.

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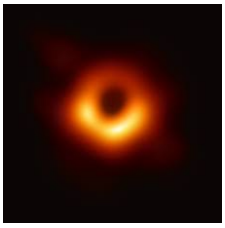
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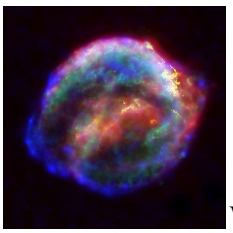
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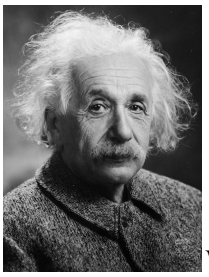
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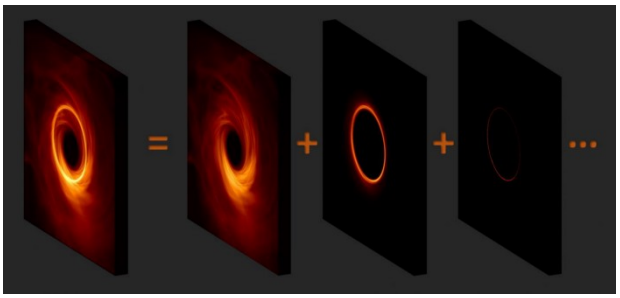

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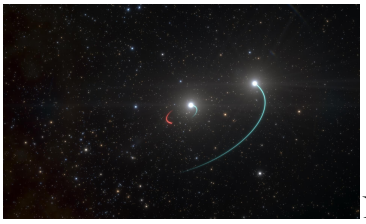
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