2019 THE BLACK HOLE

美星英文

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WARM UP

1. Before going through this worksheet, how much do you know about this topic?

FACTS ABOUT THIS EVENT

Watch the short introductory clip provided by CNN on the Black Hole and skim through the article to answer the questions:
https://edition.cnn.com/2019/04/12/world/black-hole-name-powehi-scli-intl/index.html

2. What is the name of the project?
3. How many radio telescopes did the scientists use to make the black hole image?
4. Where were they located?
5. Why did they need so many different telescopes?
6. What are names of the two black holes introduced in the video?
7. According to the reading, what is the name of the picture of the black hole?

LISTEN AND LEARN

Voice of America: Why the black hole is such a big deal (2019/04/10)
https://www.youtube.com/watch?v=pAoEHR4aW8I
Watch the video without the transcript and try to answer the following questions.

8. When did this project start?
9. Which black hole did they take a picture of?
10. What is at the center of that black hole?
11. The heated matter emits what which can be detected by our telescopes?
12. Why did they choose m87 instead of Sagittarius A*?
13. For scientists to be able to take this picture, they first needed what to travel all the way to the end of the black hole?
14. Once the data was collected, how was it analyzed?
15. According to the scientist, why is this picture real?

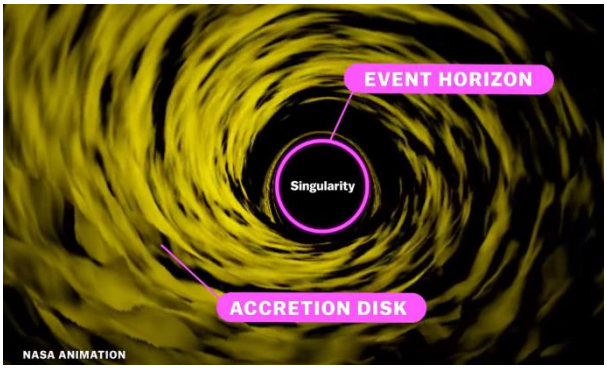
CHECK THE TRANSCRIPT

Watch the video again, this time with the transcript, and review your answers.

On April 4th, 2017, a privileged group of telescopes on mountains across the planet switched on at the same time. For the next week, they danced in unison, collecting radio waves dispatched from the center of our Milky Way galaxy and from the galaxy M87. Together they make up the event horizon telescope, a global project to capture the first ever picture of a black hole. That's right. Ever since **physicists** first conceived a black hole centuries ago, every image of one from our textbooks and our space agencies, they were all illustrations. Until now. “We are delighted to be able to report to you today that we have seen what we thought was unseeable.”

For centuries, physicists have **theorized** that an object with enough mass and density could trap even light in its gravitational field, just as you have to travel faster to leave Earth than you do to leave the Moon. There could be a place where you'd have to travel faster than the speed of light to escape. And nothing moves faster than light.

01:03



The math from Einstein's theory of general relativity describes an area completely invisible to us within a boundary called the "**event horizon**," and at the center of that black hole is a **singularity**, a point of infinite density which is where physics as we know it breaks down. “They showed up in the math long ago and they kept reappearing and they sort of persistently would not go away, but Einstein always thought that there must be some physical mechanism that prevents stars from collapsing to an infinitely small point, which is actually pretty reasonable. I mean, because it sounds insane.”

Eventually scientists began to see things that only made sense if black holes were real, like the **orbits** of these stars around the center of the Milky Way galaxy. “You see these stars just **sling shotting** around an invisible point and a black hole is the most likely explanation for putting that amount of mass in that small space, for something that's completely dark.”

We can also see the glowing material that **spirals** around black holes: **Friction** heats this matter up tens of millions of degrees and anything that hot emits X-rays that we can detect with telescopes that orbit above Earth's atmosphere.

02:14

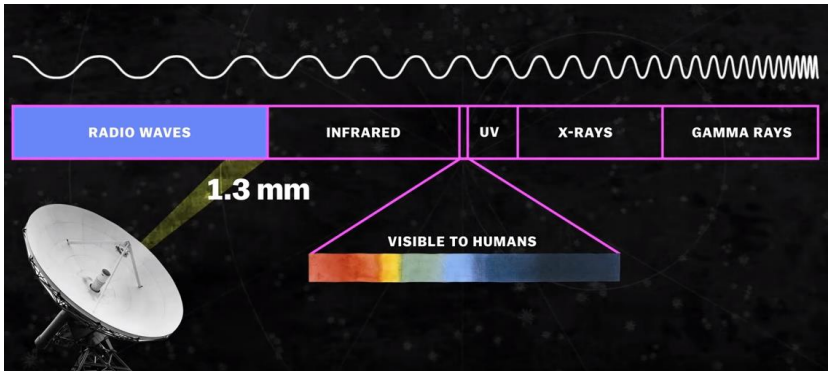
This is a pair of galaxies that pass through each other. There are at least nine suspected black holes here, but you can only see them when you look at the X-ray layer. These dots are X-ray sources linked to suspected supermassive black holes at the center of galaxies three to ten billion light-years away. And that's just from this small patch of sky. Some super massive black holes also feature gigantic jets of particles, seen here in radio wave data from the galaxy M87,

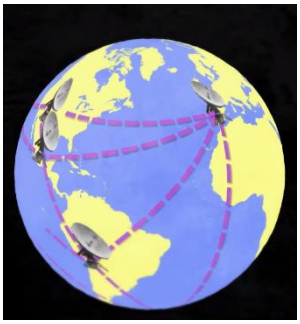
which has a much bigger black hole than the one in the center of the Milky Way. No other known source of energy could power these things and nothing we know of besides two black holes **colliding** could have produced the gravitational waves we detected in 2015.

02:57

Scientists think there are black holes large and small all over the universe. We can see their fingerprints but we didn't have the mug shot. Directly imaging a black hole has been impossible because they're either too small, too far away, or both.

Sagittarius A*, the black hole at the center of our galaxy has the mass of four million Suns, but it would fit inside the orbit of Mercury. Imaging it from Earth is like taking a picture of a DVD on the surface of the Moon, with huge clouds of dust and gas in between. “So many things had to go right for this image to exist, so the first thing that has to happen is there has to be some slice of light that travels all the way from the edge of the black hole without getting **knocked off** course or absorbed by any of the gas or anything in between, and then it also has to make it through the Earth's atmosphere which a lot of frequencies of light don't.”



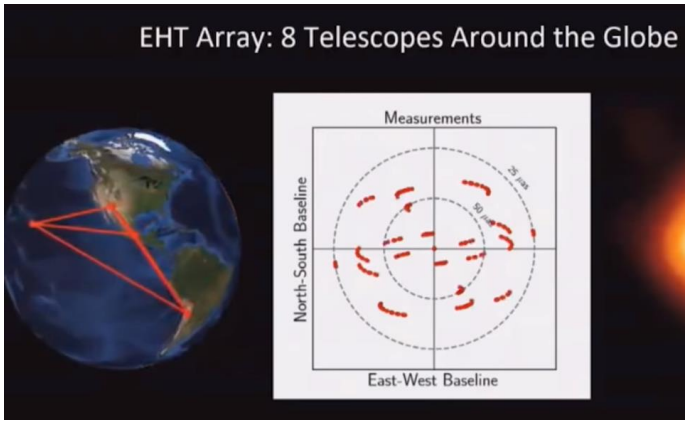


They landed on a wavelength of 1.3 millimeters at the high frequency end of the radio spectrum. With that wavelength and with eight observatories across the world, the event horizon telescope had a chance at seeing a black hole, as long as the weather cooperated. “You have to have clear weather in all of those places at a time when the Earth is oriented in such a way that all of those telescopes can see the black hole simultaneously. They can really only observe once a year.”

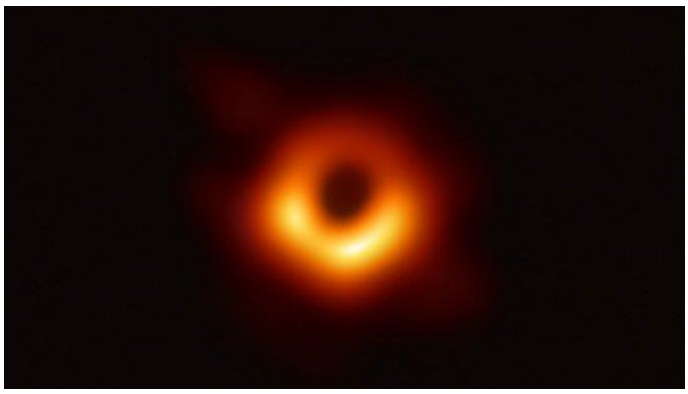
04:19

There was so much data involved that it had to be flown on airplanes. They waited six months for the hard drives to arrive from the South Pole, which closes during winter time.

This multi-telescope method is called "Very long baseline interferometry," it correlates timestamped data from distant telescopes to boost the signal and quiet the noise. Each pairing of telescopes contributes a piece of the puzzle, but the image doesn't just pop out after that. They had four groups working for months to generate the image that best represents the data. “Each group was working individually, and like, in isolation from the other groups, working with the same data, to see that each group came up with the same image or not.”



And the result of all that work is this.



The bright parts are the matter and lights swirling around the black hole and it's brighter on the side that's moving toward us. And the dark part is the black hole's shadow, which includes the event horizon plus a region where light could escape, but doesn't. The size and shape of the shadow appear to confirm the theory of general relativity. “Today, general relativity has passed another crucial test, this one spanning from horizons to the stars.”

05:42

Humanity's first image of a black hole isn't crisp and beautiful like the illustrations or the movie Interstellar. It's better. “The picture we see this week is made of **scraps and bits** of light that's been traveling across the universe and collected by these, you know, aluminum dishes on top of mountaintops and then combined in a supercomputer to make this image. So that's why it's real.”

DISCUSSION

16. Do you think this image is real? Why or why not?

17. Do you think the government should spend more funding on space exploration? Why or why not?

VOCABULARY

Look up not just the meaning but also the part of speech and pronunciation. If there are more unfamiliar vocabulary words, continue to learn by making your own chart!

Word	Part of speech	Pronunciation	Meaning
1. physicist			
2. theorize			
3. event horizon			
4. singularity			
5. orbit			
6. slingshotting			
7. spiral			
8. friction			
9. collide			
10. knocked off			

MAKE SENTENCES

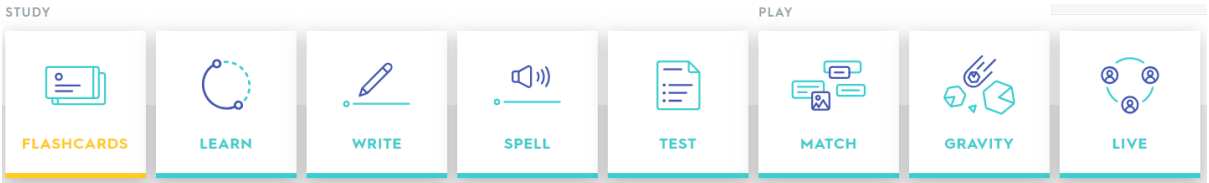
Please make 6 sentences with all the 10 words above.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

QUIZLET

Review vocabulary using Quizlet. The app allows you to review the words through flashcards, quizzes, or other fun games!

Here is the set for this worksheet: https://quizlet.com/_6i1zxy



KAHOOT REVIEW

Review your comprehension of this worksheet by playing the Kahoot game! ☺

https://create.kahoot.it/share/news-the-black-hole/b85c2bee-1ea5-4225-8dfe-f3b823f7bba6

REFLECT AND LEARN

Either in outline format or paragraph format, reflect on what you learned from doing this worksheet? For example, how is it relevant to your life? What new information did you learn? How can you use the newly learned vocabularies in your life? Will you follow up on this news?

FURTHER DIGGING

After doing this topic, you might have more questions. Feel free to find more videos or articles to answer those questions.

Example: I found this Ted talk on "How to take a picture of the black hole" to help me understand how the algorithm worked.
https://www.ted.com/talks/katie_bouman_what_does_a_black_hole_look_like?language=en

Now it's your turn to dig deeper!