

Perspective

Is Black Hole A Hole?

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SUMMARY

The first picture of black hole was released on April 10th, 2019. This breakthrough came after a decade of collaborative work to align the myriad parts of the giant project and gain the highest resolution possible from the Earth's surface. Even from our original consideration, black hole is a mysterious greedy hole that can suck anything away no matter how big the matter is. However, the newly released results indicated that black hole is not the imaginary hole; it is as a dark shadow within a doughnut-like ring of hot, glowing material with almost the size of our solar system. ■

KEYWORDS Black hole; Universe; Gravity; Matter; Radiation

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In the view of the common world, it is a “hole” formed in time and space, increasing its own quality by constantly consuming the surrounding matter; and it is also the “cage” of photons; it is insatiable and never stops eating everything around it. Yes, this is the general picture of the black hole: both bully and greedy. However, is that true?

On April 10th, 2019, The Event Horizon Telescope Collaboration including 200 collaborating members released the first black hole image (**Figure 1**) taken by the “Event Horizon Telescope” (EHT) in the journal of The Astrophysical Journal Letters with six papers published simultaneously (1-6). This long-awaited explorative message made the whole physics community boil. The black hole, the fascinating celestial body, began to emerge our body.

HOW DOES THE BLACK HOLE FORM?

When a star shrinks to a certain critical radius – Schwarzschild radius, the gravitational force on the surface became so strong that the light could no longer escape. According to the theory of relativity, nothing can travel faster than light. If light cannot escape, other things are even less likely: everything will be pulled back by the gravitational field. In this way, there is a collection of events or spatio-temporal areas where light or anything else cannot escape from that area and then reach farther distance to the observers, as thus we call this area a black hole and its boundary the event horizon (7).

All stars are nuclear fusion reactors, in which light elements (majorly hydrogen) are aggregated into heavy elements. The nuclear fusion process provides most of the energy of a star’s life. However, in the end, the nuclear fuel is exhausted, and the energy generated by the center is no longer able to withstand the huge body of the outer casing, and then gravity begins to dominate (8). So, it is relatively proposed that the star-size black hole is the remains of the star collapse; whereas the massive black hole may come from the medium mass black holes accumulating via other unknown mechanisms.

In 1928, on his way to Britain, Subrahmanyan Chandrasekhar calculated and got the so-called “Chandrasekhar Limit” that is approximately 1.44 solar mass by indicating that if after all the fuel was exhausted, how many stars could continue to defend themselves

against their own gravity. Of course, this value is of great significance to the final destination of a massive star. In general, if the mass of a star is less than 9 times the solar mass, a white dwarf will eventually form; if about 9-25 solar masses, the stars will evolve into supernova explosions and eventually collapse into neutron stars; and if above 25 the solar mass, then it will form black holes (9).

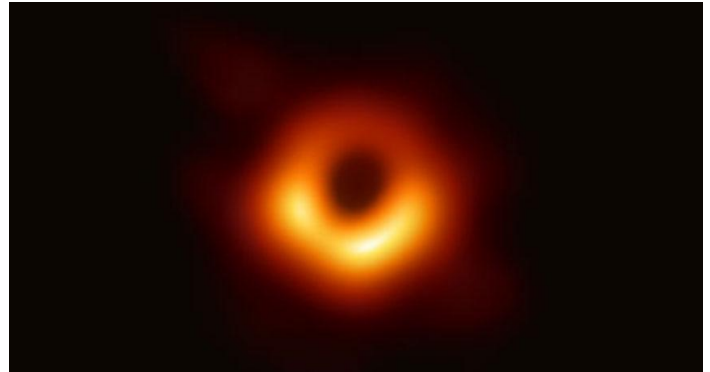


Figure 1. The first image of a black hole. The picture shows a bright ring with a dark, central spot. That ring is a bright disk of gas orbiting the supermassive behemoth in the galaxy M87, and the spot is the black hole’s shadow.

PICKY VERSUS GREEDY: THE BLACK HOLE’S INTERNAL PROPERTY

Black holes are different in properties. Some are greedy, so they can suck large amounts of gas and dust; but others are very picky.

For instance, the Sagittarius A* in the center of the Milky Way seems to be very picky. Although it is 4 million times the solar mass, its accretion disk (a flat plate-shaped mass consists of gas and diffused matter etc. rotating around a black hole or a neutron star) is surprisingly dim (10). However, the black hole in the M87 galaxy is a greedy diner with a mass between 3.5 billion and 7.22 billion solar masses. Not only does it have a very bright accretion disk, but it also ejects a bright, fast stream of charged subatomic particles that extend for around 5,000 light years (11). The potential reason for such a big difference between black holes is majorly from its distinctive central environments, i.e., some centers of galaxies are affected by disturbances such as galaxy collision that provides with enough gas to the central black hole as food; but others are relatively stable, and only a small amount of gas can reach the vicinity of the black hole, which makes the black hole have to be shallow and slow.

THE POTENTIAL EFFECT OF BLACK HOLE

Although people's enthusiasm for black holes is high, they can only be viewed from a distance, but the consequences are very serious. If you are too close to the black hole, you will be stretched like a piece of spaghetti. This phenomenon has been named "spaghetti effect" (12). The reason for this effect is that the amount of gravity that is received throughout the body varies. If you fly your feet down towards the black hole, because your feet are closer to the black hole, it will get more gravitational than the head. To make matters worse, because the arms are not in the center of the body, they are elongated in a slightly different direction from the head, and the edges of your body are pulled into the body. The eventual result is that your body is not only stretched, but also thinned. Therefore, before you arrive at the center of the black hole, you will become that piece of spaghetti early.

Although classical black hole theory believes that no matter and radiation can escape from it, whereas the quantum mechanics theory shows that information can be regained after falling into black holes. This is the so-called "information paradox" (13). In 2016, Hawking et al. suggested that the information part of the particles falling into the black hole does not disappear, but just released in different forms, the thing we cannot do is how to restore and decipher them.

The fact is that in March 2015, Hawking has revised the black hole theory by claiming that the black hole is actually "grey". From it, the "Grey Hole" theory stated that matter and energy are trapped by black holes for a period of time, and they will be released into the universe again. He also pointed out that black holes are not "eternal cages", but some information will be released in different forms (14).

However, currently, a new theory have proposed that the black hole rips from which the information escape consist of "soft charged hair" that are particles consisting of photons and gravitational forces on the event horizon. These particles with extremely low or even zero energy can capture and store information about particles falling into a black hole, just as human nasal hairs do by capturing dust. The interesting thing from this is that the particles fall into the black hole seems to face a fate of "have no return", but the fact is some of the information is still stored in these "soft hairs" and continues to linger around its boundary (15).

According to Hawking's explanation, the information stored inside the black hole was not as most people thought, but was stored in the event horizon. The information of the particles entering the black hole does really return to the space, but with a chaotic form. This was mostly like a burnt encyclopedia, it was extremely difficult to translate and decipher it even the information on the page, theoretically, was not lost. Therefore, black holes are not the kind of permanent prison that people once thought. If you were trapped in a black hole, don't give up, there is a way to escape.

WHAT IS THE FINAL FATE OF THE BLACK HOLE?

As early as in 1973, Hawking found that the "black hole is not black" in the study of Quantum Field Theory in Curved Spacetime (16). From the black hole quantum mechanics, black hole can emit blackbody radiation through a certain mechanism - this is the so-called Hawking radiation. Although this idea was widely questioned when it was first proposed, most scientists later concluded that if other concepts of general relativity and quantum mechanics are correct, then the black hole may be like a hot body emitting particles and radiation. However, it is known that nothing can escape from the black hole's event horizon. So how can black holes emit particles? To this question, quantum theory answered it as the particles do not come out of the black hole, but from the "empty space" outside of the black hole's event horizon.

Furthermore, the smaller the quality of the black hole, the higher its temperature. Thus, as the black hole loses its mass, its temperature and emissivity increase, which results in a faster loss of its mass. Therefore, for small-mass black holes, the Hawking radiation would be strong, and then they will quickly evaporate. A black hole with a mass of 10^{15} gram will be evaporated as the time required is similar to the age of the universe (17).

Theory is theory. Too many things need to be tested and confirmed. Given the uncertainty of the radiation from the black hole, it is difficult to confirm the "Hawking radiation" yet, some declared that evidence sufficient to support the "Hawking radiation" theory has been found, though.

So, then, now have you figured out the fact: is black hole a hole?■

ARTICLE INFORMATION

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REFERENCES

1. The Event Horizon Telescope Collaboration. First M87 Event Horizon Telescope Results. I. The Shadow of the Supermassive Black Hole. *Astrophysic J Lett* 2019; 875:L1.
2. The Event Horizon Telescope Collaboration. First M87 Event Horizon Telescope Results. II. Array and Instrumentation. *Astrophysic J Lett* 2019; 875:L2.
3. The Event Horizon Telescope Collaboration. First M87 Event Horizon Telescope Results. III. Data Processing and Calibration. *Astrophysic J Lett* 2019; 875:L3.
4. The Event Horizon Telescope Collaboration. First M87 Event Horizon Telescope Results. IV. Imaging the Central Supermassive Black Hole. *Astrophysic J Lett* 2019; 875:L4.
5. The Event Horizon Telescope Collaboration. First M87 Event Horizon Telescope Results. V. Physical Origin of the Asymmetric Ring. *Astrophysic J Lett* 2019; 875:L5.
6. The Event Horizon Telescope Collaboration. First M87 Event Horizon Telescope Results. VI. The Shadow and Mass of the Central Black Hole. *Astrophysic J Lett* 2019; 875:L6.
7. Schwarzschild Radius. <http://astronomy.swin.edu.au/cosmos/S/Schwarzschild+Radius>. Last access to: April 11, 2019.
8. Nuclear Fusion – Keeping the Universe Alive Since the Beginning. https://www.chem.uwec.edu/chem115_f02/casparj/project.html. Last access to: April 11, 2019.
9. Important Scientists: Subrahmanyan Chandrasekhar (1910 - 1995). https://www.physicsoftheuniverse.com/scientists_chandrasekhar.html. Last access to: April 11, 2019.
10. Supermassive Black Hole Sagittarius A*. https://www.nasa.gov/mission_pages/chandra/multimedia/black-hole-SagittariusA.html. Last access to: April 11, 2019.
11. M87 Galaxy Facts. <https://spacefacts.com/m87-galaxy/>. Last access to: April 11, 2019.
12. Paoletta R. This is Indisputably the Coolest Way to Die in Space. <https://www.inverse.com/article/42955-what-is-black-hole-spaghettification-science-explains>. Released on March 28, 2018. Last access to: April 11, 2019.
13. Cain F. What is the black hole information paradox? <https://phys.org/news/2015-10-black-hole-paradox.html>. Released on October 29, 2015. Last access to: April 11, 2019.
14. Thomson I. Prof Stephen Hawking: 'There are NO black holes' – they're GREY! New paper may solve galactic firewall riddle. https://www.theregister.co.uk/2014/01/25/stephen_hawking_black_holes/. Released on 25 Jan 2014. Last access to: April 11, 2019.
15. Hawking SW, Perry MJ, Strominger A. Soft Hair on Black Holes. *Phys Rev Lett* 2016; 116:231301.
16. Wald RM. Quantum Field Theory in Curved Spacetime and Black Hole Thermodynamics (Chicago Lectures in Physics). 1st Edition. ISBN-13: 978-0226870274. University of Chicago Press. 1994.
17. Hawking S. A Brief History of Time Paperback – Unabridged, September 1, 1998. 10th Anniversary Edition. ISBN-13: 978-0553380163. Bantam. 1998. ■