

Ask people about black holes and they will probably give an explanation that is most likely fiction from TV and movies. Ideas of time travel, rips in the space time continuum, or other popular myths dominate the general perception of black holes. While scientists have learned a wealth of information about black holes, they remain one of the greatest enigmas in the galaxy, their very existence both provoking famous scientists such as Einstein to change society's ways of thinking and posing difficult questions that challenge the perception the universe. Numerous theories about the possibilities of space travel and the nature of the universe have been birthed through attempting to solve this mystery, many of which end up as the next big science-fiction blockbuster (although heavily altered and stylized). Widespread knowledge about the existence of black holes can not be debated but most people generally do not know fact from fiction regarding black holes.

### **Forming an Understanding**

A black hole is defined as a region of space in which the gravitational pull is so strong that nothing can escape after a certain point. The name itself is derived from its ability to pull in even light, rendering its

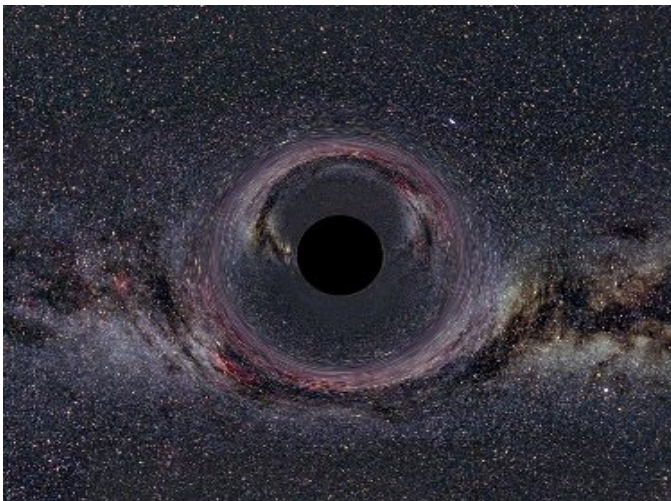


Figure 1: What Scientists believe a black hole looks like; notice the warping effect around it due to the bending of light. (Wikipedia)

visage as a huge gaping hole in the middle

of space (figure 1). The current definition

is derived from Einstein's theory of

general relativity (archive). Black holes

are formed from the collapse of a star into

a dense singularity; the size of the star

before it collapses determines whether it

will be a black hole or not. The reason for

the collapse is due to a failure to maintain

equilibrium between the gravity that

pushes on the star, and the

electromagnetic radiation (photons of

light, etc) that the star creates itself (archive). When a star begins to die, the production of electromagnetic

radiation begins to wane, allowing the gravity that it creates to push the star into a singularity; the reason

that size is a factor is because the bigger an object, the stronger it's gravitational pull. The singularity keeps

the same mass that it originally had when it was a massive star, creating an extremely powerful gravitational vacuum.

A black hole is characterized by several different parts. First is the singularity, the center of the entire structure and the point at which all matter trapped by its gravitational pull is going toward; what really happens at the singularity is currently unknown. Surrounding the singularity is the event horizon, a barrier or point in the black hole where light can not escape the pull of gravity. This is the part of the mass that looks like an actual “hole,” as it is nothing but a black void in space. Nobody has been able to determine what happens inside the

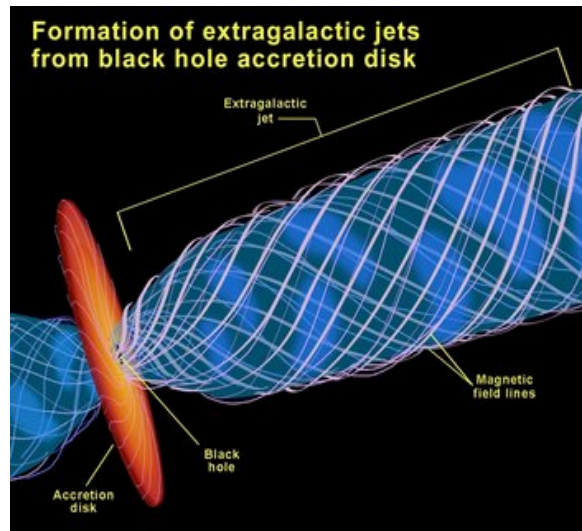


Figure 2: Parts (colored) of a black hole. (answers.com)

event horizon (amazing-space). For a few black holes another part is present, an acceleration disk (figure 2), which is a superheated spiral that emits x-rays and forms around the event horizon when gas and dust collide with each other as they spin around the singularity. Its shape is similar to the way the Milky Way. The acceleration disk spirals out of the event horizon, similarly to how matter looks spiraling around the center of the galaxy (Melia). Other parts are jets of gas, which shoot out from the event horizon perpendicularly to the acceleration disk. Able to stretch on for light years, jets of gas form due to particles spiraling around the magnetic field lines above and below the black hole (amazing-space).

Further characterizing a black hole are the two different types: rotating, charged and non-rotating, uncharged. So far, the parts and characteristics of an uncharged, non-rotating black hole have been discussed; the characteristics of a charged, rotating black hole aren't that different from the characteristics of the previous one. Theoretically, the singularity of a rotating black hole is thought to be in a ring shape because general relativity, the best theory we have to describe such phenomena, predicts this shape (Wikipedia). The other difference is the presence of an ergosphere. An ergosphere is an oblong boundary around the event horizon in which light is just barely able to escape a black hole's gravitational pull, creating a region in which the light of stars seem to warp around the event horizon (howstuffworks).

Because the non-rotating, uncharged black holes are simpler to understand and the differences between the two types of black holes are miniscule at best, this paper will refer to the former.

**Effects on Matter**

If one was to drop an object like a clock or chair into a black hole, quite a few things would happen to it. A black hole’s effects on matter as it circles around and eventually hits the center are varied and relatively unknown beyond the event horizon. What we do know, however, is that it most likely would be destroyed (hubblesite).

Say that a book was dropped into a black hole and one was able to watch it go in at a safe distance. At first it would seem to just be coasting into it; then, the book would slow down and eventually stop before it ever hits the invisible border of the event horizon, constantly suspended there. Simultaneously, the color of the book would slowly shift from its normal color of, say blue, to a deep red. The reasons for these phenomena are because of the bending and weakening of light (imagine).

Light is measured according to a spectrum of colors from red (weakest) to violet (strongest),

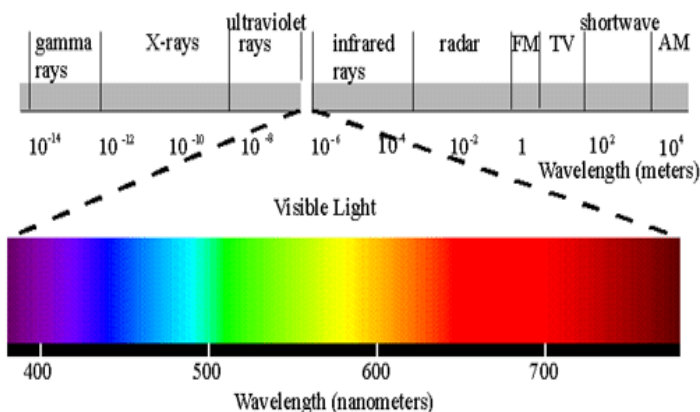


Figure 3: Color spectrum that provides the strength of light wavelengths and their corresponding colors (violet being the strongest and red being the weakest). (topbulb.com)

representing visible light (figure 3). When the light illuminating the object falling in becomes weaker, it reverts to its weaker red stage, making the object turn red. This weakening of light is due to the pulling apart of wavelengths; the farther apart wavelengths are, the weaker the light is.

This phenomenon is referred to as gravitational red shift.

As light gets closer to the event horizon, it takes a longer time for the light to escape from the intense pull of gravity. Because of this, the light that illuminates the object takes a longer time to hit your eyes, and as a result the object seems to be slowing down. It seems suspended at the event horizon because the light can no longer escape the pull of gravity (hubblesite).

If a person fell into a black hole themselves, things would change dramatically. As one floated towards the center, nothing would change, time would flow at the same speed and they wouldn’t change

colors. Even as they passed the event horizon, nothing would change, but because that person passed the horizon it would be impossible for them to escape. Taking into account the size of the black hole, at about eight minutes from the center, their body would begin to go through a process called spaghettification (cosmology).

Spaghettification is the process in which the body (or any other object) is stretched into a long, narrow shape similar to spaghetti (figure 4). The reason for this is because of the effect that the intense gravity forces have at different parts of the body. Say one's feet were closest to the center and the head was farthest. The feet would experience a stronger pull than the head and stretch out due to the difference in pulls (hubblesite).

Eventually, that person's body would probably stretch out so much that it would either rip apart and get crushed or get crushed *then* rip apart. Either way, the matter is destroyed as it approaches the singularity. What happens to matter when it meets the singularity, however, is unknown and subject to debate (cosmology).



Figure 4: Artists depiction of an unlucky astronaut experiencing spaghettification due to gravitational forces. (woodsie)

### **The Mysteries that Remain**

The biggest questions surrounding black holes are sprung from the fact that we can't see anything beyond the event horizon and physics related problems with the nature of a black hole's singularity. Currently it is unknown what exactly happens to matter or where it goes when it meets the singularity or even when it passes the event horizon.

As previously described, the singularity is the center of the entire black hole, the final destination of cosmic matter as it spirals to the center. It is currently regarded as a region of zero volume and infinite gravitational pull rather than an actual physical part. Because of this, scientists run into a paradox in which, mathematically, they conclude that the matter is pulled to a point of zero volume, essentially destroying it. According to the laws of physics, however, matter can not be destroyed (archives). It is in this light that we take a look at two theories that attempt to describe what happens to matter as it meets the singularity: the wormhole theory and Hawking radiation.

The wormhole theory was at first a highly experimental idea that eventually grew into a theory through the efforts of Roy Kerr in 1965. The theory describes black holes as passages or shortcuts through the universe (figure 5). Highly controversial and unpopular, the theory calls for the existence of white holes (masses that actually repel matter rather than attract), a separate universe altogether, and only accounts for rotating black holes (astro).

Hawking radiation, developed by Steven Hawking in 1972, describes a black hole that loses the matter that it attracts through the loss of a special type of radiation, implying that they can (eventually) evaporate. The idea that radiation was created as a byproduct came from the intense heat

that black holes create. It has remained a theory due to the fact that no one has seen the theoretical radiation. On top of that there is currently no way to measure or test the existence of the radiation (cosmology).

### **Mystery Solved?**

As research continues and more advances are made in the field of astronomy and physics, only more light can be shed on the current questions researchers have regarding black holes. Due to the ever changing nature and climate of black hole research, the information talked about is constantly being updated, changed, or altogether disproved. The best way to keep up to date with this fascinating field of science is to take the research into one's own hands, such as keeping up with popular science or astronomy magazines.

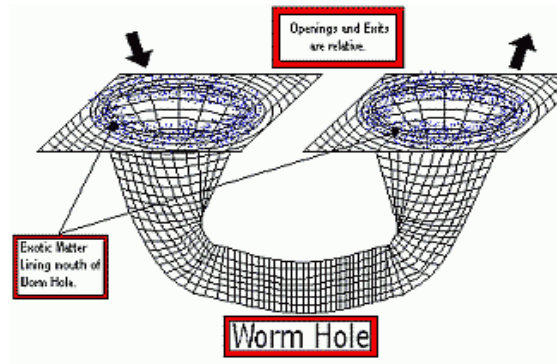


Figure 5: Theoretical diagram of a wormhole; the black hole is on the left and the theoretical white hole is to the right. (Khal)

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