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Black Holes

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Abstract: ***What are black holes? Composed? And how do they look? What happens to the information inside it? More importantly, what happens to you if you enter the black hole? Believe me the most terrifying thing you can hear about the universe, is having something like black holes. Worse, it falls into one.***

Keywords: Black Hole

1. Introduction

Black holes are one of the weirdest things in the universe and the focus of attention a lot and let us remove some ambiguity from them.

What is it? How does it consist? And how do they look?

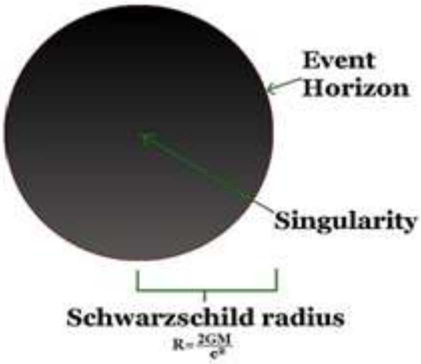
1.1 Black holes

Many of the myths and stories about the black holes have been woven, many of them forever Hollywood, and their television and film images as tunnels to travel through time to another dimension, as well as a cosmic universe that swallows everything on the horizon and much more. But the truth is that the black holes are just the "evolutionary endpoint of the massive stars."

However, this simple interpretation does not remove the black holes from its ambiguity, nor makes it an easy material to understand and study.

1.2 What is black hole?

Black holes get three "layers": internal and external The Event Horizon and singularity. Black holes are the evolutionary endpoint of stars that have a mass greater than the mass of the Sun by at least 10 to 15 times. If a star of such magnitude and magnitude undergoes a supernova explosion, leaving behind a huge, burning starry remnant, and with no external forces to resist the force of gravity, its remains will collapse, and eventually the star collapses to a point of zero magnitude and infinite intensity, forming what is known as [0].the"Singular Central"(Singularity)



This central individual is surrounded by an area of great gravity, so light cannot escape from it, so we cannot get any information from this area. It is therefore, called the "black hole". Its surface is called the Event Horizon.[1]

In classical mechanics, physics, nothing can escape a black hole, but things change a bit when you add quantum mechanics to the equation. In quantum mechanics for each particle anti particle, there is a particle with the same mass but opposite electric charge, when he meets serious binary and particle, it can consume each other, and if a bilateral anti-particle particle creation beyond the event horizon, it is possible to draw one into the black hole, while firing a For most of the black hole itself, to be the result of diminishing the event horizon with possibility analyzes the black hole, and is rejected in classical mechanics, and this area is confusing and vague prompting scientists to work and more research to understand black holes and all the rest of it.[2]

Astronomers estimated that there are between 10 million to one billion stellar black hole mass, Bechtel affinity triple block Sun in milky way only.

And if the star very close to the black hole can be torn to pieces.

The gravity of the black hole, if you throw the ball up in the air, it will reach a certain height and then fall back to you the faster you launch, the higher you go. If you can fly it fast enough, you will escape the Earth's gravity and swim in space. This speed is known as the "speed of escape", which is 11 km / s. The speed of the escape is less if you are on the moon is 2.4 km / s. [2]

But if you're on a black hole (that's if you're alive), you'll need a faster speed than light to reach the speed of escape.

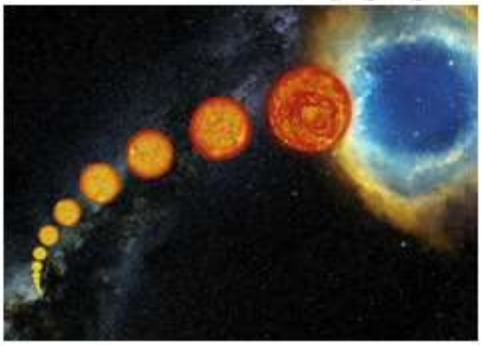
Humanity knew nothing faster than light. Did you imagine the gravitational force of the black holes now?

But unlike mythology, the black hole is not a cosmic sweep! If our sun is suddenly replaced by a black hole with the same mass of the Sun, there will be no change in Earth's rotation around the Sun, but of course the Earth's temperature will change, and there will be no solar wind or solar magnetic storms affecting us.

2. History of the discovery of black hole

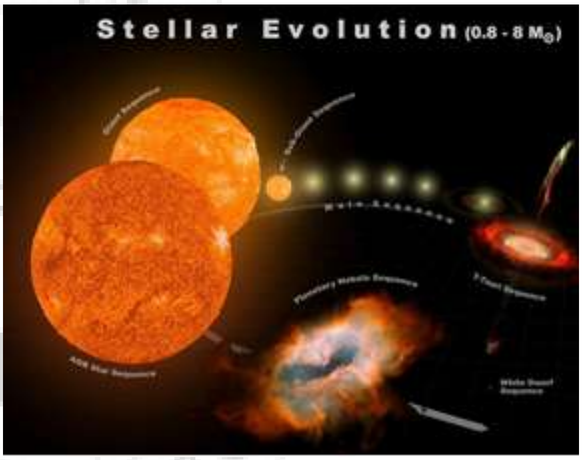
He put the premise the possibility of the existence of such a phenomenon is the discovery that definite speed light Romer, this discovery raised the question why not increase the speed of light to faster?, explain that it may be because of gravity effect on the light, and this discovery was written by John minshl in 1783, an article which indicated that it might be For thick very attractive compact star, even light cannot escape, no light is emitted from the surface of the star return this attraction. There's also the premise that there are many stars of these stars, although we can't see its light, it doesn't send him but we can discern their appeal, these stars are what we call the "black holes", any gaps in space, have these ideas, because the wave theory of light was prevalent at the time, In 1796, Pierre Simon Laplace French world reiterated that idea to the forefront in writing (French: Exposition du Système du) (introduction to the cosmic order), but his contemporaries questioned the concept of vulnerability theory, that came general relativity of Albert Einstein, which demonstrated the possibility of a Black holes, astronomers began to find their effects, using ground-based and space telescopes where it was discovered that Cygnus x-1 is likely to be a potential black hole year 1971 and transformed views on black hole facts watch via radio astronomical telescope which allows monitors watch Universe more clearly, and make an acceptable scientific fact relativity when most Darcy physics. [3]

3. Black holes it's the beginning of the end



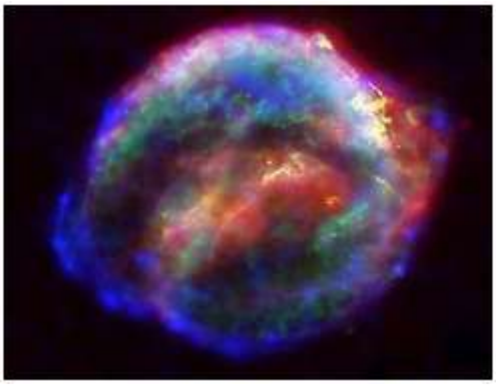
Artist's depiction of the life cycle of a Sun-like star, starting as a main-sequence star at lower left then expanding through the subgiant and giant phases, until its outer envelope is expelled to form a planetary nebula at upper right[4]

That's what makes the Sun and other stars round is the balance between gravitational force that tries to make the star collapses focused area, and force feed gases that works from the inside out, and thus resistant to breakdown the force of gravity. So, the two forces working in opposite directions which makes equilibrium star pie as a balloon. But this situation forever, the deceleration of the Mag release gases that works from the inside out from so-called nuclear fusion in the stars. For example, integrate Hydrogen (H_2) atoms in the Sun and generates Atom Helium(He) and some other particles in addition to thermal energy in sunlight that enjoy summers:).And with high temperature stars are merging more and more atoms heavier elements problem, heavier than Hydrogen (H_2) into Helium (He) to Carbon (C), Neon (Ne), Oxygen (O_2), Silicon(Si), finally into Iron(Fe), making the star resembles onion as in the adjacent figure.[6][7]



Evolution of the star from his birth to his death if its mass is equal to 1.4 from Sun or less

But when the Iron(Fe) reaches the star to a standstill, it cannot incorporate iron after more atoms, thus gravitational force will begin to work on the star's collapse violently. And at this stage depends on the star to reduce weight or mass, or reach a disaster, just like humans! If the star's mass is less than or equal to 1.4 from the mass of the Sun, "it called "The Chandrasekhar limit", stellar collapse towards the Center will stop by a mechanism called "Electron degeneracy pressure", which comes from quantum mechanics, specifically the principle of Pauli exclusion. This principle stipulates that the electrons in the atom what she can't take the four quantum numbers. In other words, not can apply one big wave."Can this process occurs only for the particle are elementary particles called, at absolute zero all apply some particle in one big wave and curious! This process is called Bose-Einstein ".[6][7]



Multiwavelength X-ray, infrared, and optical compilation image of Kepler's supernova remnant, SN 1604. [5]

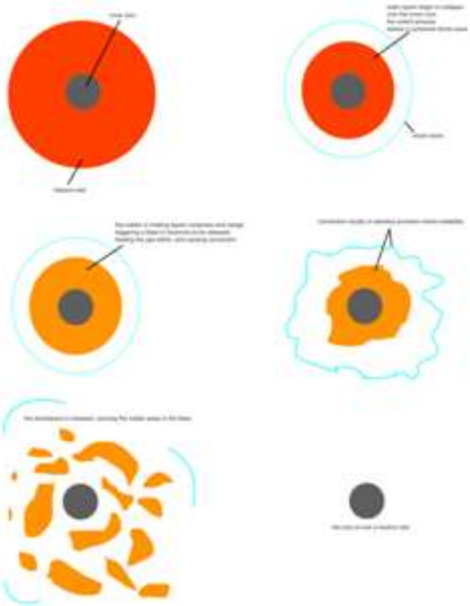
This process will create pressure of working from the inside out so it will stop the collapse caused by the force of gravity. And the final product will be very thick and stable carbon star called a White Dwarf.

If it's did not maintain weight, couldn't compress the gravitational collapse can stop electronic inviter, Star ends in disaster.[6][7]

When nuclear fusion iron element that superstar will reach an impasse, could not release heat to the outside, so the heat will rise to star fairy degrees soles, while the outer layers of the star are cooler, leading to the development of unstable and therefore heat will move abruptly and very fast The Center, which will tear shreds and star tooth will be strewn everywhere.Star explode, and this process is called Supernova.

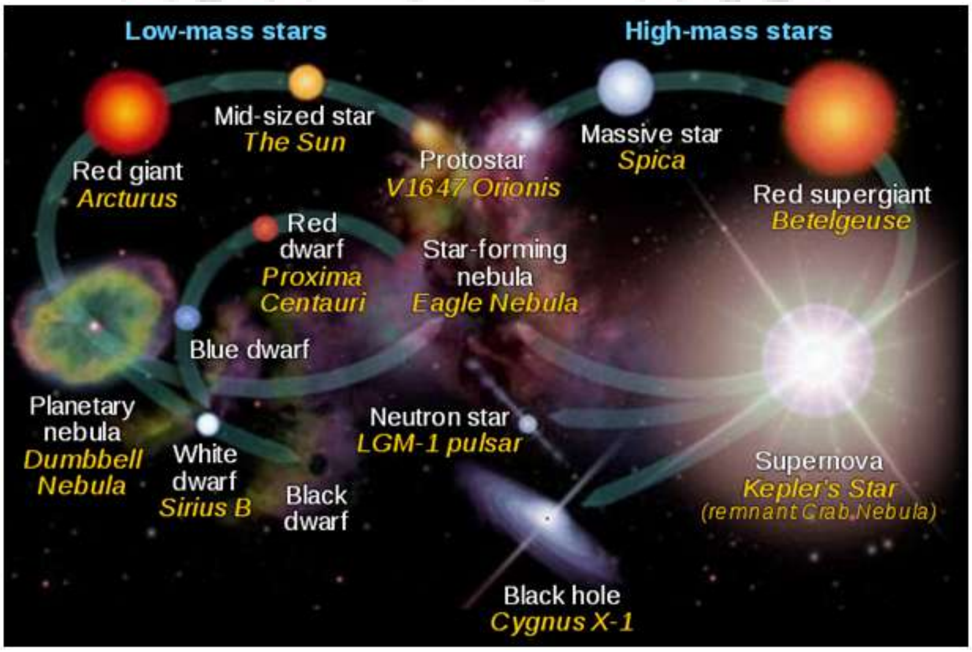
As a result, very violent collapse in the Center after the explosion, the leftovers today, disregard of its electrons, nuclei which will convert most of the protons into neutrons through the process of inverse beta, this process can occur when swallow's proton electron, it turns into neutrons, called the neutrino:

$e^- + p \rightarrow v_e + n$



So, after the explosion, indescribable intensity star consists of words, most article neutrons, called a neutron star. Halfradiuss this star up to 10 km! Imagine that it's compressing the Sun until it becomes a radius of 10 km with the same original density![6][7]

This isn't the end of the story! A neutron star has to reduce its mass also or will collapse into the heart of the star by the force of gravity. There is a line called the Oppenheimer-Volkov-Tolman, equal to 3-4 of the mass of the Sun, which is based on general relativity accounts. If she passes the star's mass, it will meet the final destiny star black, will become a black hole![6][7]



4. What is the gravity of black holes?

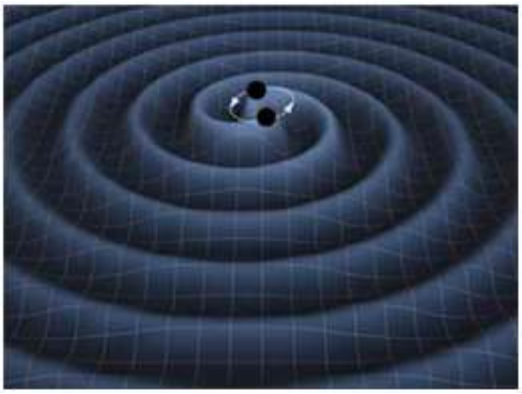
Here's the deal: nothing can travel faster than light. A black hole traps everything including light. So how does gravity escape a black hole? It's a great question, and a perfectly reasonable one given most people's understanding of gravity. The answer is that gravity doesn’t work the way you probably think it does.

The most common way to think of gravity is as a force between two masses. For example, the Earth exerts a gravitational force on the Moon, and the Moon pulls back on the Earth in return. This “force model” of gravity is what Newton used to develop his law of universal gravity, which stood as the definite theory of gravity until the early 1900s and is still used to this day. But built into this model of gravity are some assumptions that we can explore by playing the “What if?”[8]

Suppose we had a universe with a single mass. Imagine empty space extending as far as you like, with a single mass in the center (which we’ll call Adam). Would such a mass have gravity? If gravity is a force of one object on another object, then the answer would be no. There’s no other mass for Bob to pull on, so there’s no gravitational force. If we add another mass to our universe (call this one Asia), then Adam and Asia would each exert a force on each other, and gravity would exist. But gravity would only exist between Adam and Asia, and nowhere else in our empty universe.[8]

One of the problems with this force model is that it requires masses to exert forces on other masses across empty space. This "action at a distance" problem was resolved in part by Pierre-Simon Laplace in the early 1800s. His idea was that a mass must reach out to other masses with some kind of energy, which he called a field. Other masses would sense this field as a force acting upon them. So, if we again imagine our Adam mass in a lonely universe, we would say that Adam has a gravitational field surrounding it, even if there were no other masses in the universe. This eliminates the need for action-at-a-distance, because when we put Asia into the universe, it simply detects whatever gravitational field is at its location and experiences a force. We know the gravitational field is due to Adam some distance away, but Asia simply knows there is a gravitational field at its location.[8]

Both the force model and field model of Newtonian gravity give the same predictions, so experimentally there’s no real way to distinguish one from the other. However, fields are often an easier concept to work with mathematically, and fields are also used to describe things like electricity and magnetism, so we generally think of Newtonian gravity as a field.[8]

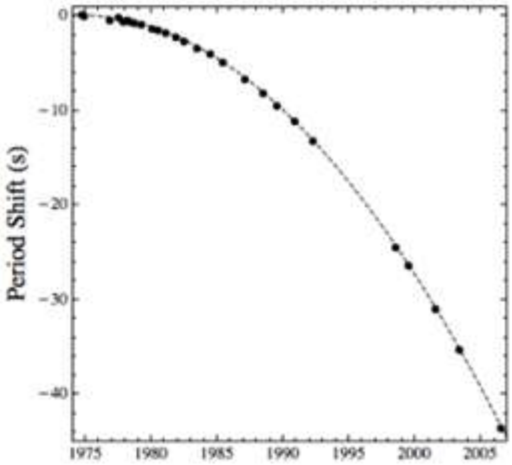


If the speed of gravity was finite, it would create gravitational waves.

But this raises another question. Suppose in our Adam and Asia universe we suddenly shift Adam's position. How long will it take for Asia to recognize the change? In other words, if we change the position of Asia, at what speed does the change propagate through the gravitational field? When Laplace looked at this idea he found that changes in a gravitational field had to happen instantly.

The “speed of gravity” would have to be infinite. For example, if gravity travelled at the speed of light, the Earth would try to orbit the point where the Sun was 8.3 minutes ago (the time it takes light to travel from the Sun to Earth). As a result, Earth’s orbit would become unstable over time.[8]

At the time, the idea of gravity acting at infinite speed wasn’t seen as a problem. In fact, it was used as an argument against alternative gravity ideas proposed at the time. But in the early 1900s Einstein developed his special theory of relativity, which (among other things) required that nothing could travel faster than light. If that’s the case, then there’s something wrong with our theory of gravity. By 1915 Einstein had developed a new model of gravity known as general relativity, which satisfied both Newton’s gravitational model and special relativity.[8]

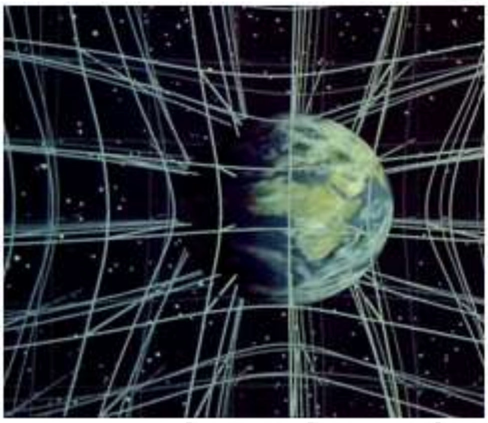


Decay of a pulsar orbit compared to general relativity (dotted line).

According to theory, for example, when two large masses such as neutron stars orbit each other, they should produce gravitational waves that radiate away from them. These gravitational waves should travel at the speed of light. There have been experimental attempts to detect such gravitational waves, “An international scientific team announced at the National Science Foundation in Washington and Moscow University Thursday, February 11, 2017 detect gravitational waves that was talked about Albert Einstein world for 100 years ago.”. We have, however, found indirect evidence of gravitational waves. By observing a binary pulsar, we have observed its orbit decay slightly over time. This orbital decay is due to the fact that gravitational waves carry energy away from the system. The rate of this decay matches the prediction of general relativity perfectly. Since this rate of decay depends crucially on the speed of gravitational waves, this is also indirect confirmation that gravitational waves move at the speed of light.[8]

But wait a minute, how can a gravitational field have a finite speed and act instantly at the same time? A gravitational field can't, but in general relativity gravity is not an energy field.[8]

Since long before Newton, it was generally assumed that objects and energy fields interacted in space at particular times. In this way, space and time can be seen as a background against which things happen. Space and time were seen as a cosmic grid against which anything could be measured. In developing special relativity, Einstein found that space and time couldn't be an absolute background. In Newton's view, two events seen to occur at the same time will be seen to be simultaneous for all observers. But Einstein found that the constancy of light required this concept of "now" to be relative. Different observers moving at different speeds will disagree on the order of events. Rather than a fixed background, space and time is a relation between events that depends upon where and when the observer is.[8]



The distortion of space and time near earth. Credit: christopher vitale

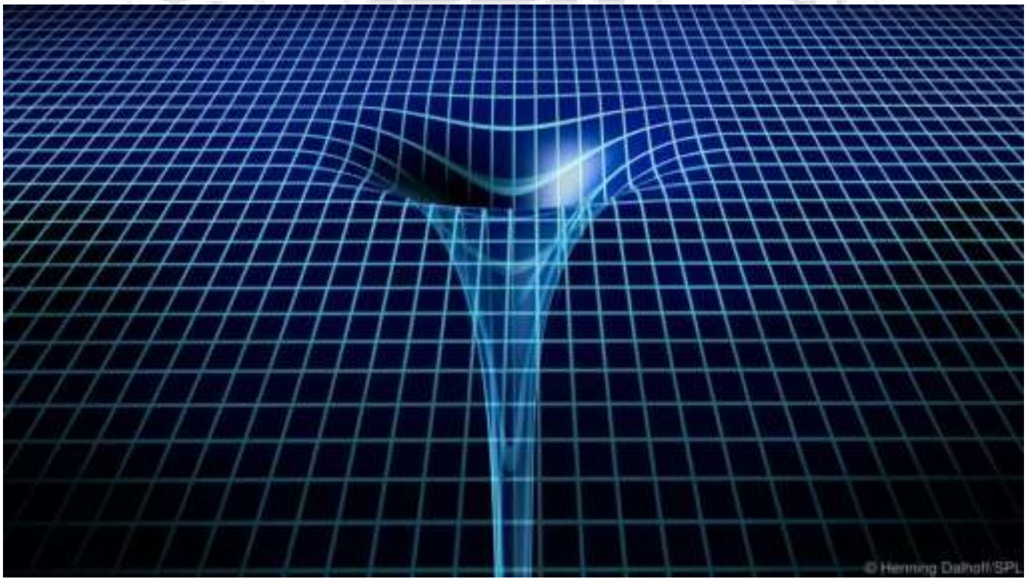
This principle carried forward into Einstein's theory of gravity. In general relativity gravity is not an energy field. Instead, mass distorts the relations between space and time. If we go back to our earlier example, if we place mass Adam in an empty universe, the relations of space and time around it is distorted. When we place mass Asia nearby, the distortion of Spacetime around it means that moves toward mass Adam. It looks as if Asia is being pulled toward Adam by a force, but it's actually due to the fact that Spacetime is distorted.[8]

As Physicist John Wheeler once said, "SpaceTime tells matter how to move; matter tells SpaceTime how to curve."

This is how gravity can seem to act instantly while gravitational waves seem to travel at the speed of light. Gravity isn't something that travels through space and time. Gravity is space and time.[8]

A black hole is an extreme distortion of space and time due to a very dense mass. Such a Spacetime distortion can prevent light and matter from ever escaping. But the Spacetime distortion is also gravity. It doesn't need to escape the black hole, because it is the black hole.[8]

That's the thing about science. Sometimes a simple question will pull you toward an unexpected answer.

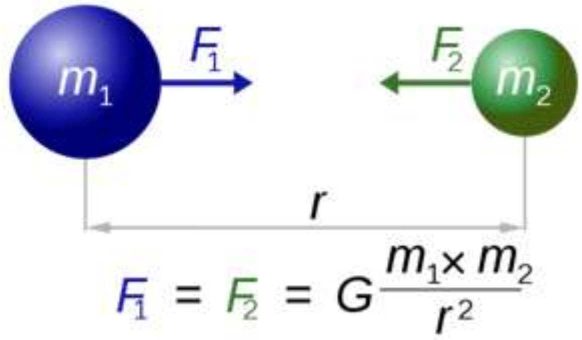


In a black hole, space becomes infinitely curved (Credit: Henning Dalhoff/SPL)

5. Mathematical equations of gravity

5.1 Gravity in classical mechanics

Newton's law of universal gravitation is every point mass attracts every single other point mass by a force pointing along the line intersecting both points. The force is proportional to the product of the two masses and inversely proportional to the square of the distance between them:



$F = G\frac{m_1 m_2}{r^2}$

FIs the force caused by gravity.
$G$is constant of universal gravitation between masses.
$m_1$is the first body mass.
$m_2$is the second body mass.
r is the distance between two objects.

Newton's law of universal gravitation doesn't explain what gravity is and cannot predict black holes. Who explain what gravity Einstein’s is, on theory of general relativity.

5.2. Gravity in modern physics

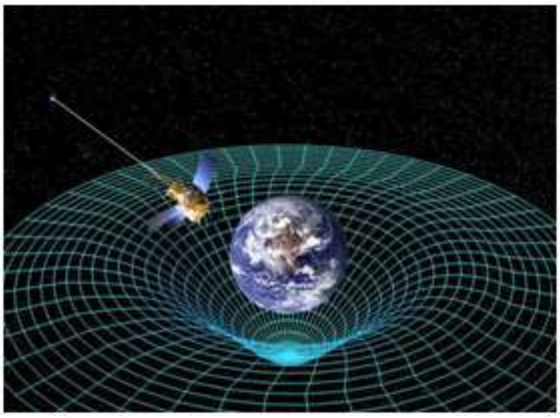
Einstein field equations The Einstein field equations (EFE) may be written in the form:

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4}T_{\mu\nu}$$

where $R_{\mu\nu}$ is the Ricci curvature tensor, R is the scalar curvature, $g_{\mu\nu}$ is the metric tensor, Λ is the cosmological constant, G is Newton's gravitational constant, c is the speed of light in vacuum, and $T\mu\nu$ is the stress–energy tensor.[9]

The EFE is a tensor equation relating a set of symmetric 4×4 tensors. Each tensor has 10 independent components. The four Bianchi identities reduce the number of independent equations from 10 to 6, leaving the metric with four gauge fixing degrees of freedom, which correspond to the freedom to choose a coordinate system.[9]

Although the Einstein field equations were initially formulated in the context of a four-dimensional theory, some theorists have explored their consequences in n dimensions. The equations in contexts outside of general relativity are still referred to as the Einstein field equations. The vacuum field equations (obtained when T is identically zero) define Einstein manifolds.[9]



Einstein's theory of general relativity predicted that the space-time around Earth would be not only warped but also twisted by the planet's rotation. Gravity Probe B showed this to be correct.
Credit: NASA

Despite the simple appearance of the equations they are actually quite complicated. Given a specified distribution of matter and energy in the form of a stress–energy tensor, the EFE are understood to be equations for the metric tensor $g_{\mu\nu}$, as both the Ricci tensor and scalar curvature depend on the metric in a complicated nonlinear manner. In fact, when fully written out, the EFE are a system of ten coupled, nonlinear, hyperbolic-elliptic partial differential equations.[9]

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One can write the EFE in a more compact form by defining the Einstein tensor

$$G_{\mu\nu} = R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu}$$

which is a symmetric second-rank tensor that is a function of the metric. The EFE can then be written as

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4}T_{\mu\nu}$$

Using geometrized units where $G = c = 1$, this can be rewritten as

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi T_{\mu\nu}$$

The expression on the left represents the curvature of spacetime as determined by the metric; the expression on the right represents the matter/energy content of spacetime. The EFE can then be interpreted as a set of equations dictating how matter/energy determines the curvature of spacetime. [10]

These equations, together with the geodesic equation, which dictates how freely-falling matter moves through space-time, form the core of the mathematical formulation of general relativity.[10]

5.2.1 Sign convention

The above form of the EFE is the standard established by Misner, Thorne, and Wheeler. The authors analyzed all conventions that exist and classified according to the following three signs (S1, S2, S3):

$$g_{\mu\nu} = [S1] \times diag(-1, +1, +1, +1)$$

$$R^{\mu}_{\alpha\beta\gamma} = [S2] \times \left(\Gamma^{\mu}_{\alpha\gamma,\beta} - \Gamma^{\mu}_{\alpha\beta,\gamma} + \Gamma^{\mu}_{\sigma\beta}\Gamma^{\sigma}_{\gamma\alpha} - \Gamma^{\mu}_{\sigma\gamma}\Gamma^{\sigma}_{\beta\alpha}\right)$$

$$G_{\mu\nu} = [S3] \times \frac{8\pi G}{c^4} T_{\mu\nu}$$

The third sign above is related to the choice of convention for the Ricci tensor:

$$R_{\mu\nu} = [S2] \times [S3] \times R^{\mu}_{\mu\alpha\nu}$$

Authors including Einstein have used a different sign in their definition for the Ricci tensor which results in the sign of the constant on the right side being negative

$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} - \Lambda g_{\mu\nu} = -\frac{8\pi G}{c^4} T_{\mu\nu}$$

The sign of the (very small) cosmological term would change in both these versions, if the $(+ - - -)$ metric sign convention is used rather than the MTW $(- + + +)$ metric sign convention adopted here. [10]

5.2.2 Equivalent formulations

Taking the trace with respect to the metric of both sides of the EFE one gets

$$R - \frac{D}{2} R + D\Lambda = \frac{8\pi G}{c^4} T$$

Where D is the space time dimension.

This expression can be rewritten as

$$R - \frac{D\Lambda}{\frac{D}{2} - 1} = \frac{8\pi G}{c^4} \frac{T}{\frac{D}{2} - 1}$$

If one adds $-\frac{1}{2} g_{\mu\nu}$ times this to the EFE, one gets the following equivalent "trace-reversed" form

$$R - \frac{\Lambda g_{\mu\nu}}{\frac{D}{2} - 1} = \frac{8\pi G}{c^4} \left(T_{\mu\nu} - \frac{1}{D - 2} T g_{\mu\nu}\right)$$

For example, in $D = 4$ dimensions this reduces to

$$R_{\mu\nu} - \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} \left(T_{\mu\nu} - \frac{1}{2} g_{\mu\nu}\right)$$

Reversing the trace again would restore the original EFE. The trace-reversed form may be more convenient in some cases (for example, when one is interested in weak-field limit and can replace $g_{\mu\nu}$ in the expression on the right with the Minkowski metric without significant loss of accuracy).[11]

5.2.3 The cosmological constant

Einstein modified his original field equations to include a cosmological constant term Λ proportional to the metric

$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

Since Λ is constant, the energy conservation law is unaffected.

The cosmological constant term was originally introduced by Einstein to allow for a universe that is not expanding or contracting. This effort was unsuccessful because:

- The universe described by this theory was unstable, and
- Observations by edwin hubble confirmed that our universe is expanding.

So, Einstein abandoned Λ, calling it the "biggest blunder [he] ever made".

Despite Einstein's motivation for introducing the cosmological constant term, there is nothing inconsistent with the presence of such a term in the equations.

For many years the cosmological constant was almost universally considered to be 0. However, recent improved astronomical techniques have found that a positive value of Λ is needed to explain the accelerating universe. Einstein thought of the cosmological constant as an independent parameter, but its term in the field equation can also be moved algebraically to the other side, written as part of the stress–energy tensor:

$$T^{(vac)}_{\mu\nu} = \frac{\Lambda c^4}{8\pi G} g_{\mu\nu}$$

The resulting vacuum energy density is constant and given by

$$\rho_{(vac)} = \frac{\Lambda c^4}{8\pi G}$$

The existence of a cosmological constant is thus equivalent to the existence of a non-zero vacuum energy. Thus, the terms "cosmological constant" and "vacuum energy" are now used interchangeably in general relativity.[11]

5.2.4 Vacuum field equations

If the energy-momentum tensor $T_{\mu\nu}$ is zero in the region under consideration, then the field equations are also referred to as the vacuum field equations. By setting $T_{\mu\nu} = 0$ in the trace-reversed field equations, the vacuum equations can be written as

$$R_{\mu\nu} = 0$$

The solutions to the vacuum field equations are called vacuum solutions. Flat Minkowski space is the simplest example of a vacuum solution. Nontrivial examples include the Schwarzschild solution and the Kerr solution.

Manifolds with a vanishing Ricci tensor, $R_{\mu\nu} = 0$, are referred to as Ricci-flat manifolds and manifolds with a Ricci tensor proportional to the metric as Einstein manifolds.[10]

5.2.5 Solutions

The solutions of the Einstein field equations are metrics of spacetime. These metrics describe the structure of the spacetime including the inertial motion of objects in the spacetime. As the field equations are non-linear, they cannot always be completely solved (i.e. without making approximations).

For example, there is no known complete solution for a spacetime with two massive bodies in it (which is a theoretical model of a binary star system, for example). However, approximations are usually made in these cases. These are commonly referred to as post-Newtonian approximations. Even so, there are numerous cases where the field equations have been solved completely, and those are called exact solutions.[10]

The study of exact solutions of Einstein's field equations is one of the activities of cosmology. It leads to the prediction of black holes and to different models of evolution of the universe.[10]

One can also discover new solutions of the Einstein field equations via the method of orthonormal frames as pioneered by Ellis and MacCallum. In this approach, the Einstein field equations are reduced to a set of coupled, nonlinear, ordinary differential equations. As discussed by Hsu and Wainwright, self-similar solutions to the Einstein field equations are fixed points of the resulting dynamical system. New solutions have been discovered using these methods by LeBlanc and Kohli and Haslam. [10]

5.3. Schwarzschild radius

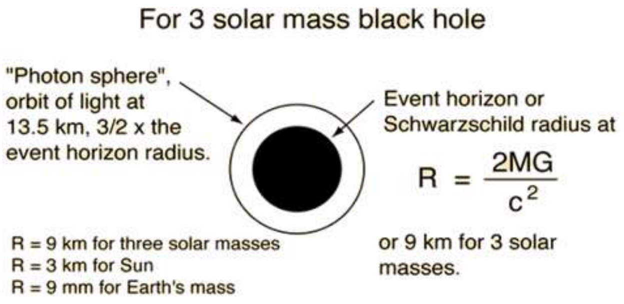
$$r_s = \frac{2MG}{c^2}$$

Anything can be turned into a black hole using this equation.

The following table gives the Schwarzschild radius of some familiar astronomical objects:

Object	Mass	R_s
Sun	2.0×10^{30} kg	3.0×10^{3} m
Earth	6.0×10^{24} kg	8.7×10^{-3} m
Moon	7.3×10^{22} kg	1.1×10^{-4} m
Jupiter	1.9×10^{27} kg	2.2 m
Neutron Star	2.8×10^{30} kg	4.2×10^{3} m

[12]



5.3.1 Karl Schwarzschild Radius Proof

As we know Schwarzschild equation represents the radius of a body of a certain mass, to which if decreased, makes it a black hole. We know the formula for escape velocity. That is:

$$v = \sqrt{2gR}$$

and since

$$F = G\frac{Mm}{R^2}$$

replacing F with ma where $a = g$

$$ma = G\frac{Mm}{R^2}$$

with implies

$$g = G\frac{M}{R^2}$$

Therefore

$$v = \sqrt{2\frac{GM}{R}}$$

$$c^2 = \frac{2GM}{R}$$

$$R = \frac{2MG}{c^2}$$

Where
R is the Schwarzschild Radius.
c is speed of electromagnetic wave through vacuum.
G is the gravitational constant.
M is mass of the body.
[12]

5.3.2 Black hole classification by Schwarzschild radius

Any object whose radius is smaller than its Schwarzschild radius is called a black hole. The surface at the Schwarzschild radius acts as an event horizon in a non-rotating body (a rotating black hole operates slightly differently). Neither light nor particles can escape through this surface from the region inside, hence the name "black hole".

Black holes can be classified based on their Schwarzschild radius, or equivalently, by their density. As the radius is linearly related to mass, while the enclosed volume corresponds to the third power of the radius, small black holes are therefore much more dense than large ones. The volume enclosed in the event horizon of the most massive black holes has an average density lower than main sequence stars.[14]

5.3.2.1 Supermassive black hole

A supermassive black hole (SMBH) is the largest type of black hole, though there are few official criteria on how such an object is considered so, on the order of hundreds of thousands to billions of solar masses. (Supermassive black holes up to 21 billion (2.1 × 1010) M⊙ have been detected, such as NGC 4889.) Unlike stellar mass black holes, supermassive black holes have comparatively low densities. (Note that a black hole is a spherical region in space that surrounds the singularity at its center; it is not the singularity itself.) With that in mind, the average density of a supermassive black hole can be less than the density of water.

The Schwarzschild radius of a body is proportional to its mass and therefore to its volume, assuming that the body has a constant mass-density. In contrast, the physical radius of the body is proportional to the cube root of its volume. Therefore, as the body accumulates matter at a given fixed density (in this example, 103 kg/m3, the density of water), its Schwarzschild radius will increase more quickly than its physical radius. When a body of this density has grown to around 136 million solar masses (1.36 × 108) M⊙, its physical radius would be overtaken by its Schwarzschild radius, and thus it would form a supermassive black hole.[14]

It is thought that supermassive black holes like these do not form immediately from the singular collapse of a cluster of stars. Instead they may begin life as smaller, stellar-sized black holes and grow larger by the accretion of matter, or even of other black holes

The Schwarzschild radius of the supermassive black hole at the Galactic Center would be approximately 13.3 million kilometers.[14]

5.3.2.2 Stellar black hole

Stellar black holes have much greater densities than supermassive black holes. If one accumulates matter at nuclear density (the density of the nucleus of an atom, about 1018 kg/m3; neutron stars also reach this density), such an accumulation would fall within its own Schwarzschild radius at about 3 M⊙ and thus would be a stellar black hole.[14]

5.3.2.3 Primordial black hole

A small mass has an extremely small Schwarzschild radius. A mass similar to Mount Everest has a Schwarzschild radius much smaller than a nanometer Its average density at that size would be so high that no known mechanism could form such extremely compact objects. Such black holes might possibly be formed in an early stage of the evolution of the universe, just after the Big Bang, when densities were extremely high. Therefore, these hypothetical miniature black holes are called primordial black holes.[14]

6. If we can't see it, how do we know it exists?

Since black holes are small asterisk-only a few or tens of kilometers in diameter-and as the light that allows us to see her he can't escape, it would be difficult (if not impossible) to see the black hole is moving in space alone through the visible spectrum.[15]

However, if a black hole through a cloud of matter- (the Interstellar medium ISM), or near normal "Star" else, then for the black hole to see article above it to be pulled towards the black hole, so you gain kinetic energy heats up, push through strong Medea. The rise in temperature causes the ionization of atoms, and when the temperature of the atoms to a few million Kelvin, emit rays (X-rays). Ray is sent into space before you cross Schwarzschild radius and marvel at the Central and unique that we can see that ray emission.[15]

Binary x-ray sources are our contacts to find strong candidates to be black holes.

The star represents utilities (Companion Star) ideal source for the fallen material inside a black hole, as it allowed binary calculating mass black hole candidate as a crime. When you create the cluster, we can determine if a neutron star or a black hole candidate, note that neutron stars have always equivalent to approximately 1.5 blocks from the mass of the Sun.[15]

Another sign of a black hole, are the random fluctuations in x version. Don't drop the article fallen into the black hole at a steady rate, but fall more heavily in intermittently, causing a marked difference in emission intensity rays. In addition, if the source of rays of a binary system we see it from a certain angle, the ray's pork chops will periodically, with obscure provenance by star facilities. When searching for a candidate black hole, all these things are taken into consideration.[15]

Many satellites scan the sky scanned in search of x-ray sources that may be a candidate as a black hole. Cygnus is (Cygnus X-1) the oldest candidate to be a black hole that was known, is highly variable and starts emitting rays, where flushing a hundred times per second (no offence to that glow faster than the time required to move the light through it, if we know that light moves 300, 000 kilometers speed per second).[15]

radius this offence is equal to a quarter of radius land, so the region emitting rays on Cygnus is quite small, and therefore his star facilities (HDE 226868) is some kind of giant B0 31000 affinity surface temperature Kelvin.
Spectral observatories showed that spectral lines (HDE 226868) fluctuate every 5 to 6 days, starting from the relationship of the mass and luminosity, this giant block was calculated, which is 30 times larger than the mass of the Sun.[15]

There are now about 20 x binaries (as of 2009) with known black holes (from measurements of the mass of the black hole). The first source is called x-including b (A0620-00). The year was 1975, and this body block is selected in mid-1980 to be greater than the mass of the Sun by 3.5 times. And clearly, excludes neutron star, even taking into consideration all the uncertainties known theory, since it has mass equal to approximately 1.5 double the mass of the Sun.[15]

The best case for a black hole probably (V404 Cygni), this compact star whose mass is not less than the mass of 10 Suns, insert 20 x binaries that are likely to contain black holes, black holes behaves agrees behavior, however, measure the blocks would not have been possible. [15]

6.1Cygnus X-1

On the left, an optical image from the Digitized Sky Survey shows Cygnus X-1, outlined in a red box. Cygnus X-1 is located near large active regions of star formation in the Milky Way, as seen in this image that spans some 700 light years across. [16] [25]

An artist's illustration on the right depicts what astronomers think is happening within the Cygnus X-1 system. Cygnus X-1 is a so-called stellar-mass black hole, a class of black holes that comes from the collapse of a massive star. The black hole pulls material from a massive, blue companion star toward it. This material forms a disk (shown in red and orange) that rotates around the black hole before falling into it or being redirected away from the black hole in the form of powerful jets. [16] [25]

A trio of papers with data from radio, optical and X-ray telescopes, including NASA's Chandra X-ray Observatory, has revealed new details about the birth of this famous black hole that took place millions of years ago.

Using X-ray data from Chandra, the Rossi X-ray Timing Explorer, and the Advanced Satellite for Cosmology and Astrophysics, scientists were able to determine the spin of Cygnus X-1 with unprecedented accuracy, showing that the black hole is spinning at very close to its maximum rate. Its event horizon -- the point of no return for material falling towards a black hole -- is spinning around more than 800 times a second. [16] [25]

Using optical observations of the companion star and its motion around its unseen companion, the team also made the most precise determination ever for the mass of Cygnus X-1, of 14.8 times the mass of the Sun. It was likely to have been almost this massive at birth, because of lack of time for it to grow appreciably. [16] [25]

The researchers also announced that they have made the most accurate distance estimate yet of Cygnus X-1 using the National Radio Observatory's Very Long Baseline Array (VLBA). The new distance is about 6,070 light years from Earth. This accurate distance was a crucial ingredient for making the precise mass and spin determinations. [16] [25]

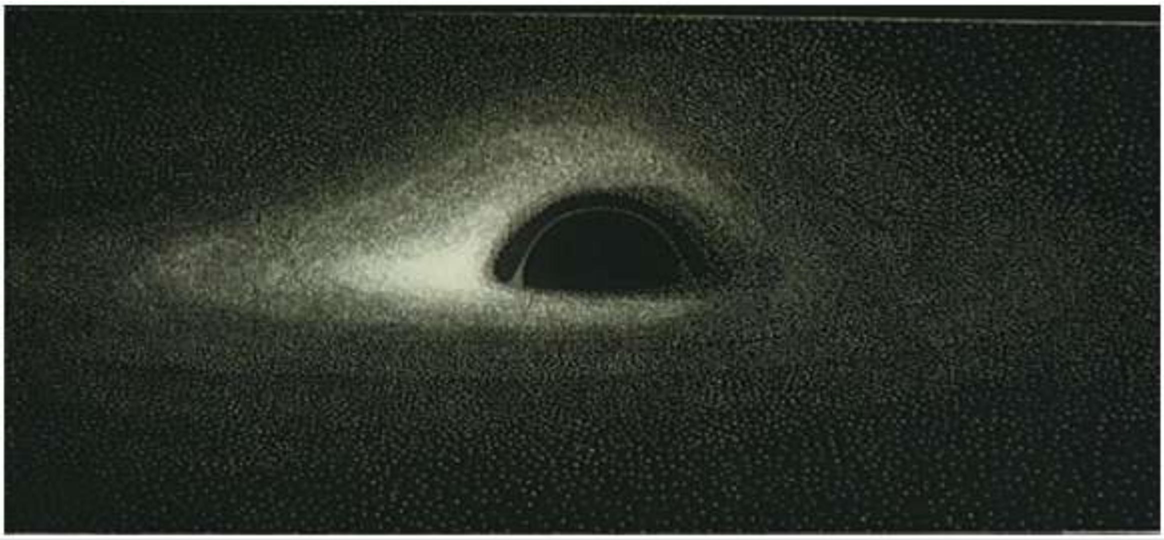
Credits: X-ray: NASA/CXC; Optical: Digitized Sky Survey.

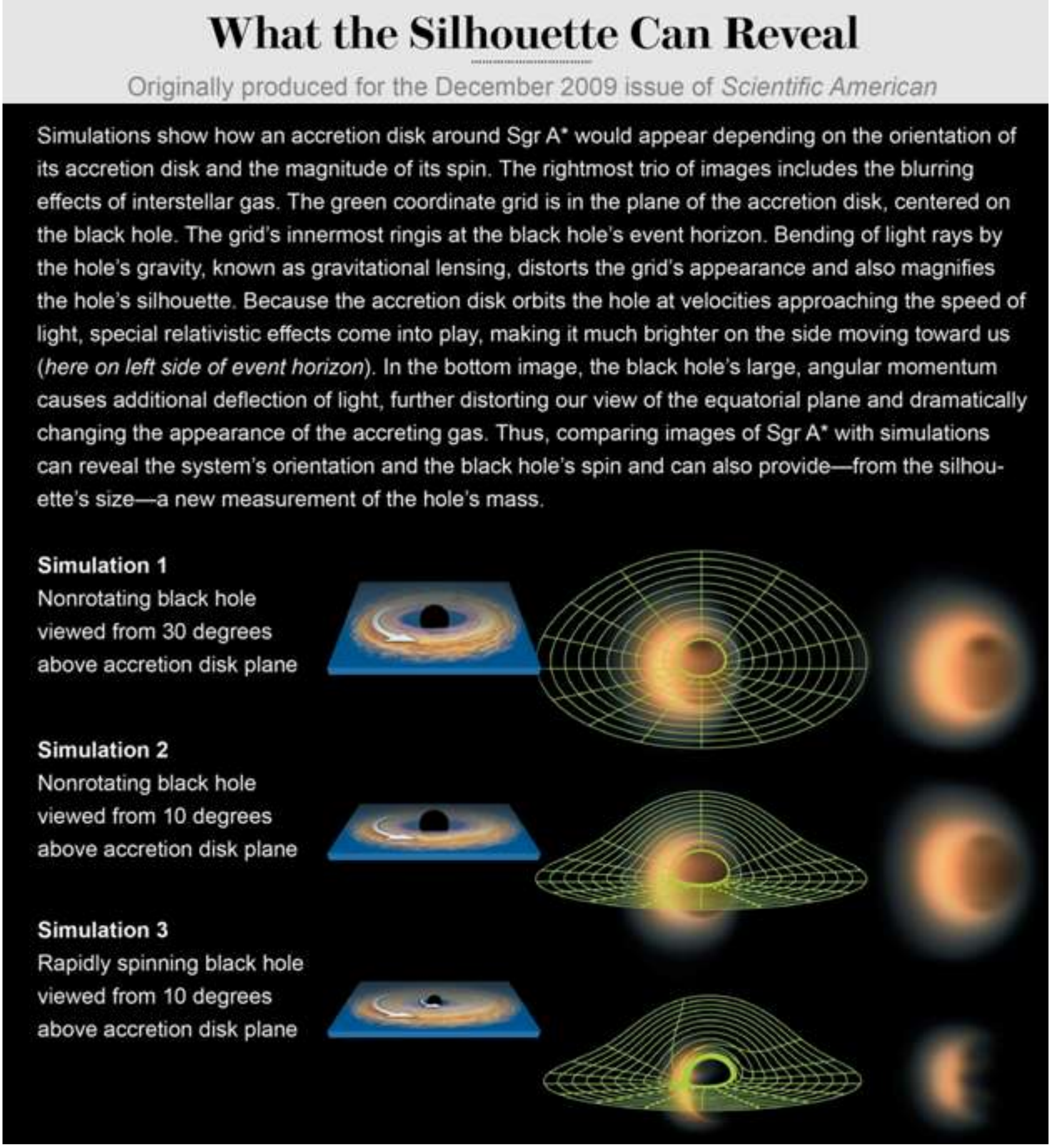
7. How does the black hole look really like?

On April 17, 2017, the Event Horizon Telescope (EHT) may have captured the first ever images of the edge of a black hole. As eager astronomers await the arrival of the pictures (which sadly will take a few months, as the hard drives containing them are stuck in Antarctica until the harsh winter gives way to safer flying conditions), the rest of us are left to wonder: what, exactly, should we expect to see? What does a black hole look like, really?

Many of us have seen the standard artist’s representation of a black hole: a giant floating disk with roiling, glowing outer rings and an abruptly dark centre from which we've assured nothing, not even light, can escape. Such images are compelling, but they fail to portray the complex physical forces manifested by the black hole itself. When viewed through a real-life telescope, it turns out these cosmological beasts take a curious shape.[26]

The first to accurately visualize a black hole was a French astrophysicist named Jean-Pierre Luminet. According to a recent Nature blog post by Davide Castelvecchi, in 1978, Luminet used punch cards to write a computer program calculating the appearance of a black hole, and then—in what must have been an equally painstaking process—reproduced the image by hand using India ink on Canson negative paper. The resulting drawing, made of individual dots converging into a pleasantly organic, asymmetrical form, is as visually engaging as it is scientifically revealing.[26]





What the Silhouette Can Reveal

Originally produced for the December 2009 issue of *Scientific American*

Simulations show how an accretion disk around Sgr A* would appear depending on the orientation of its accretion disk and the magnitude of its spin. The rightmost trio of images includes the blurring effects of interstellar gas. The green coordinate grid is in the plane of the accretion disk, centered on the black hole. The grid's innermost ringis at the black hole's event horizon. Bending of light rays by the hole's gravity, known as gravitational lensing, distorts the grid's appearance and also magnifies the hole's silhouette. Because the accretion disk orbits the hole at velocities approaching the speed of light, special relativistic effects come into play, making it much brighter on the side moving toward us (*here on left side of event horizon*). In the bottom image, the black hole's large, angular momentum causes additional deflection of light, further distorting our view of the equatorial plane and dramatically changing the appearance of the accreting gas. Thus, comparing images of Sgr A* with simulations can reveal the system's orientation and the black hole's spin and can also provide—from the silhouette's size—a new measurement of the hole's mass.

Simulation 1
Nonrotating black hole
viewed from 30 degrees
above accretion disk plane

Simulation 2
Nonrotating black hole
viewed from 10 degrees
above accretion disk plane

Simulation 3
Rapidly spinning black hole
viewed from 10 degrees
above accretion disk plane

Credit: Jean-Pierre Luminet

For an explanation of why Luminet's representation is accurate, check out the graphic below, from the December 2009 issue of Scientific American. You can also read the associated article, "Portrait of a Black Hole," to find out more about the mission to capture the EHT's primary target, a supermassive black hole at the center of the Milky Way known as Sagittarius A*, or Sgr A*.[26]
Source: Avery Broderick (computer simulations)
Credit: *Jen Christiansen*

8. Black Hole Entropy

The Bekenstein-Hawking entropy or black hole entropy is the amount of entropy that must be assigned to a black hole in order for it to comply with the laws of thermodynamics as they are interpreted by observer's external to that black hole. This is particularly true for the first and second laws.

Black hole entropy is a concept with geometric root but with many physical consequences. It ties together notions from gravitation, thermodynamics and quantum theory, and is thus regarded as a window into the as yet mostly hidden world of quantum gravity.[17]

8.1 Why black hole entropy?

A black hole may be described as a blemish in spacetime, or a locale of very high curvature. Is it meaningful or desirable to associate entropy with it?Is this possible at all?
There are several ways to justify the concept of black hole entropy (Bekenstein 1972, 1973).[18]

- A black hole is usually formed from the collapse of a quantity of matter or radiation, both of which carry entropy. However, the hole's interior and contents are veiled to an exterior observer. Thus, a thermodynamic description of the collapse from that observer's viewpoint cannot be based on the entropy of that matter or radiation because these are unobservable. Associating entropy with the black hole provides a handle on the thermodynamics.
- A stationary black hole is parametrized by just a few numbers (Ruffini and Wheeler 1971): its mass, electric charge and angular momentum (and magnetic monopole charge, except its actual existence in nature has not been demonstrated yet). For any specific choice of these parameters one can imagine many scenarios for the black hole's formation. Thus, there are many possible internal states corresponding to that black hole. In thermodynamics, one meets a similar situation: many internal microstates of a system are all compatible with the one observed (macro)state. Thermodynamic entropy quantifies the said multiplicity. Thus, by analogy one needs to associate entropy with a black hole.
- By blocking all signal travel through it, the event horizon prevents an external observer from receiving information about the black hole. Thus, a black hole can be said to hide information. In ordinary physics entropy is a measure of missing information. Hence it makes sense to attribute entropy to a black hole.[18]

8.2 Formula for black hole entropy

How to express the black hole entropy in a concrete formula? It is clear at the outset that black hole entropy should only depend on the observable properties of the black hole: mass, electric charge and angular momentum. It turns out that these three parameters enter only in the same combination as that which represents the surface area of the black hole.[19]

One way to understand why is to recall the "area theorem" (Hawking 1971, Misner, Thorne and Wheeler 1973): the event horizon area of a black hole cannot decrease; it increases in most transformations of the black hole. This increasing behavior is reminiscent of thermodynamic entropy of closed systems. Thus, it is reasonable that the black hole entropy should be a monotonic function of area, and it turns out to be simplest such function.[19]

If A stands for the surface area of a black hole (area of the event horizon), then the black hole entropy, in dimensionless form, is given by

$$S_{BH} = \frac{A}{4L_p^2} = \frac{c^2}{4Gh} \qquad (7,2,1)$$

where L_p stands for the Planck length ${Gh}/{c^3}$ while G,h and c denote, respectively, Newton's gravity constant, the Planck-Dirac constant $({h}/{(2\pi)})$ and the speed of light.

Of course, if the entropy in the usual (chemist's) form is required, the above should be multiplied by Boltzmann's constant k.(19)

For the spherically symmetric and stationary, or Schwarzschild, black hole (see Schwarzschild metric up), the only parameter is the black hole's mass M, the horizon's radius is$r_h = {2gM}/{c^2}$, and its area is naturally given by $4\pi r_h^2$, or

$$A = 16\pi \left(\frac{GM}{c^2}\right)^2 \qquad (7,2,2)$$

Note that a one-solar mass Schwarzschild black hole has a horizon area of the same order as the municipal area of Atlanta or Chicago. Its entropy is about 4×10^{77} , which is about twenty orders of magnitude larger than the thermodynamic entropy of the sun. This observation underscores the fact that one should not think of black hole entropy as the entropy that fell into the black hole when it was formed.[19]

For the most general type of stationary black hole, the Kerr-Newman black hole (rotating black hole), the hole's parameters are mass M, electric charge Q and angular momentum J, and the horizon is no longer spherical. Nevertheless, in the popular Boyer-Lindquist coordinates {t,r,θ,φ}(see Misner, Thorne and Wheeler 1973 or Kerr-Newman metric) it lies at the fixed radial coordinate

$$r = r \equiv \frac{GM}{c^2} + \sqrt{\left(\frac{GM}{c^2}\right)^2 - \left(G^{1/2}\frac{Q}{c^2}\right)^2 - \left(\frac{J}{Mc}\right)^2} \qquad (7,2,3)$$

Consequently, the horizon area is given by

$$A = \int_0^{\pi} d\theta \int_0^{2\pi} d\varphi \sqrt{g_{\theta\theta}\, g_{\varphi\varphi}} = 4\pi \left(r_h^2 + \left(\frac{J}{Mc}\right)^2\right) (7,2,4)$$

(19)

8.3The first law of black hole thermodynamics

When near to equilibrium a thermodynamic system at temperature T changes its state, the consequent increments of its energy E and entropy S are related by the first law of thermodynamics:

$$TdS = dE - dW \qquad (7,3,1)$$

Here dW is the work done on the system by exterior agents. When the system is one rotating with angular frequency Ω and charged up to electric potential Φ, the changes in its angular momentum J and charge Q contribute the work

$$dW = \Omega dJ + \Phi DQ \qquad (7,3,2)$$

A stationary black hole admits a similar relation (Bekenstein 1973). The differential dA from equation (4), when multiplied by a suitable factor, takes the form

$$\Theta\, dA = d(M c^2) - \Omega_{BH} dJ - \Phi_{BH} dQ \qquad (7,3,3)$$

$$\Theta \equiv c^4 (2GA)^{-1} \left(r_h - \frac{GM}{c^2} \right); \qquad (7,3,4)$$

$$\Omega_{BH} \equiv \left(\frac{GM}{c}\right)\left(r_h^2 + \left(\frac{J}{Mc}\right)^2\right)^{-1}; \qquad (7,3,5)$$

$$\Phi_{BH} \equiv Q r_h \left(r_h + \left(\frac{J}{Mc}\right)^2\right)^{-1}. \qquad (7,3,6)$$

Just now this is just a relation between increments in mechanical and geometrical properties. It turns out that $\Omega_{BH}$is precisely the angular rotation frequency of the black hole in the sense that any test body dropped into it, as it approaches the horizon no matter where, ends up circumnavigating it at just this frequency. And Φ_{BH} turns out to be black hole's electric potential in the sense that it equals the line integral of the hole's electric field from infinity to any location on the horizon.(19)

Because Mc^2 is the hole's energy, equation (7,3,3) obviously looks like the first law for an ordinary thermodynamic system. It will be the first law if black hole entropy is required to be a function of A and of nothing else, so that $dS_{BH} \propto dA$ (Gour and Mayo 2001). With the choice in equation (7,2,1) the black hole temperature T_{BH} must be

$$T_{BH} = 4L_p^2 \Theta = \frac{\hbar c}{2\pi} \frac{\sqrt{\left(\frac{GM}{c^2}\right)^2 - \left(G^{1/2}\frac{Q}{c^2}\right)^2 - \left(\frac{J}{Mc}\right)^2}}{r_h^2 + \left(\frac{J}{Mc}\right)^2} \qquad (7,3,7)$$

The truth of the black hole temperature was brought back to the house when Hawking (1974, 1975) showed that the non-eternal black hole should be emitted automatically from the heat radiation (Hawking radiation) to the exact degree (the original calculation is J = 0, Q = 0, But it is now clear that equation (7,3,4) is valid for all J and Q). This finding provided calibration of the numerical factor in equation (7,2,1).[19]

8.4The generalized second law of thermodynamics

In ordinary thermodynamics, the second law requires that the entropy of a closed system shall never decrease, and shall typically increase as a consequence of generic transformations. While this law may hold good for a system including a black hole, it is not informative in its original form. For example, if an ordinary system falls into a black hole, the ordinary entropy becomes invisible to an exterior observer, so from her viewpoint, saying that ordinary entropy increases does not provide any insight: the ordinary second law is transcended.[19]

Including the black hole entropy in the entropy ledger gives a more useful law, the generalized second law of thermodynamics (GSL) (Bekenstein 1972, 1973, 1974): the sum of ordinary entropy So outside black holes and the total black hole entropy never decreases and typically increases as a consequence of generic transformations of the black hole. In equations

$$\Delta S_0 + \Delta S_{BH} \geq 0$$

The GSL extends the reach of the area theorem in both classical and quantum physics as follows:

When matter entropy flows into a black hole, the GSL demands that the increase in black hole entropy shall more than compensate for the disappearance of ordinary entropy from sight. This has been verified by examples (Bekenstein 1973). [19]

During the process of Hawking radiation, the black hole's area decreases (basically because of the decrement of black hole mass), in violation of the area theorem. This is known to reflect a failure of the energy condition (assumed by the theorem) as a result of the very quantum fluctuations which engender the radiation. The GSL predicts that the emergent Hawking radiation entropy shall more than compensate for the drop in black hole entropy. This has been verified amply (Bekenstein 1975, Hawking 1976), and stands as testament to the predictive power of the GSL which was formulated two years before the Hawking radiation was put in evidence. Varied theoretical arguments have been given in support of the GSL (Frolov and Page 1993, Bombelli et al 1986)[19]

8.5Status of the third law of black hole thermodynamics

In ordinary thermodynamics, the third law may be stated in two ways:

- Nernst-Simon statement: The entropy of a system at absolute zero temperature either vanishes or becomes independent of the intensive thermodynamic parameters, e.g. pressure, magnetic field, electric potential, etc.
- Unattainability statement: To bring a system to absolute zero temperature involves an infinite number of processes or steps.

From formula (7,3,4) it is clear that the black hole temperature vanishes when

$$\left(\frac{GM}{c^2}\right)^2 - \left(G^{1/2}\frac{Q}{c^2}\right)^2 - \left(\frac{J}{Mc}\right)^2 = 0$$

Kerr-Newman black holes satisfying this condition are called extreme. From equations (7,2,1) and (7,2,3) - (7,2,4) it is clear that for $T_{BH} = 0$the black hole entropy is not only no vanishing, but depends on (J/Mc). Now this last quantity is an analog of a thermodynamic intensive parameter.

For example, it is directly related to the hole's angular velocity in equation (7,3,5) and angular velocity of a thermodynamic system is an intensive parameter. Thus, the Nernst-Simon statement of the third law fails for black holes.[19]

There is some evidence that the unattainability statement of the third law is satisfied by black holes. For example, in an astrophysical setting the process of spinning up a Q=0 black hole gets "hung up" at (J/Mc) ≈0.998GM/c^2, before the externality condition can be satisfied (Thorne 1973).[19]

9. Hawking radiation

Let us imagine such a creation of particles in the vicinity of the horizon of a black hole.

If one of these antiparticles falls beyond the horizon, the remaining particle can escape to a large distance from the hole, carrying a positive energy. As it cannot annihilate with its antiparticle, it becomes a real particle, and for a distant observer, it will seem to have been emitted by the black hole.

In order to compensate for this energy, carried away by the particle, the black hole has to lose the same amount of energy.[20]

Note: the opposite phenomenon is impossible.

If the particle which falls back into the black hole carries a positive energy, then the other particle will also have to fall, because a particle cannot exist in our universe with a negative energy.[20]

Pairs of virtual particles/antiparticles are continuously created in the vicinity of the horizon of the black hole. Among these pairs, some of them won't be able to annihilate, because one of the particles has fallen back into the black hole.

The outgoing particle carries energy with it, giving the illusion that the black hole radiates.[20]

So, an evaporating radiation does appear, coming from the black hole. The calculation shows that this radiation exhibits a typical black body spectrum.

The heavier the black hole is, the lower is its temperature. A stellar black hole of 6 solar masses has a temperature of 10^{-8}K.
Indeed, the smaller the black hole is, the shorter is the distance for the virtual particle to travel before it becomes a real particle. The emission rate and the temperature are hence higher for a small - i.e. light - black hole.

Since the black hole radiates, it evaporates. Hence its lifetime is finite. For our 6-solar mass black hole, its lifetime is about 2×10^{68} years.[20]

The temperature of a black hole whose mass is M is given by

$$T = \frac{\hbar c^2}{8\pi kGM}$$

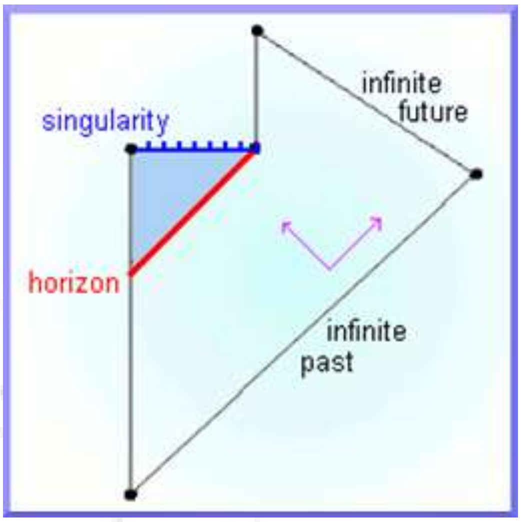
where h is the reduced Planck constant

$$\hbar = \frac{h}{2\pi}$$

And its lifetime is $T \approx (\frac{M}{M_\Theta})^3 \times 10^{66}$ years.[20]

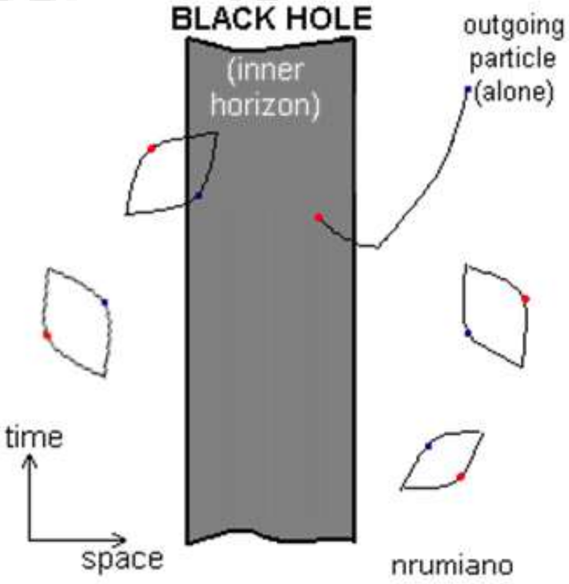
Obviously, with such a weak value, it is completely impossible to try to measure the radiation as it escapes the black hole. We can't have a direct experimental confirmation. [20]

At the end of its life, the mass of the black hole becomes smaller and smaller, and hence its temperature tends towards infinity. The black hole disappears in a fantastic explosion. [20]



The current physics is unable to explain the last phases of the evaporation of the black hole.

The Penrose diagram of the black hole *is shown on the left:* the singularity has a beginning and an end. After its end, the universe again becomes the same as it was before.[20]



There is another explanation for this radiation, more rigorous, and it was found by Hawking himself in 1975; it is based on an analogy with the Unruh radiation. [20]

William Unruh showed in 1976 that a uniformly accelerating observer in a vacuum will find himself surrounded by a thermal bath, the "Unruh radiation", whose temperature T is proportional to acceleration γ (this effect is quite weak: T~1 K for γ $=10^{19}\, m/s^2$).[20]

This effect implies a close relationship between acceleration, gravitation, thermodynamics and quantum mechanics.
We won't go into details of the necessary calculations; they rest on a semi-classical approach, with a quantization of an existing field.[20]

With the Hawking radiation, there is a decreasing of the area of the black hole, due to the decreasing of its mass with the evaporation. We've seen that this area is comparable to the entropy, but as the loss of entropy of the black hole is exactly compensated with the increase of entropy of the thermal radiation, there is no violation of the second principle of thermodynamics. [20]

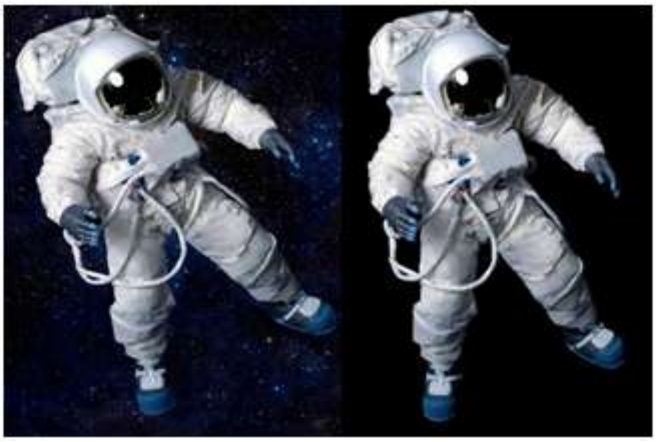
9.1 Eerie Theories on What Happens Inside a Black Hole

Black holes are mysterious bodies that defy the laws of physics as we know it. We can barely grasp the concept of one. We don’t know for certain what exactly black holes exactly are of what they do. It’s impossible to know. However, what we can do is observe black holes and then theorize on what they’re capable of. Henceforth comes the inevitable question: What would happen if someone jumped into a black hole? Well, here are 10 of the most eerie theories on what would happen if you entered a black hole.[22][23]

9.2 Cloning

The black hole information paradox is an enigma that has eluded physicists for centuries now. It has been the trigger for endless debates on what actually happens once you enter a black hole. To fully understand the paradox, we’re going to need the help of your friend, Asia. Asia decided to back out at the last second and is currently watching you from afar as you enter a black hole alone. As you proceed closer, she sees you slowly get stretched until you eventually evaporate into a crisp. Asia now thinks you’re dead and is glad that she didn’t listen to you.

But, wait . . . that’s not how the story ends. You’re actually still alive and well, and you’re venturing endlessly through the black hole. What actually happens to you next doesn’t concern us at this point. What is really intriguing, though, is the fact that you’re still alive, even though Asia just saw you die.



This is the black hole information paradox. It isn’t an illusion, and neither you nor Asia have lost your minds. It just simply is. The laws of physics dictate that you’re both dead outside the black hole and alive within it. Some physicists have theorized that there isn’t a paradox at all, as both realities cannot be observed at the same time. Others have nominated cloning (that two realities of you exist) as the solution to this paradox, even though it defies quantum mechanics laws pertaining to conservation of information.

In the end, there is no certain answer to this paradox (yet). Perhaps thousands of years from now, we’ll understand what really goes on. However, we do know for certain that you shouldn’t take Asia with you on trips anymore.[21] [22][23]

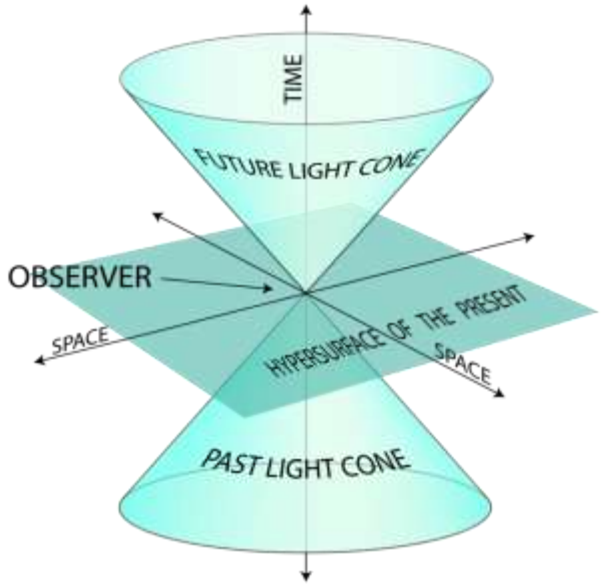
9.3 Spaghettification

It’s theorized that once you enter the event horizon of a black hole, you would start to experience tidal forces from the massive gravity.

As you’re falling through the blackhole, the force applied to you, compared to the cohesiveness of your body, would cause you to be ripped into pieces.

Moreover, if you decided to boldly jump in head first into a black hole, your head would be pulled so far apart from your feet, that you would start to look like spaghetti. The idea is that the difference in acceleration due to gravity between your head and feet is so tremendous at that point that you would be stretched and shaped that resembles spaghetti. Thus, physicists have coined the process as spaghettification.[21] [22] [23]

9.4 Distortion of Light, Space, and Time



The first thing anyone would notice upon entering the event horizon of a black hole is how different light, space, and time are. Once you get inside, the laws of physics as we know it cease to exist, and new laws are put into place.

The infinite amount of gravity that is produced from the singularity at the center of the black hole is capable of warping space, altering time, and disfiguring light. Because of this, your perception of what is going on would be tremendously compared to how you viewed things before you transitioned through the event horizon. Of course, this will only last until you're engulfed in the lonesome darkness and are no longer able to perceive anything.[21] [22] [23]

9.5 Time Travel

The greatest physicists to ever grace this humble planet of ours, like Einstein and Hawking, have theorized that time traveling into the future is possible by abusing the ethereal laws of a black hole. As previously mentioned, the laws of physics are null inside a black hole, and a new set of laws are put into place. One thing that is excruciatingly different in a black hole compared to our world is time. Gravity warps time, and a black hole is essentially a massive gravitational body.

With that in mind, the idea is that the time distortion allows for the possibility of time travel. By abusing the tremendous disparity of time between inside and outside the event horizon, you could actually come back to a futuristic world where you're still 25, but your best friend is now 60, due to gravitational time dilatation.

Of course, we have to take into consideration that, at the moment, we have no way of traveling to a black hole, let alone a way of entering one and coming out unscathed. [21] [22] [23]

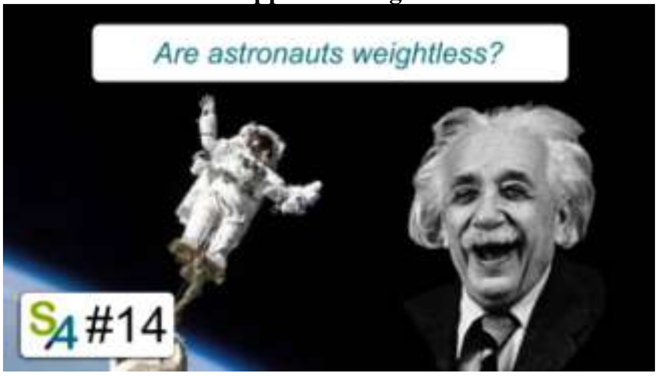
9.6 You Live Normally

If we had the option of picking a black hole to enter, we should probably pick out a supermassive or a Kerr black hole.

If we managed to travel to the black hole at the center our galaxy, which is 25,000 light years away and 4.3 million times more massive than our Sun, we could possibly live out our lives normally inside of it. The concept behind this is that the tidal force applied to anyone entering is insignificant, as the event horizon is much further away the black hole's center. Thus, you would continue living like usual inside the event horizon until you die of hunger or dehydration or finally hit the singularity. Take your bets on what would happen first, because no one knows. [22] [23]

Moreover, it is also theoretically possible to live your life in a black hole if it happens to be a Kerr black hole, which is a unique type of black hole that was theorized in 1963 by Roy Kerr. He believed that if dying stars were to collapse inside "a rotating ring of neutron stars," then it would be possible to enter a black hole unharmed, as the centrifugal force produced would prevent the formation of a singularity. The lack of a singularity in a black hole would mean that you wouldn't have to fear infinite gravitational forces, and thus, you could live out your life normally.[22] [23]

9.7 Live Einstein's Happiest Thought

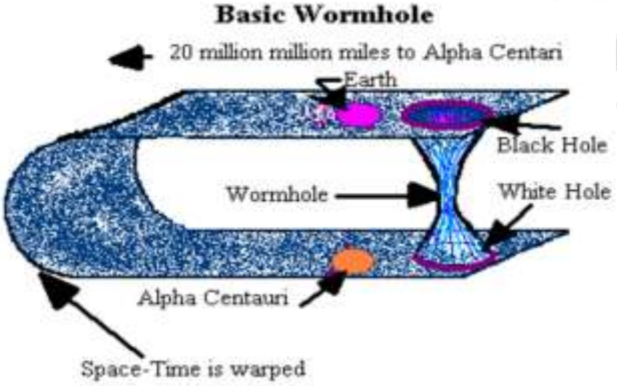


Einstein imagined that by entering a certain freely falling motion, you would be able to cancel out the force of gravity. This would mean that a person would stop feeling his own weight while freely falling, and anything else that was dropped at the same time wouldn't seem as if it was dropping at all, but rather hovering.

Einstein coined this idea, from which he based his world-renowned theory of general relativity, as his happiest thought ever. And it could be your happiest thought too, if you jumped into a black hole. Even though you are freely falling into God knows what, you wouldn't be able to notice that you're falling until you hit the black hole's singularity. However, if someone were able to view you, they would obviously see you falling. This is due to the fact that whatever surrounds you is dropping relative to you, while it isn't for whoever is observing from the outside. [22] [23]

9.8 White Hole

It's well-known that a black hole absorbs everything that enters its event horizon, to the extent that even light cannot escape it. Less well-known is where those doomed particles end up. One theory is that whatever ends up inside of a black hole comes out at its other end, which is a white hole.



Of course, no one has ever seen a white hole before, so no one actually knows if it's actually white or not. But the reason behind why it is named so is because a white hole represents the complete opposite of what a black hole is. Instead of absorbing everything that enters it, it spits out everything that is inside of it. And just like how you cannot escape a black hole, the opposite is true in a white hole, as you wouldn't be able to enter one. [25]

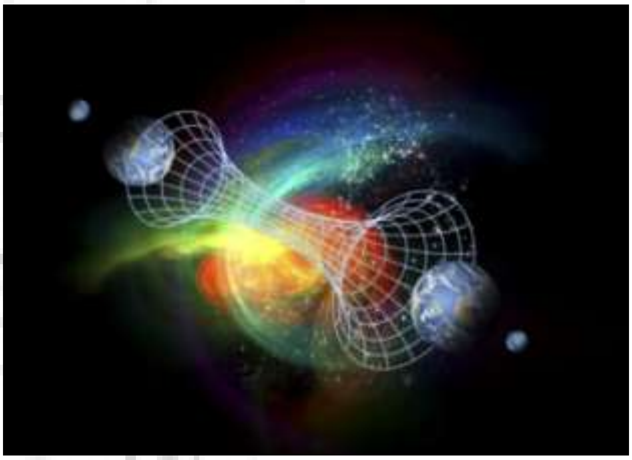
The white hole, in short, spits out whatever the black hole has swallowed into an alternate universe. This theory has made physicists consider white holes as the basis of the creation of our universe as we know it. If you manage to survive falling into ablack hole and somehow travel out of its white hole, you are most likely never going to be able to access this universe ever again. [21] [22] [23]

9.9 Watch the History of the Universe Play Itself Out

As we've mentioned previously, it's possible to encounter a black hole with no singularity. Such a black hole would have a wormhole in its place instead. If we manage to actually travel through the wormhole, we would witness the history of the universe play itself out in front of our eyes in the process of transiting to whatever is at the end of the wormhole. It would be as if someone played a video tape of the universe's history on infinite fast-forward.

However, this story has a bad ending, as the faster the speed of the picture gets, the closer you are to dying. The light will become more and more blue shifted and energetic until it instantly fries you alive with radiation. [21] [22] [23]

9.10 Travel to A Parallel Universe



If you somehow manage to get yourself stuck in a black hole, whether by choice or not, just look around you; there might be a way out. Even though it would be impossible to return to the universe you once loved and cherished, you would still be safe (or at least safer) in a new, parallel universe.

Physicists have theorized that once you reach a black hole's singularity, it could act as a bridge to an alternate reality, or a so-called "parallel universe." What this new universe possess is really up to the imagination. Some theories even say that an infinite amount of alternate different yours lie in an equally infinite amount of alternate universes.

So, have you ever wondered what could have been—what could have happened if you went after that dream of yours instead of settling, what could have been if you were richer or poorer, or if you chased after that cute girl/guy? Well, you might actually find out (if you jump into a black hole).[21] [22] [23]

9.11 You Become Part of the Universe

Hawking theorized that certain particles that enter a black hole are filtered out into positive and negative particles. These particles are slowly absorbed by the black hole. As the negative particles fall in they decrease its mass. Positive particles have just enough energy to remain outside of the black hole as radiation.

As the black hole, slowly but surely starts to lose mass and gets hotter and hotter, it explodes its contents, referred to as Hawking radiation, back to the universe. This, in concept, means that you might become a part of the universe, like a phoenix rising from atomic ashes.[21] [22] [23]

9.12 You'll Just. . . Die ☺

Sometimes, we like to ignore obvious and grim reality while being blinded by the opportunity to yearn for something greater.

As sadistic as it sounds, the most likely outcome of falling into a black hole is that before you could even acknowledge your presence within it, you'd be torn to smithereens. You wouldn't even understand that you were witnessing what physicists claim as the key to understanding the universe's eerie mysteries. [22] [23]

10. Black holes, Holographic principle and access to the theory of everything

Professor Kostas Skenderis of Southampton University, the lead author of the study, said in a statement: "Imagine that everything you see, see and hear in three dimensions (and your perception of time) actually stems from a two-dimensional flat place, and this idea is similar to that in the normal hologram where a three-dimensional image symbolizes a two-dimensional surface, Hologram on credit card. However, this time, will symbolize the entire universe".[7][24]

The researchers tested a series of three-dimensional models that are not compatible with the models observed at the early beginnings of the universe provided by the European Space Agency's Planck Observatory. The team was able to exclude some models, but they were waiting for the rest of the forms to get feedback.[7] [24]

This was an interesting result, because it gives better guidance to scientists to investigate the possibility of accepting a hologram (or three-dimensional) universe.[7] [24]

Although the performance of the models tested (their success rate) was slightly worse than the standard model, it is assumed that the universe consists of dark energy, dark matter and a small portion of visible matter. [7] [24]

Kostas Skenderis says: "Einstein's theory of general relativity explains everything almost universally and very well, but begins to collapse when studying its origins and mechanisms at quantum level."

He continued: "For decades scientists have worked to combine Einstein's theory of relativity with quantum theory. Some believe that the concept of the hologram universe has the ability to reconcile the two. Our research will take us another step towards this. "[7] [24]

The hologram principle was developed in the study of black holes and was used extensively in string theory.[7] [24]

It may and may not lead to the theory of everything «Stephen Hawking's world theory», but it is interesting to see that its versions can interpret the universe that we see now.[7] [24]

This solution carries a very insane idea; the hologram principle states that each three-dimensional object can be described as a two-dimensional hologram, just like the film projector. This means, my dear reader Hologram, that everything in the universe is only a three-dimensional hologram projection of something more dimensions!! [7]

Is it reasonable that we are in the end just a movie projection!!

Is this real? We do not know yet…

Done, by
Ayoub Fahad M Almughamisi
3/3/1439 AH, 21/11/2017 AD.

11. Conclusion

We know what are black holes? Composed? And how do they look? What happens to the information inside it? More importantly, what happens to you if you enter the black hole? Believe me the most terrifying thing you can hear about the universe, is having something like black holes. Worse, it falls into one.

I would recommend watching a movie *"interstellar 2014"*

12. Dedication

To my mother **Mrs. Bahia Almughamisi**, my father **Mr. Fahad Almughamisi,** my brothers. And everyone who encouraged me in what I love

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