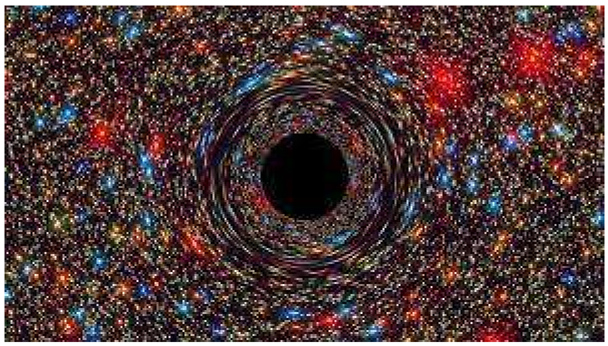
St .John Baptist De La Salle catholic school

Physics group project of 2nd quarter

Black Holes: history, origin & scientific significance



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Acknowledgment

We are grateful to God and to all members of the two groups. Without the participation of them the group project wouldn't completed in time. We are lucky to get this project because it is an amazing and interesting project. It is about black holes which is one of the mysterious objects in the universe. In our project we discussed about the history, origin and scientific significance of black holes.

Introduction of black holes

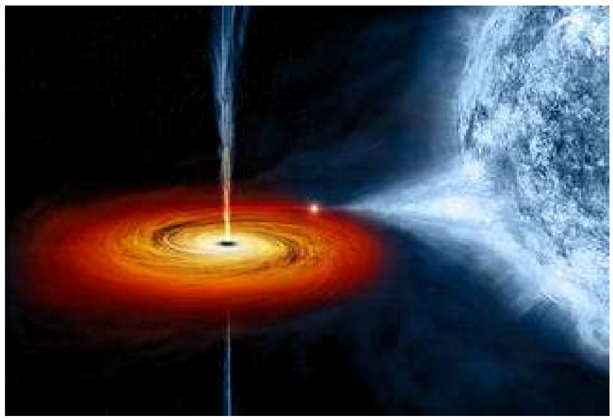
A black hole is a region of spacetime where gravity is so strong that nothing, including light or other electromagnetic waves, has enough energy to escape its event horizon. A black hole is a place in space where gravity pulls so much. The gravity is so strong because matter has been squeezed into a tiny space. This can happen when a star is dying. Black holes have many mysteries that scientist are still trying to understand ,and they are one of the strongest and fearsome things in the universe.

Definition and origin of Black holes

What is a black hole

A black hole is a region in space where the pulling force of gravity is so strong that light is not able to escape. The strong gravity occurs because matter has been pressed into a small space. This compression can take place at the end of a star's life. Some black holes are a result of dying stars.

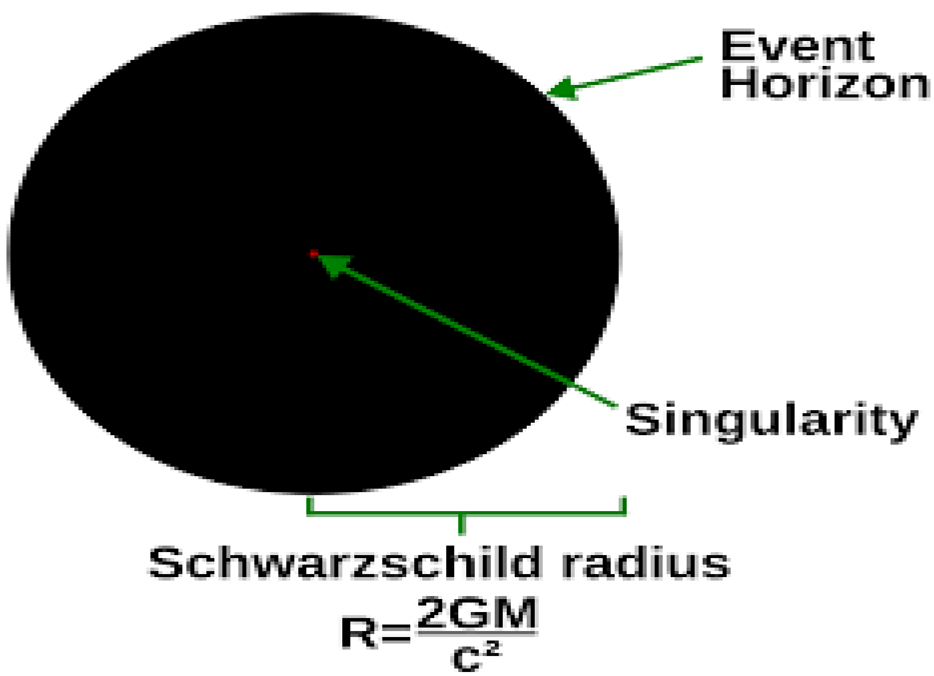
Because no light can escape, black holes are invisible. However, space telescopes with special instruments can help find black holes. They can observe the behavior of material and stars that are very close to black holes.



How Do Black Holes Form?

Scientists think the smallest black holes(primordial black holes) formed when the universe began(born). The essential ingredient for the formation of a primordial black hole is a fluctuation in the density of the Universe, inducing its gravitational collapse. Stellar black holes are made when the center of a very big star falls in upon itself or collapses because the star runs out of fuel. This fuel generate energy that helps the star to overcome the gravity. When it collapses , it causes a supernova. A supernova is an explosion of star that blasts part of the star into space. Intermediate-mass black holes are thought to form when many stellar black holes undergo a series of mergers(combinations) with one another. These mergers frequently happen in crowded areas of galaxies. Merging stellar-mass black holes spend a very long time in the early stages of their merging.

A **super massive black hole** (**SMBH** or sometimes **SBH**) is the largest type of black hole. Astronomers are still not sure how these super massive black holes formed. Scientists think super massive black holes were made at the same time as the galaxy they are in. Another idea is that a stellar black hole consumes enormous amounts of material over millions of years, growing to super massive black hole proportions or a cluster of stellar black holes form and eventually merge into a supermassive black hole. Imagine taking a matter at some fixed mass M, and crushing it. Einstein's theory of gravity says that when you squeeze it in to a small enough region of space with a size known as the schwarzschild radius, RS(M) the object becomes a qualitatively new kind of beast ,a black hole. A black hole is a collection of matter so dense that even light cannot escape it's event horizon. Therefore, it's interior working remain mystery to us. RS(M)=2GM/c2,where G is the gravitational constant and c is the speed of light. If you put an amount of mass M or larger in a sphere of radius smaller than RS(M), then it will become a black hole.



HISTORYOF BLACK HOLE

JANUARY-10-2022

HISTORY

John Michelle was an English astronomical pioneer and clergyman. During 1783 geologist John Michelle wrote a letter to Henry Cavendish about his expectations on the properties of dark stars. Michelle calculated that when the escape velocity is equals to or greater than the speed of light. John Michelle used the term "dark star" in a November 1783 letter to Henry Cavendish and in the early 20th century, physicists used the term "gravitationally collapsed object". Science writer Marcia Bartusiak traces the term "black hole" to physicist Robert H.Dicke ,who in the early 1960s reportedly compared the phenomenon to the Black Hole of Calcutta, notorious as a prison where people entered but never left alive. Black hole and Dark stars are similar because they have the same surface escape velocity which is equals to greater than the speed of light. Also they have the same critical radius of $r \leq 2M$.

Modern physics discredits the idea of Michelle's notation of light ray shooting directly from the surface of a supermassive star, being slowed down by the star's gravity, stopping, and then free-falling back to the star's surface.

Albert Einstein develop his theory (The general relativity). This theory show that gravity does influence the light's motion. After a few months, later Karl Schwarzschild found the exact solution to Einstein field equations that describes the gravitational field of a point mass and a spherical mass. Schwarzschild found the Schwarzschild radius. He calculate the exact solution for the theory of general relativity in 1916. The Schwarzschild radius is given by:

Rs=2GM/C^2, where,

Rs – Schwarzschild radius ,	G- gravitational constant
C – the speed of light	M- mass of an object

Schwarzschildradius was later named as Singular. In 1924, Arthur Eddington showed that the singularity disappeared after a change of coordinates.

In 1958, David Finkelstein identified the Schwarzschild surface as an event horizon, "a perfect unidirectional membrane: causal influences can cross it in only one direction". Arthur Eddington did however comment on the possibility of a star with mass compressed to the Schwarzschild radius in a 1926 book, noting that Einstein's theory allows us to rule out overly large densities for visible stars like Betelgeuse because "a star of 250 million km radius could not possibly have so high a density as the Sun. Firstly, the force of gravitation would be so great that light would be unable to escape from it, the rays falling back to the star like a stone to the earth. Secondly, the red shift of the spectral lines would be so great that the spectrum would be shifted out of existence. Thirdly, the mass would produce so much curvature of the spacetime metric that space would close up around the star, leaving us outside.

In1931, Subrahmanyan Chandrasekhar calculated, using special relativity, that a non-rotating body of electron-degenerate matter above a certain limiting mass (called the Chandrasekhar limit at 1.4 mass of the sun) has no stable solutions. In 1939, Robert Oppenheimer and others predicted that neutron stars above another limit (the Tolman–Oppenheimer–Volkoff limit) would collapse further for the reasons presented by Chandrasekhar, and concluded that no law of physics was likely to intervene and stop at least some stars from collapsing to black holes.

Their original calculations, based on the Pauli exclusion principle, gave it as 0.7 *mass of the sun*; subsequent consideration of neutron-neutron repulsion mediated by the strong force raised the estimate to approximately 1.5 to 3.0 *mass of the sun* Observations of the neutron star merger GW170817, which is thought to have generated a black hole shortly afterward, have refined the TOV limit estimate to ~2.17mass of the sun.

In the Golden age general black hole solutions were found more than the other periods. In 1963, Roy Kerr found the exact solution for a rotating black hole. Two years later, Ezra Newman found the axisymmetric solution for a black hole that is both rotating and electricallycharged. Through the work of Werner Israel, Brandon Carter, and David Robinson the no-hair theorem emerged, stating that a stationary black hole solution is completely described by the three parameters of the Kerr–Newman metric: mass, angular momentum, and electric charge.

Black Hole Thermo dynamic was formulated in early 1970s, by James Bardeen and Jacob Bekenstein. These laws describe the behavior of black hole by relating it with the *law of thermodynamic* by relating mass to energy, area toentropy, and surface gravity to temperature. The analogy was completing when Hawking, in 1974, show that *quantum field theory* implies that black holes should radiate like a black body with a temperature proportional to the surface gravity of the black hole, predicting the effect now known as *Hawking radiation*.

Etymology of black hole

John Michell-------“black stars” in November 1783 letter to Henry Cavendish.

In early 20th century physicists --------- “gravitationally collapsed objects”.

Marcia Bartusiak -------- “black hole” to physicist Robert H. Dicke.

In present Black holes are defined as:

NASA:NASA describe black hole as Black Hole is a space Where the gravity is so strong. In which light can't pass through it. NASA launched a small rocket(X-ray) to photograph the black hole.

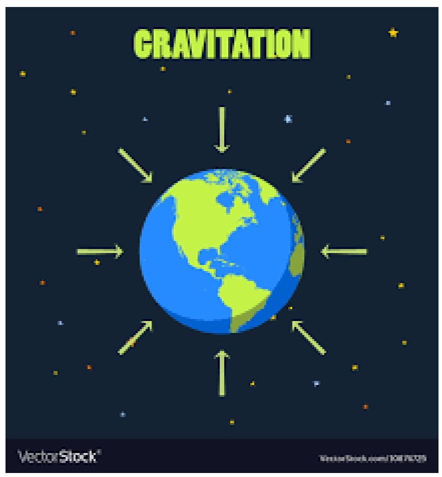
Intense X-ray flares thought to be caused by a black hole devouring a star.

Scientific significance of Black Holes

Black holes seems dangerous and useless to us ,but there is no near black holes near our planet so at least they are not dangerous to us also black holes are not use less they help scientist in many things.

1.To understand gravitation:

Black holes have large gravity so it is helping researchers to understand gravitation which fundamental to great extent.



2.To know the history of the universe:

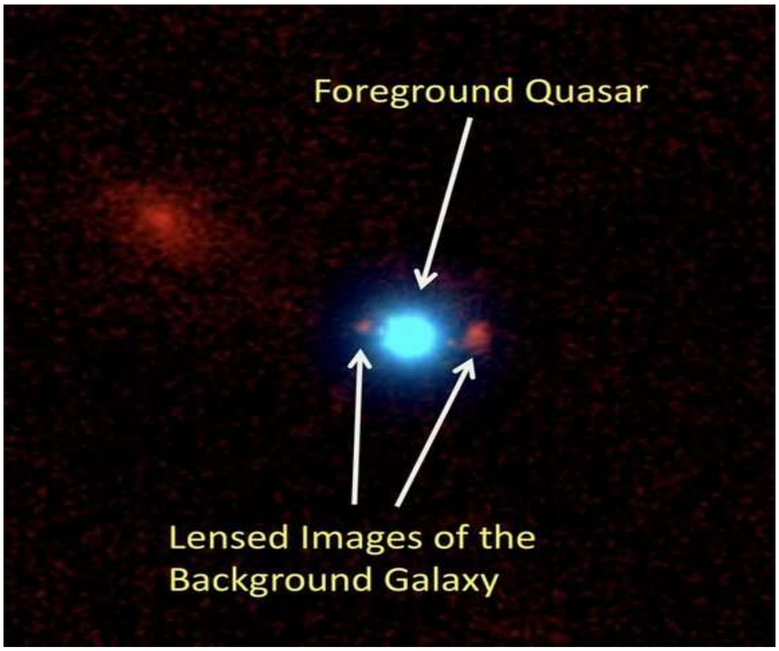
By knowing how fast a black hole is feeding, its mass, and the amount of radiation nearby, researchers can determine when some black holes underwent their biggest growth spurts. That information, in turn, can tell them about the history of the universe.

3.For the effect they have on time:

Black holes are also studied for the effect they have on time. It thought that the singularity at the center is essentially point where time comes to a halt(stops), and distinctions between cause and effect can no longer be made. An understanding of this singularity may have major effects for how we think of time.

4.Help to study other objects:

Black holes are also useful to study other objects. Due to the intense warping of spacetime, black holes can function as a gravitational lense, so they can act as a magnifying glass. Below is an image taken with the Keck II telescope where a supermassive black hole is spouting energy from inside the galaxy and thereby magnifying a much more distant galaxy behind it. Black holes could in principle also be used to view objects behind its host galaxy which couldn't normally be seen.



5.To measure distances:

When too much mass enters into black holes at once, beams of energy will emerge from the poles in the form of x-rays and gamma -rays. This beams of energy are the brightest sources of light in the universe which are called 'standard candles'. They help in astronomy to measure distances.

6.To solve the information paradox:

Black holes are also studied to resolve the information paradox, which is the outcome of the combination of the prediction of quantum mechanics and general relativity .Quantum mechanics says that physical information is never lost ,but according to general relativity the information that enters a black holes is lost forever.

7.To develop new technologies:

The curiosity of researchers to know about something motivate them to develop technologies that enable them to study the thing. So to understand black holes they might make technologies that help them to learn about it and the technology may help them in another scientific experiment.

finally, black holes are studied because they constitute the end point of stars of a sufficient mass.

The study of black holes is a necessary component of astrophysics, if we truly want to understand stars and the universe at large.

summary

Black holes are fearsome and weird objects. Black holes can come in a range of sizes, but there are three main types of black holes. The black hole's mass and size determine what kind it is. The smallest ones are known as primordial black holes. Scientists believe this type of black hole is as small as a single atom but with the mass of a large mountain. Primordial black holes are thought to have formed in the early universe, soon after the big bang. Stellar black holes form when the center of a very massive star collapses in upon itself. This collapse also causes a supernova, or an exploding star, that blasts part of the star into space. Scientists think super massive black holes formed at the same time as the galaxy they are in.

The idea of a body so strong that even light could not escape was briefly proposed by English astronomical pioneer and clergyman John Michell in a letter published in November 1784. Michell referred to these bodies as dark stars. Karl Schwarzschild a German physicist and astronomer developed the idea for black holes from relativity's equations in 1916, just a year after Einstein published his theory. In 2019 scientist get the first photograph of black hole in the super giant galaxy of M87.This discovery proof that black holes are real and not just theoretical things.

Black holes have many benefits to science. For example studying black hole s help us to understand gravity(gravitation),to measure distance ,to develop new technologies and e.t.c. So studying black holes helps science to develop and benefit us in our live.

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