SPACE EXPLORATION SOCIETY, IIT BHILAI

PRESENTS

STELLAR REBIRTH

THE ANNUAL SES MAGAZINE

A JOURNEY THROUGH THE FABRIC OF SPACETIME

TAILORED WITH ♥

CONTENTS

SPACE WEEK 2021 THEME

WOMEN IN SPACE

As of March 2021, 65 women have flown in space, including cosmonauts, astronauts, payload specialists, and space station participants. During the International Space Week 2021, SES celebrated womanhood by looking at some of the women who are the best in their field. The first woman in space was Russian cosmonaut Valentina Tereshkova, who flew on Vostok 6 on June 16, 1963.

Nicole Oliveira

World's Youngest Astronomer

Nicole Oliveira, an eight-year-old from Alagoas, Brazil, found seven asteroids for NASA recently. She has been named the youngest astronomer in the world.

Remember when we were 7 years old and were fascinated by the night sky? Well, that was the age when Nicole Oliviera, a young Brazilian girl discovered not one, not two, but seven asteroids! This indeed is a remarkable thing to do when you're 7 years old. Her interest and love for astronomy began when she was 2 years old.

Nicole not only is passionate about astronomy but also inspires many other young people to pursue their passion. She has given astronomy talks at various schools and events. She recently delivered a lecture in the International seminar on Astronomy and Aeronautics conducted by the Ministry of Science, Technology and Innovation, Brazil.

Kalpana Chawla

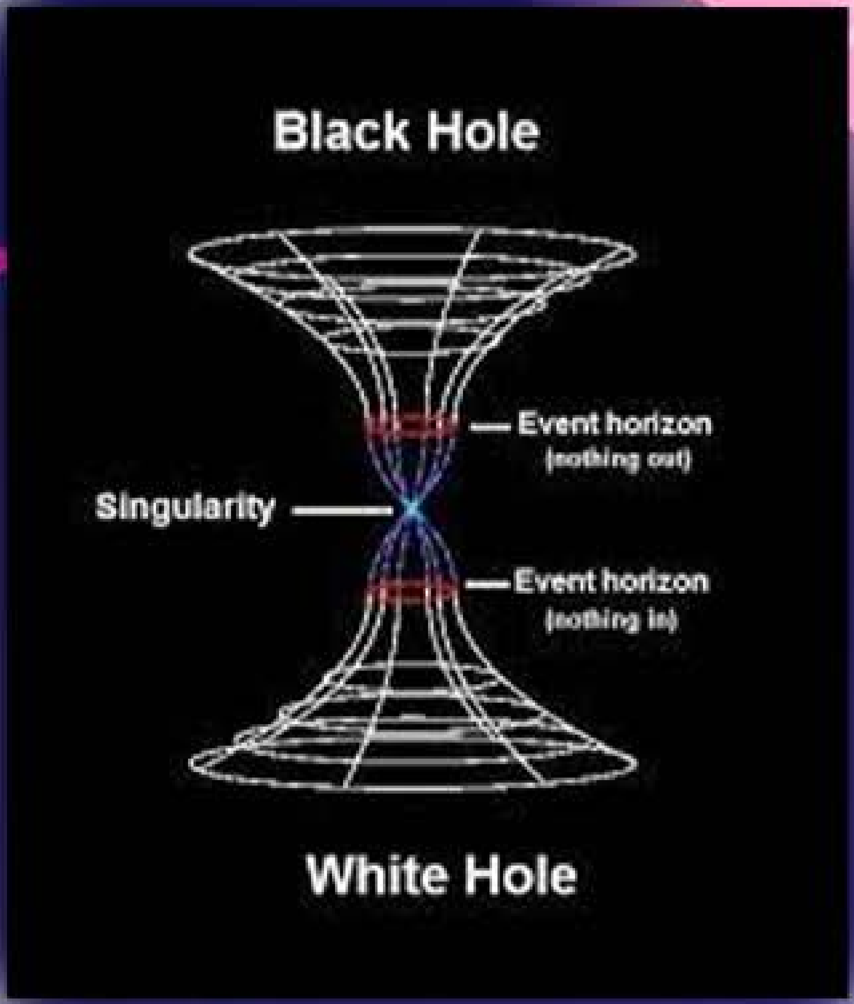
First Indian Woman in Space

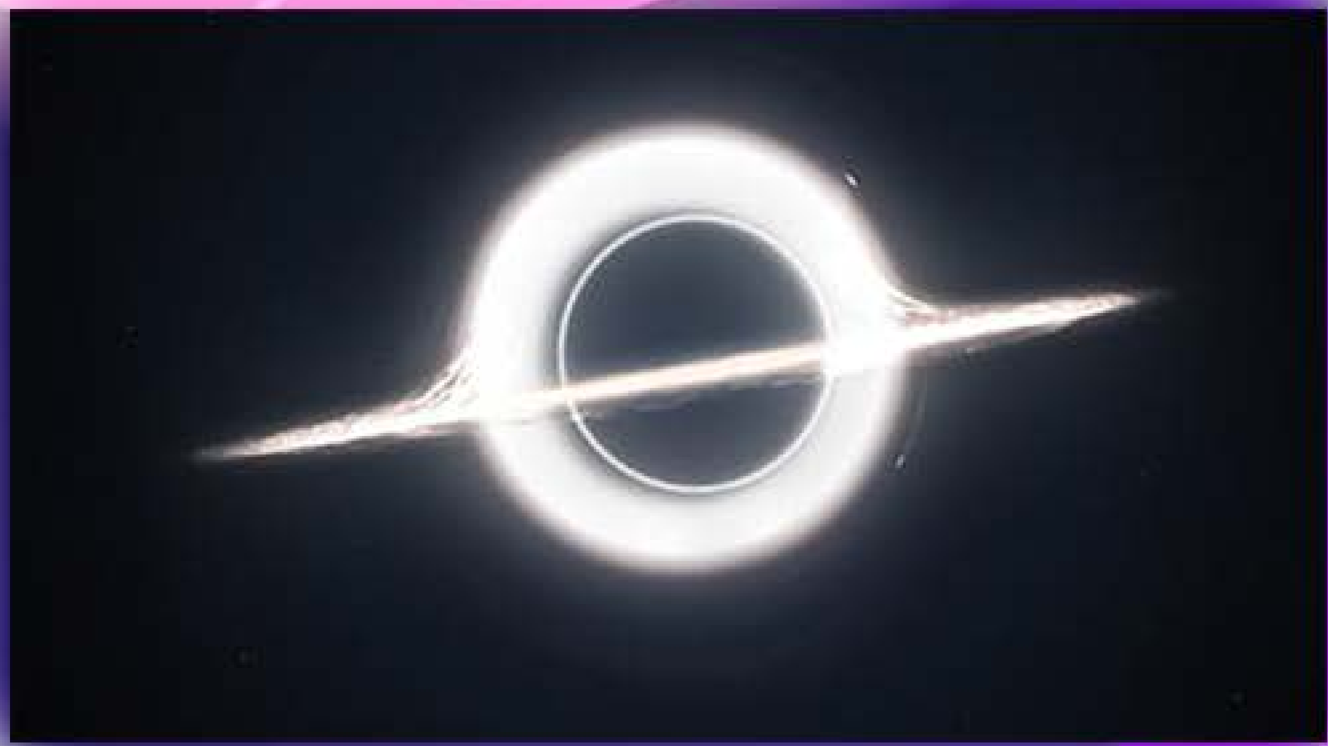
On Feb 1, 2003, when the world awaited for the return of the space shuttle Columbia flight STS-107, it disintegrated over Texas during its re-entry into the atmosphere. The disaster killed a seven-member crew including Kalpana Chawla, the first Indian woman to have been to space.

She was about three or four years old when she first saw a plane. Kalpana's joys knew no bounds when she was taken to the flying club for a ride . She always wanted to fly. With such admiration she studied aeronautical engineering at Punjab engineering college, many tried to dissuade her from further pursuing it telling that there is no scope for this subject in India. But she was adamant and finally ended up at NASA. She started working at the NASA Ames Research Center in 1988. In 1997, she became the first Indian woman and second Indian to fly to space in her flight on the Space Shuttle Columbia. In 2000, Kalpana was selected for her second flight as a part of the crew of STS-107 but it turned out to be her last. Kalpana was posthumously awarded the Congressional Space Medal of Honor, NASA Space Flight Medal and NASA Distinguished Service Medal.In order to honour her, NASA named one of its spacecraft after Kalpana Chawla.

~ By Tanmay, Prarabdh, Aditya VK.

WHITE HOLES





We all know about the black holes, they come in existence either at the end of life of stars or after gravitational collapse triggered by huge astronomical events like The Big Bang. At the end of star's life, when all its fuel gets exhausted it either turns into white dwarf or either becomes a black hole. The fate of any star is decided by its mass through Chandrasekhar limit. White hole has connection with black hole which I have discussed in detail further.

White hole is basically one of the solutions of Einstein field equations, though it is a hypothetical region but we know some of its properties through the solution of Einstein's field equations. It's a region of spacetime and singularity that can't be entered from outside only energy-mass information can escape from it. It works in opposite manner than black hole. Black hole is an inward flow of spacetime whereas white hole is outward flow of spacetime. Karl Schwarzschild, a German physicist, found the solution of field equations for a particular case using the polar spherical coordinates: gravitational field around spherical body with no charge, no angular momentum and universal cosmological constant is taken to be zero.

When the radius of the body is less than Schwarzschild's radius it converts into a black hole, in this particular case this type of black hole is called static/eternal hole, ideally these types of black holes don't exist. Static black holes don't have any angular momentum and charge. Schwarzschild wanted to simulate the condition of stars / planets with small rotational speed.

$$R_{sch} = \frac{2GM}{c^2}$$

Rsch= Schwarzschild's radius

Static black holes in the past are basically white holes of the present because the flow of spacetime in white holes is outward. The light escaping the white holes can't reach us because they are in infinite past.

so the question is can we create white holes? Well, the mathematical description in GTR(general theory of relativity) of white holes is so beautiful and perfect that it seems that they can be created/exist easily, but in need to be created it has to follow all the physics laws , which it fails to follow. Second law of thermodynamics is not followed by the white holes as the entropy change for its survival/existence must be negative, which is not possible in high magnitude ,I am saying high magnitude because "entropy dips" are observed in the universe particularly at the time of The Big Bang . You might be surprised to know that many physicists believe that the Big Bang was also a kind of white hole .

- Sumit Maheshwari

Worlds beyond Space and Time

This article is an excerpt from "Hyperspace", written by Dr. Michio Kaku.

Happy reading!

I remember that my parents would sometimes take me to visit the famous Japanese Tea Garden in San Francisco. One of my happiest childhood memories is of crouching next to the pond, mesmerized by the brilliantly coloured carp swimming slowly beneath the water lilies.
In these quiet moments, I felt free to let my imagination wander; I would ask myself silly questions that only a child might ask, such as how the carp in that pond would view the world around them. I thought, what a strange world theirs must be!

Living their entire lives in the shallow pond, the carp would believe that their "universe" consisted of the murky water and the lilies. Spending most of their time foraging on the bottom of the pond, they would be only dimly aware that an alien world could exist above the surface.
The nature of my world was beyond their comprehension. I was intrigued that I could sit only a few inches from the carp, yet be separated from them by an immense chasm. The carp and I spent our lives in two distinct universes, never entering each other's world, yet were separated by only the thinnest barrier, the water's surface.

I once imagined that there may be carp "scientists" living among the fish. They would, I thought, scoff at any fish who proposed that a parallel world could exist just above the lilies. To a carp "scientist," the only things that were real were what the fish could see or touch. The pond was everything. An unseen world beyond the pond made no scientific sense.

Once I was caught in a rainstorm. I noticed that the pond's surface was bombarded by thousands of tiny raindrops. The pond's surface became turbulent, and the water lilies were being pushed in all directions by water waves. Taking shelter from the wind and the rain, I wondered how all this appeared to the carp. To them, the water lilies would appear to be moving around by themselves, without anything pushing them. Since the water they lived in would appear invisible, much like the air and space around us, they would be baffled that the water lilies could move around by themselves. Their "scientists," I imagined, would concoct a clever invention called a "force" in order to hide their ignorance. Unable to comprehend that there could be waves on the unseen surface, they would conclude that lilies could move without being touched because a mysterious, invisible entity called a force acted between them. They might give this illusion impressive, lofty names (such as action-at-a-distance, or the ability of the lilies to move without anything touching them).

Once I imagined what would happen if I reached down and lifted one of the carp "scientists" out of the pond. Before I threw him back into the water, he might wiggle furiously as I examined him. I wondered how this would appear to the rest of the carp. To them, it would be a truly unsettling event. They would first notice that one of their "scientists" had disappeared from their universe. Simply vanished, without leaving a trace. Wherever they would look, there would be no evidence of the missing carp in their universe. Then, seconds later, when I threw him back into the pond, the "scientist" would abruptly reappear out of nowhere. To the other carp, it would appear that a miracle had happened. After collecting his wits, the "scientist" would tell a truly amazing story. "Without warning," he would say, "I was somehow lifted out of the universe (the pond) and hurled into a mysterious nether world, with blinding lights and strangely shaped objects that I had never seen before. The strangest of all was the creature who held me prisoner, who did not resemble a fish in the slightest. I was shocked to see that it had no fins whatsoever, but nevertheless could move without them. It struck me that the familiar laws of nature no longer applied in this nether world. Then, just as suddenly, I found myself thrown back into our universe." (This story, of course, of a journey beyond the universe would be so fantastic that most of the carp would dismiss it as utter poppycock.)

I often think that we are like the carp swimming contentedly in that pond. We live out our lives in our own "pond," confident that our universe consists of only those things we can see or touch. Like the carp, our universe consists of only the familiar and the visible. We smugly refuse to admit that parallel universes or dimensions can exist next to ours, just beyond our grasp. If our scientists invent concepts like forces, it is only because they cannot visualize the invisible vibrations that fill the empty space around us. Some scientists sneer at the mention of higher dimensions because they cannot be conveniently measured in the laboratory. Ever since that time, I have been fascinated by the possibility of other dimensions. Like most children, I devoured adventure stories in which time travelers entered other dimensions and explored unseen parallel universes, where the usual laws of physics could be conveniently suspended. I grew up wondering if ships that wandered into the Bermuda Triangle mysteriously vanished into a hole in space; I marveled at Isaac Asimov's Foundation Series, in which the discovery of hyperspace travel led to the rise of a Galactic Empire.

~Rishabh Ranjan

DRONES
DESIGN, CONSTRUCTION AND TESTING

Abstract -
Unmanned Aerial Vehicles (UAVs) like drones and quad copters have revolutionised flight. They help humans to take to the air in new, profound ways. The military use of larger size UAVs has grown because of their ability to operate in dangerous locations while keeping their human operators at a safe distance. Here quad copter as a small UAV is discussed. It is the unmanned air vehicles and playing a predominant role in different areas like surveillance, military operations, fire sensing, traffic control and commercial and industrial applications. The main objective of the paper is to learn the design, construction and testing procedure of quad copter. In the proposed system, design is based on the approximate payload carry by quad copter and weight of individual components which gives corresponding electronic components selection. The selection of materials for the structure is based on weight, forces acting on them, mechanical properties and cost.

Keywords: UAV, Quad copter, BLDC, ESC, Propellers, Motion, Thrust, Lift, Microcontroller, Test

Read More...

- Spandan Das

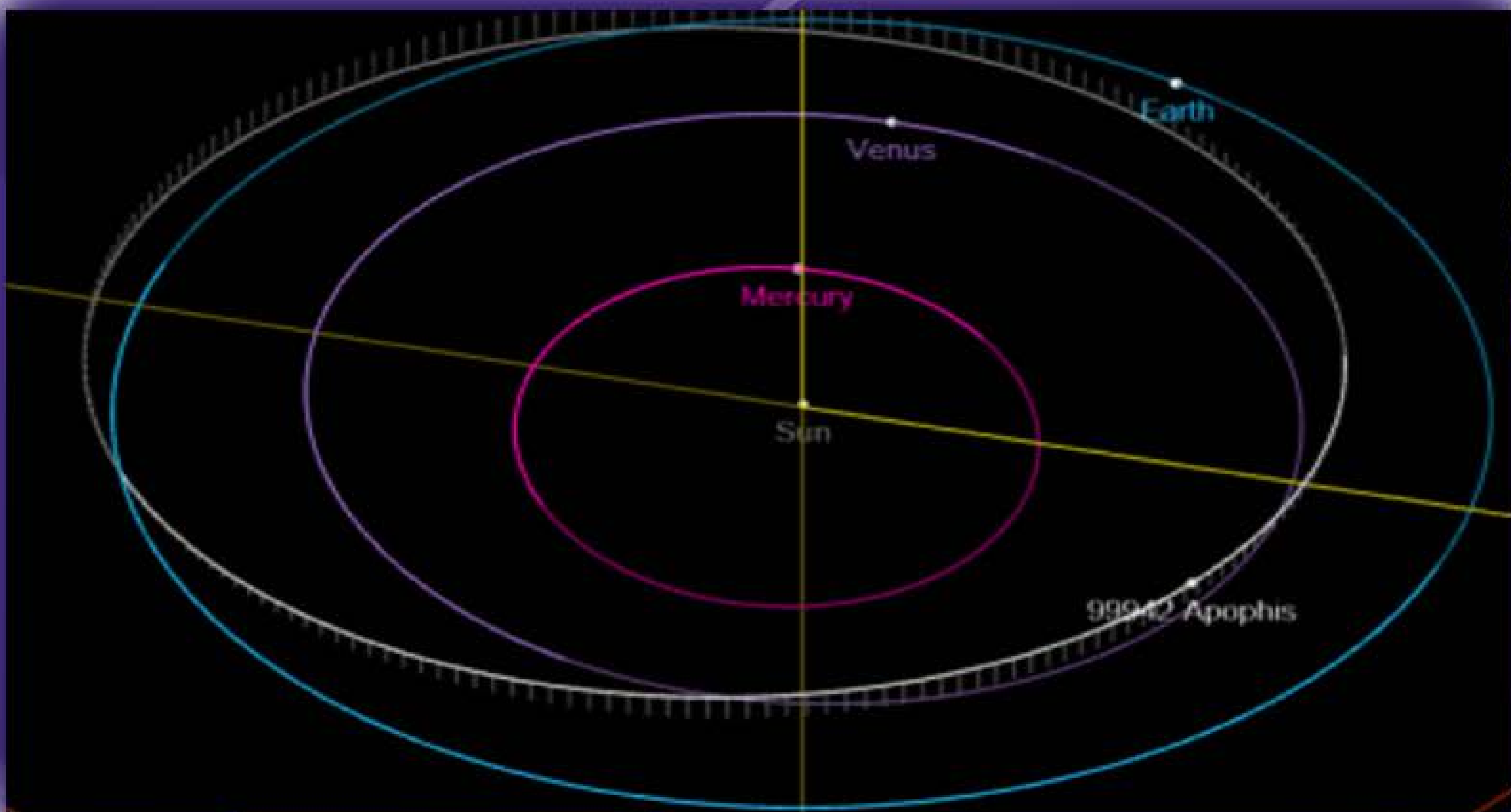
The Probability of Apophis Collision

Until the 2010s, there was a remote possibility that the Earth would be struck by Apophis, a NEO (Near-Earth Object) asteroid discovered in 2004 by planetologist David Tholen of the University of Hawaii's IfA. Note that Apophis is also referenced in the catalogs under the NEO code 99942 and 2004 NM4. Apophis will already stress us somewhat in 2029, when it will pass within 31,000 km of the Earth's surface, that is to say lower than the orbit of most communications satellites. But it will come back in 2036 then in 2068.

Before considering a disaster scenario, let's see what are the probabilities of collision during the closest passages of Apophis to the Earth.

Predictions for 2029 and 2036

The company Astrium of the European consortium EADS had proposed in 2013 to launch a space probe which was to meet Apophis when it was less than 66 million kilometers from Earth. But this project was abandoned. The same year the CNES proposed a mission to Apophis for its next visit expected on April 13, 2029. Other groups took up this idea because the Planetary Society offered a prize of $ 50,000 to the author of the project which would be selected. for a space mission. The first prize was won by an American team.



"It is imperative to gather data on Apophis as soon as we can, because once we know he is on a collision course with Earth, the surest way to avoid disaster will be to push bend the asteroid so that it changes orbit, "said Mike Healy, director of the Astronautics department at Astrium.

“If we wait too long, it will be impossible to build a spacecraft powerful enough to change its trajectory. At best, we should push it back before 2025 to make sure we miss it,” he said.

However, there is still an unknown for 2029, when Apophis will get close enough to Earth to be deviated from its path. If this deviation causes it to pass through a particular point in space called “the keyhole”, it risks hitting the Earth during its next passage in 2036. But nothing is confirmed.

In 2007, astronomers had calculated that Apophis had a 1 in 5500 chance of going through “the keyhole”, which corresponds to an area of space that extends over 600 meters. The possible resulting impact is predicted on April 13, 2036 and would have a 1 in 12,000 chance of occurring.

From the data collected in December 2004, the probability calculations indicated that Apophis had a 2.7% (bad) chance of hitting the Earth in 2029. This probability fell to 2.4% in 2013 (cf. D. Farnocchia et al. , 2013). New measures have further reduced this risk

Predictions for 2068:

In early 2020, Tholen and his colleagues spotted Apophis at 21st magnitude using the 820m Subaru telescope in Hawaii. It was located 0.5 AU from Earth or 75 million km. Its position was slightly different from the forecast. Astronomers determined that it picked up speed following the Yarkovsky effect or YORP effect. As a reminder, when a body such as an asteroid is exposed to the radiation of a star, in this case the Sun, it absorbs its radiation and re-emits it in the form of heat which acts as a tiny propellant. This emission produces a slow drift of its trajectory which modifies the major axis of its orbit. The Yarkovsky effect can affect asteroids hundreds of astronomical units from the Sun, much further than Pluto. For a body 500 m in length, the effect manifests itself up to about 50 AU. Before astronomers found out that Apophis was experiencing this effect, this asteroid had no chance of colliding with Earth in 2068. But taking into account the Yarkovsky effect, the researchers changed their minds although the result is little different.

New simulations carried out in February 2021 indicated that Apophis had a one in 380,000 chance of hitting Earth in 2068. In theory, if the risk of collision is not zero, in practice it is just like a slight nudge due to sunlight. The researchers nevertheless that the other observations aiming to refine the amplitude of the Yarkovsky effect and how it affects Apophis' orbit were in progress.

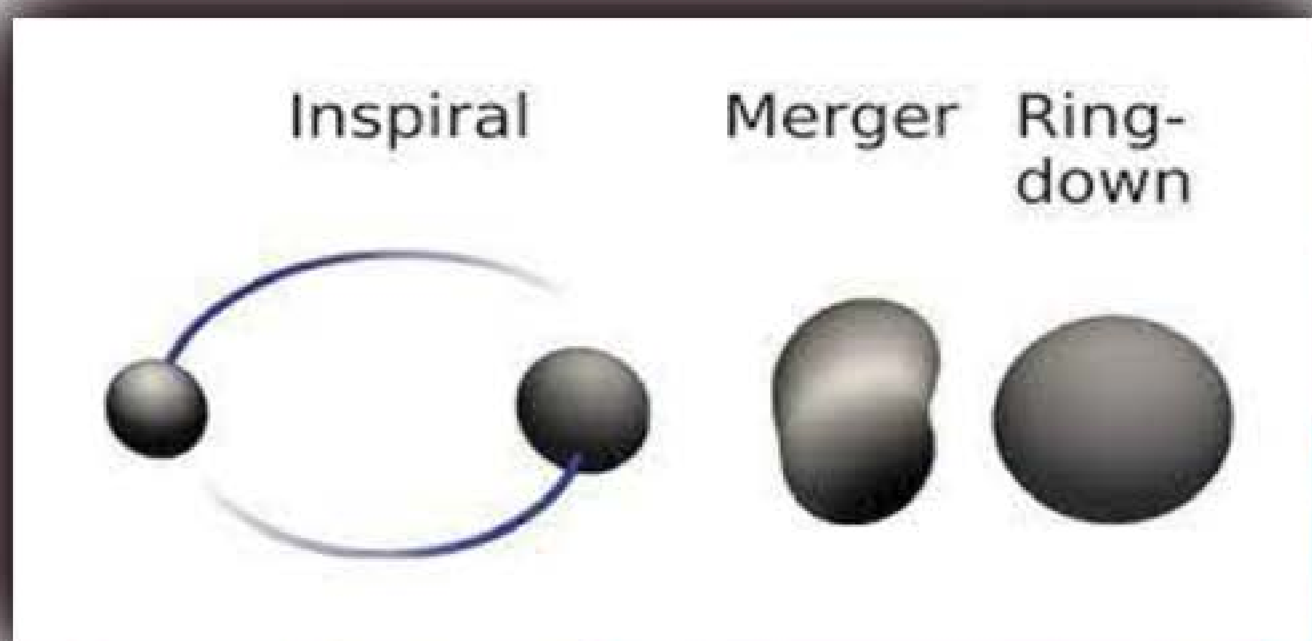
- Moka Krishna

Was Stephen Hawking Right or Wrong?!

For the first time in 50 years physicists have confirmed Hawking's black hole area theorem with 95% probability.

The black hole area theorem: - According to Stephen Hawking, the total area of the event horizon of a black hole can never decrease with time. It was well proven with the help of Einstein's General theory of relativity in 1971 but was not observed with the help of any experimental data until now.

To prove this theorem, physicist Maximiliano Isi at MIT, analysed the signal GW150914 which was detected by LIGO (gravitational waves observatory) detectors in 2015. This gravitational wave signal was produced due to merging of binary black hole (BBH) 1.3 billion years ago.



The GW signal is analyzed by dividing into two parts i.e., before and after merging of BBH which are Inspiral phase (gradually shrinking orbit) and Ringdown phase (merging of BBH and emission of gravitational waves). Analysing the data, Researchers proved that the final area of the event horizon of a merged black hole is greater than that of BBH.

Physicists have always tried to solve the paradox of Black hole area. As Its area increases with mass, also the black hole surface area shrinks as more it spins. So, is it possible to throw an object inside black hole hard enough to make black hole spin fast enough to decrease its surface area? Now, physicist Maximiliano Isi has stated that whatever you do, the increase in surface area due to mass will always be greater than the decrease due to its spin, it will spin more but will not be able to counter the mass added. The mass and spin will always end up resulting in a higher area.

Black hole radiation: - This theory was established by Stephen Hawking in 1973. According to which black hole emits radiation of quantum particles and even some bigger particles, this theory is well consistent with Quantum Physics and law of conservation of information. Thus, the size of black hole should shrink and ultimately evaporate over time.

So, two theories contradict with each other and in the process of solving them we would discover some new physics. To solve this contradiction with 100% certainty, we Would need to analyse more data of merging black holes.

Whatever be the final theory Stephen Hawking will be right and wrong both at the same time, But Physics will always be right than the previous one!

- Mohit Kumar

Black Holes
The craziest stuff in the universe

When we talk of black holes in general, what is the first image that comes to your mind? Do you often think of it as a vortex in space? Or a spherical region, surrounded by a highly warped matter disc? (Spoiler alert: the latter is correct)
So, what exactly is a black hole? As quoted by Pierre-Simon Laplace in 1798, "A luminous star, of the same density as Earth, and whose diameter should not be two hundred and fifty times larger than that of the Sun, would not, in consequence of its attraction, allow any of its rays to arrive at us; it is, therefore, possible that the largest luminous bodies in the universe may, through this cause, be invisible." I shall give you some time to re-read the sentence and let that sink in.
Well, in reality, black holes are just collapsing dead stars, so massive and dense, that even light can't escape them. It all starts with the explosive death of a star as a supernova. After the explosion, the core remnant of the star starts collapsing under its weight. If the mass of the core is not enough to form a black hole, then neutron stars are formed (this celestial object is damn interesting, but let's focus on crazier stuff ;)). If the mass of the core is sufficient enough (greater than 2 to 3 solar masses), then the collapsing star core will turn into a black hole.

Okay, so a black hole is just a dead star collapsing under its weight, and not even light can escape it, that's all, right? So why is there so much fuss about black holes in astrophysics? You see, when you approach the event horizon, things start to get weird and crazy. Apart from the imminent death due to the lethal tidal forces, the extreme gravity bends the laws of physics to its extreme, which we'll discuss later in this article. Even crazier are the supermassive black holes. These are the matter-sucking behemoths usually present at the centres of galaxies. Their masses usually range from 105 solar masses to a whopping 109 solar masses. The thing that makes these behemoths crazier is their formation, which is still a mystery and is a topic of active research involving many sub-disciplines of cosmology and astrophysics. But why is the formation of supermassive black holes still a mystery? A stellar black hole consuming a lot of matter and merging frequently with other stellar-mass black holes can form a supermassive black hole within a few billion years, right? Yeah, that's true, but it is very unlikely for a black hole to continuously consume matter for around ten billion years and grow up into a supermassive black hole, given the very poor matter consumption nature of black holes. In short, black holes are very messy eaters. An example of this messy characteristic of a black hole is the accretion disk. When a star is sucked by a black hole, the massive gravitational and magnetic forces of the black hole superheat the gas and dust falling into it. This causes those particles to emit radiation, and they just orbit the black hole in accretion disks till the time they lose energy and fall into their inevitable destiny (dread it, run from it, destiny still arrives ;)).

Sometimes, due to the high gravitational forces of a black hole, a fraction of particles get accelerated to speeds close to the speed of light. These high energy relativistic jets are spewn out in two narrow beams along the axis of rotation of the black hole. These jets are very powerful and destructive, destroying everything that comes into their path. These jets are somewhat responsible for the decrease in star formation rates in galaxies like M87 (the galaxy whose black hole was first “photographed” in 2017, and again in 2021). Although these jets destroy everything that comes into their path, some scientists believe that they are responsible for pushing the matter to the outer edges of a galaxy, thereby increasing the star formation rate in those regions. This was all theoretical and might be boring for some people. So, let’s make things interesting and go on an adventurous ride to the centre of a black hole and see what exactly happens beyond the boundaries of the event horizon. Well, we cannot venture into any random black hole; the tidal forces would tear us apart in a stellar black hole before we even reach the photon sphere. We would have to choose a black hole that doesn’t tear us apart into a stream of particles before reaching the event horizon. Because we have to explore beyond the event horizon, the tidal forces acting on our body at the event horizon should be less than the maximum tension force our body can withstand before breaking into pieces (sounds painful, doesn’t it?), and that’s where non-rotating supermassive black holes come into the picture.

Why did we choose a supermassive black hole for our exploration? The answer to this question lies in the size of a black hole. For this, let us calculate the force on a point object of mass m at the surface of a non-rotating black hole with no charge (Schwarzschild black hole). First of all, we should calculate the Schwarzschild radius of the black hole:

$$R_{sch} = \frac{2GM}{c^2}$$

Where G=Gravitation constant,
M=Mass of the black hole, c=speed of light
Using Newton's law of gravitation, we get

$$F_{EH} = \frac{GMm}{R_{sch}^2} = \frac{mc^4}{4GM}$$

Where FEH=force at the event horizon , Assuming m to be constant,

We can see that the force at the event horizon depends solely on the mass of a black hole. We can notice that as we increase the mass of a black hole, the force on a point object at the event horizon decreases. So, this implies that the tidal forces acting on our body will not tear us apart if we cross the event horizon of a supermassive black hole. That makes it fit for our exploration. Hence, we should start our journey to the centre of the black hole.

As we approach the event horizon, things start getting weirder. We'll discuss only a few things here to not make this article longer than it already is now :'). One of the weird things that you'll explore is the photon sphere. You can get a rough idea by the name itself that it would be kind of a "light sphere". Yup, you're right. Due to the extreme gravity of black holes, light literally "orbits" it and this zone is called the photon sphere. You can see your back in front of you in a photon sphere. Crazy, isn't it? But these orbits are not stable, i.e., photons orbit the black hole a few times, and then lose their energy and start their journey towards the event horizon. So you don't see something unique in the photon sphere.

Let's continue our journey to the event horizon. As you approach the event horizon, the major part of our field of view starts to turn pitch black (of course, a black hole doesn't emit light, so all you can see is the darkness!). This black zone will grow until it completely covers your field of view. Now it's time to bid adieu to the universe you know, as you are never gonna return from this point. Welcome to the Event Horizon!

Oh, and I forgot to tell you, if any of your friends or your family would be watching you (well, if they're alive), then they'll see you moving slower and slower as you approach the event horizon, and according to them, you never crossed the event horizon. You just redshifted, and faded away in their perspective. Well, this is it. This is the end of everything, all your memories, your family, your friends, nothing matters here. You can never go back, and no one can ever reach out to you now.

Beyond the event horizon, we don't know what will happen. Even with the best of technology, we would never be able to know what's inside a black hole. All we can do is hypothesize some theories based on whatever data we have. As you all know, black holes have a singularity, a point where the curvature of spacetime is supposed to be infinity. You'll be headed towards your imminent death with a speed greater than the speed of light (well, you will be torn into a stream of fundamental particles before you cross the speed of light). And that's it. This ends our one-way trip to a black hole. Now it's for you to think about what all can happen in a black hole. Explore the various possibilities and do share your crazy ideas! One of the crazy ideas I have is that the singularity of a black hole is a very narrow pathway to a new universe, or what we call a wormhole.

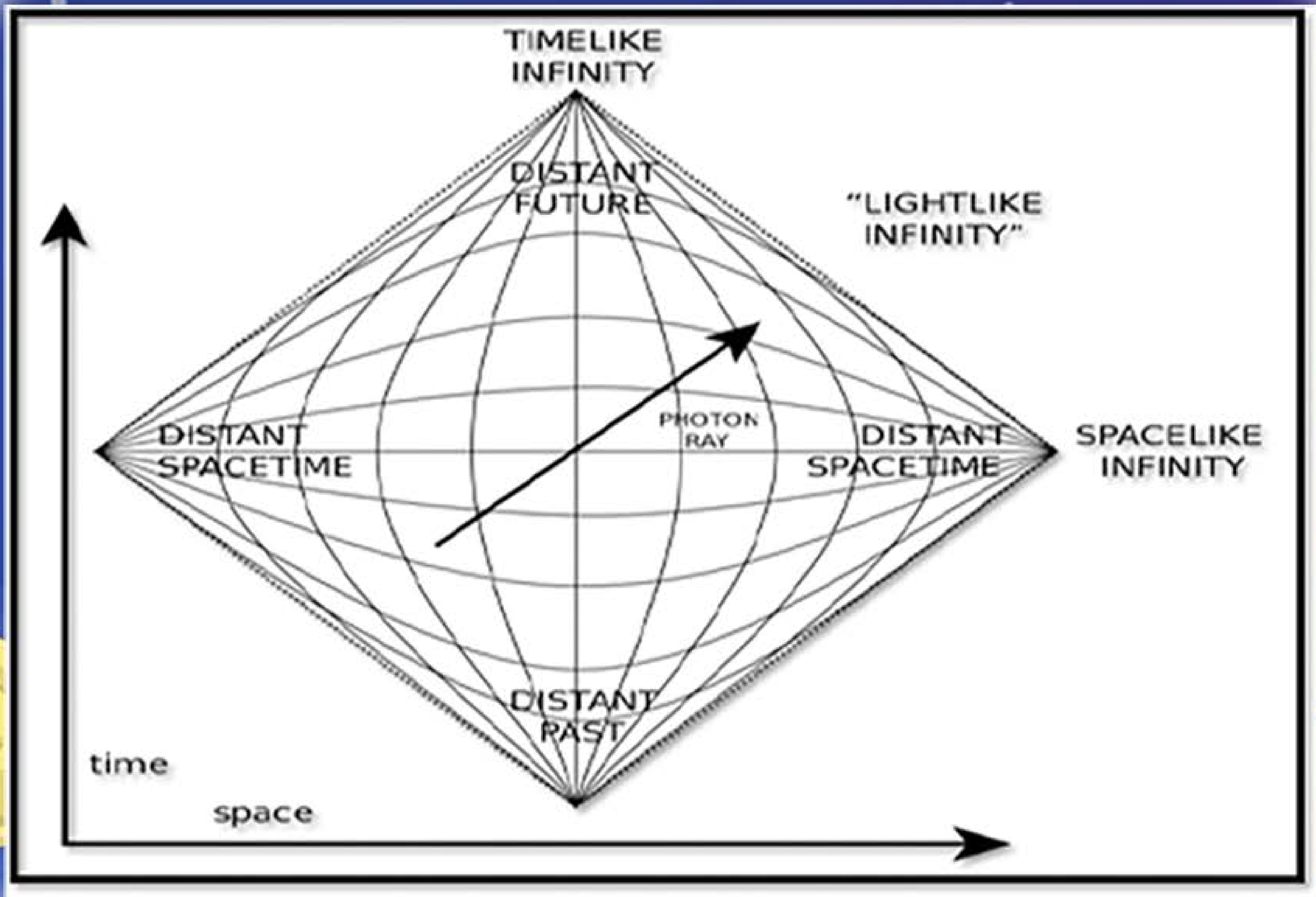
PS: This article is based on what I got to know about black holes from various sources, and hence, there is a high chance that I may be wrong somewhere (I'm not a God, heck, I'm not even a scientist). If you find anything wrong, kindly bring it to my notice, so that I may correct my flawed knowledge on the topic. Thanks for reading!

- Rishabh Ranjan

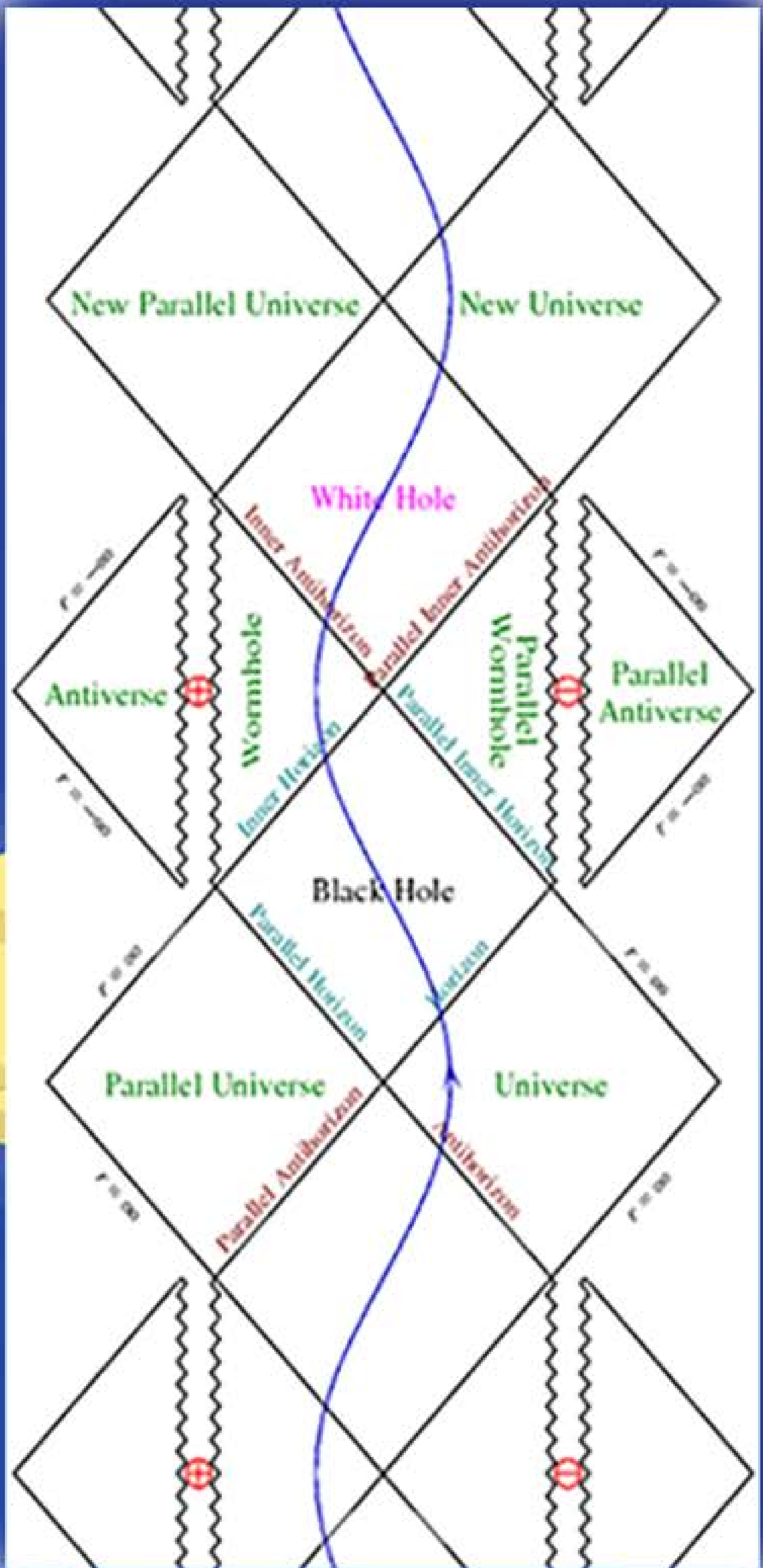
Penrose Diagram and Multiverse

We often fantasize about the multiverse. Today I will be discussing about it using Penrose diagram. For that we should firstly ponder the question:

" What really is Penrose diagram?"



Penrose diagram is a 2-D representation which defines the relation between any 2 points in space time using conformal/angle preserving treatment of infinity. The lines as you can see in above picture are not straight these are hyperbolic to represent conformal infinity on paper. In Penrose diagram the horizontal axis represents space while the vertical axis represents time. Light in Penrose diagram travels at an angle of 45 degree while all the other objects travel steeper than that because it cannot travel at the speed greater than light. Penrose diagrams are basically the map for the multiverse, isn't it fascinating. Let's see how it maps the multiverse.

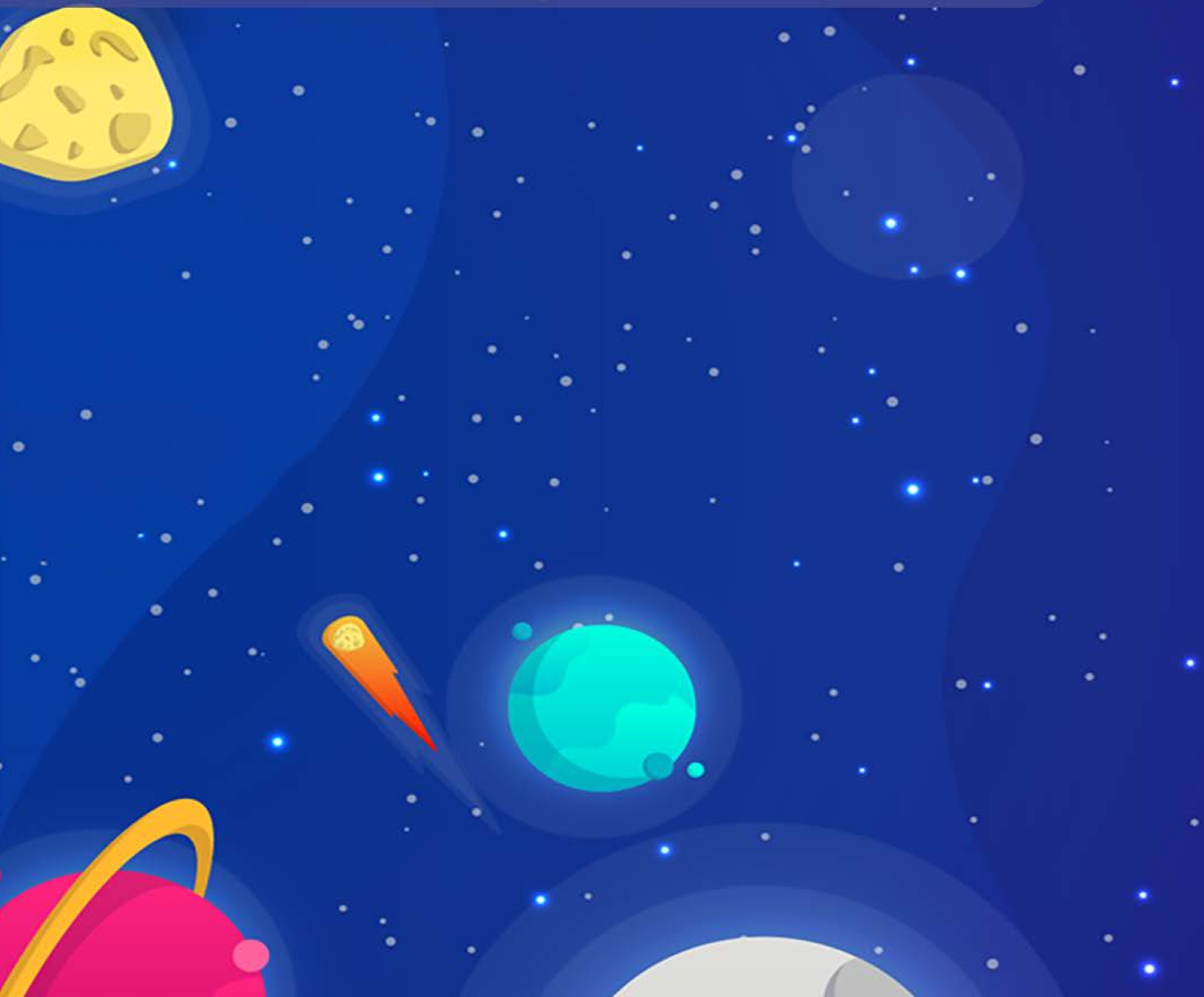


The figure on the left is basically a combination of multiple Penrose diagrams which maps the multiverse. The Kerr black hole (a rotating black hole with no charge) in this figure is somewhat considered as the gateway for another universe. When you reach the horizon of a black hole the future becomes downward as you will be dragged faster than the speed of light due to falling space and hence coordinate system gets reversed.in a regular black hole no one could survive because of the central singularity which might tear the person apart, but in the case of Kerr black hole the outward pressure because of the rotation of black hole will protect you from the inward flow, then it will lead you to the second horizon known as inner horizon as you can see in the figure also.

In the inner horizon u will see another singularity which will not behave as the previous one it will be anti gravitational and you might not be able to survive it but let's assume you survive it and able to plunge in it you will reach in the space-time having different nature . you can travel back from that inner horizon singularity shown as red mark on the middle left, but this time you will be travelling the same space but at different time as all the events were in the past so this time you will reach a white hole which is basically in past of the eternal black hole. This white hole will eject you out of it because of its nature which is opposite to black hole .It will eject you in a completely new universe as shown in figure as "New Universe"

The Penrose diagram has a lot of future applications and it uses very advanced mathematics to calculate the data. It uses General Relativity to give us the idea about the existence of the other universes and we can access them in one way or the other .This fascinating idea of multiverse is one of the most complicated open theory .

- Sumit Maheshwari



The Big Freeze

Like all things, the Universe will also come to an end one day. There are various theories that have been proposed for the end of the universe. The Big Freeze is the most widely accepted theory.

Entropy -
A revisit to this concept of thermodyanmics (which is discussed everywhere ranging from high school to grad school physics classes) is necessary for the very reason that it lies at the heart of the Big Freeze theory. In layman terms, entropy is a measure of randomness.

The second law of thermodyanmics states:

"It is impossible for a self-acting machine, unaided by any external agency, to convey heat from one body to another at a higher temperature." The above, however, is Kelvin's version of the law (in case you're wondering, yes! The 2nd Law has many versions- Kelvin, Clausius, Carnot, Planck and Caratheodory).

For understanding the Big Freeze, the Planck statement is of interest to us:

"Every process occurring in nature proceeds in the sense in which the sum of the entropies of all bodies taking part in the process is increased. In the limit, i.e. for reversible processes, the sum of the entropies remains unchanged."

The interesting thing to note here is that the obvious interpretation(which is that Entropy always increases) is the only law in Physics that comments on time! Entropy will always increase with time and never decrease. This helps us use entropy as a measure of time.

Composition of the Universe -

Matter as we know it, makes up only 5 percent of the observable universe. This is what is called Baryonic Matter in an advanced Physics class. Experiments have supported this. What remains to answer is: What is the other 95 percent made of? Well, this is one of the hottest areas of physics and new developments are taking place everyday. For the sake of this article, we can assume that this 95 percent is composed of two things that even scientists don't fully understand:

1. Dark Matter(27%)
2. Dark Energy(68%)

These terms indeed sound as gibberish to most people as they do to you. We cannot fully comment on what these really are, but we can surely say one thing:

Dark Energy is responsible for the accelerated expansion of the universe. And this is not something random, but a fact that has come out of the research that is being conducted in this area. A more abstract representation of Dark Energy can be found in Einstein's field equations:

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

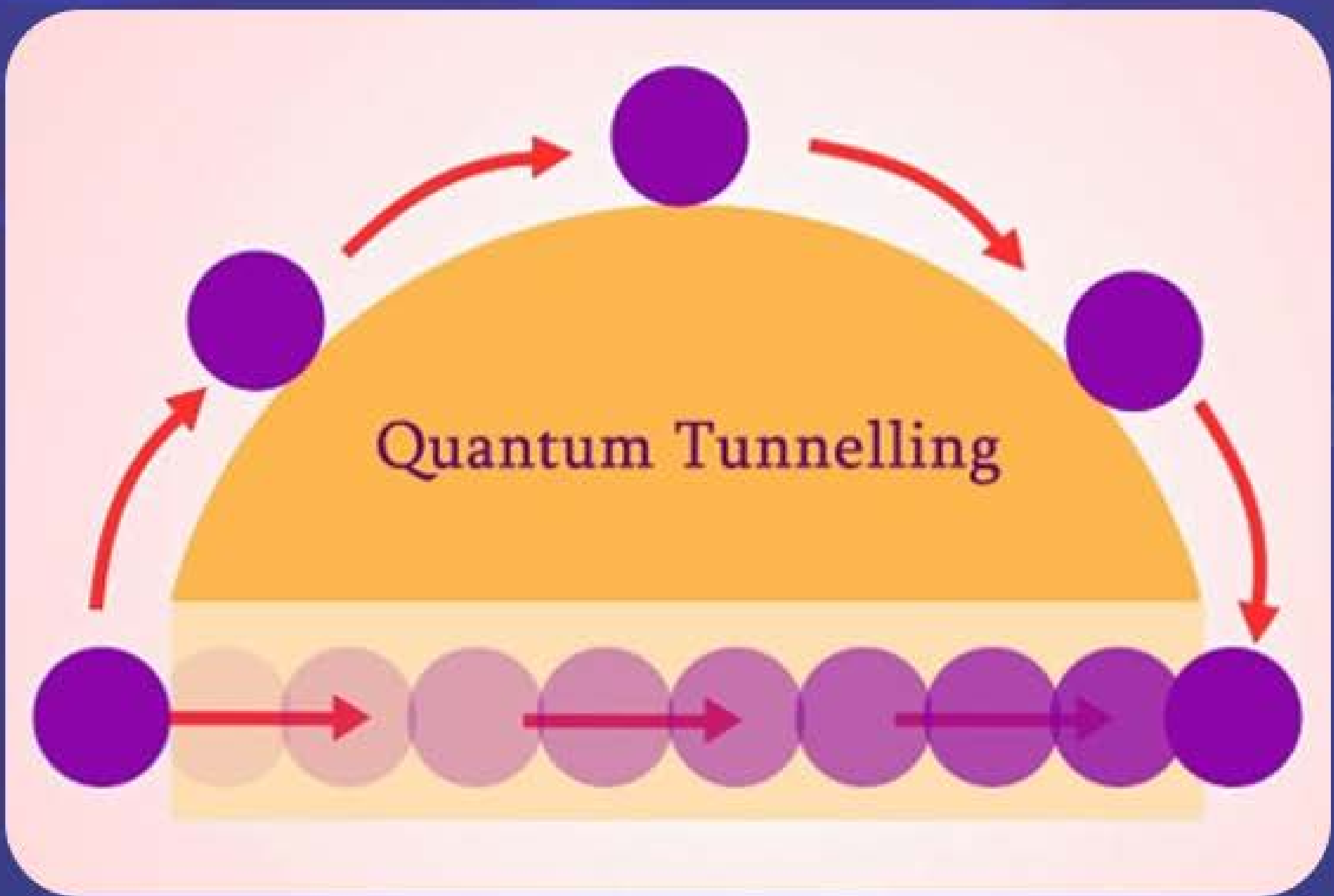
Here the constant Λ is called the cosmological constant and it is associated with dark energy. Experiments thus far have hinted towards a positive value of the cosmological constant. The value of the cosmological constant being positive means that the universe will continue to expand forever.

The Big Freeze -

Since all experimental data suggests a positive value of the cosmological constant, many in science community accept the Big Freeze as the ultimate fate of the universe. In the Universe, there is always a tug-of-war between gravity and the forces of expansion. The accelerated expansion of the universe tends to separate things while gravity tries to keep them together. But now that we know that the universe will continue to expand forever, there will come a time when the distance between celestial objects increases a lot. First, the galaxies will become isolated. When the distance between two galaxies increases beyond a certain limit, we will not be able to observe space outside of our own local group. In the meantime, the stars will run out of nuclear fuel and the last star in he universe will die. Now the universe will have mostly black holes left. Black Holes will then succumb to Hawking Radiation .What will be left behind in the dark and lifeless universe will be baryons(protons, neutrons,etc). Although there is no concrete evidence, some scientists predict that over the course of many many(and really many!) years, these will also decay into radiation. The universe will now remain empty with radiation struggling to interact with other radiation. This is when most activity in the universe will cease. Energy and mass will be equally distributed and entropy will be at its maximum possible value. I'd like to call this moment the 'Death of Time'.

Quantum Tunneling -

This story of the universe may seem depressing to you and indeed it is. This cheerful and vibrant universe dying a death so tragic is a lot to take in for anyone who is passionate about astrophysics and astronomy. However, all hope is not lost. We know that the Quantum world is full of phenomena that is counter intuitive and one such phenomenon might actually save the day when the universe will die. Look at the figure below. According to classical physics(and intuitivelyas well), we know that the purple ball cannot go to the other side of the yellow hill without help from an external agent.But in the quantum realm, this is no sorcery. The purple ball has a really small but non-zero probability of being on the other side of the hill. This phenomenon is called Quantum Tunneling.



Remember how we related time to entropy? The reason time died at the end of the universe is because entropy was at its maximum. To resurrect time, we need to make sure entropy increases. There is only one way to do that-To decrease it from its maximum value. Quantum tunneling could provide us the much needed decrease in entropy due to its probabilistic nature. This sudden decrease will trigger a new big bang. The rest of it...is well...history

-Prarabdh Shukla

5 Mind-Blowing Planets

1.HD 133199Ab:

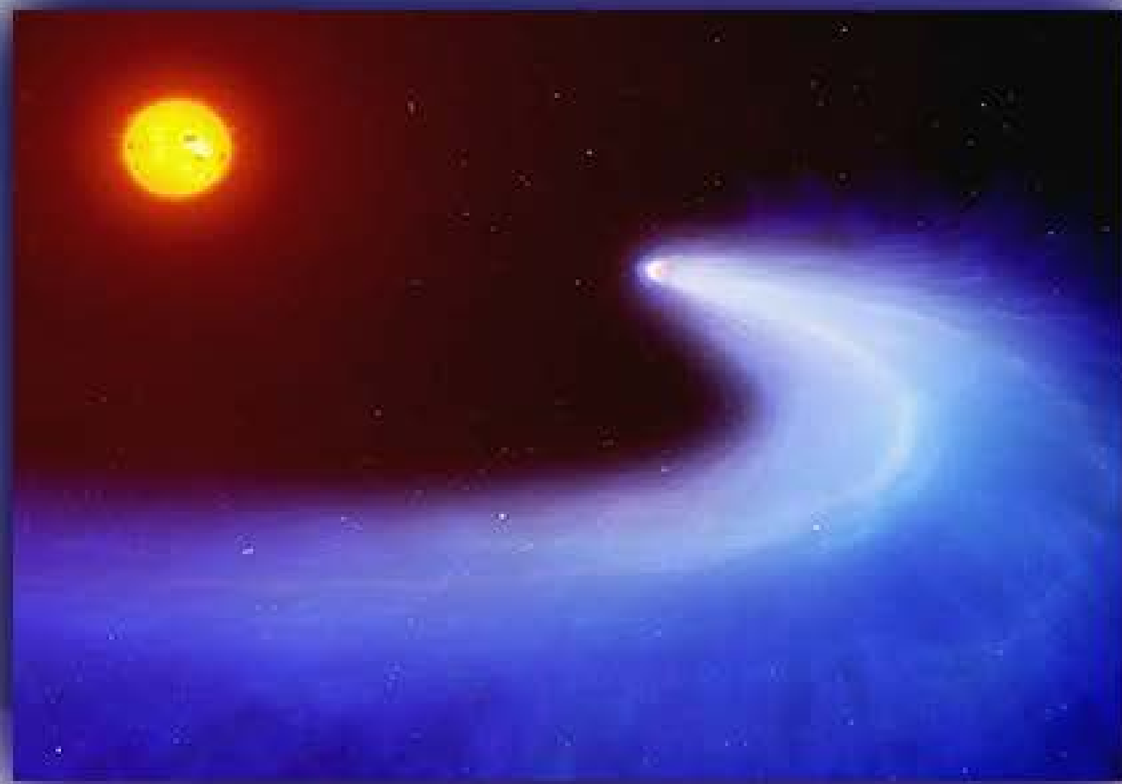
On this planet an observer can take an experience of either 3 sunrise and sunsets per day or constant daylight depending on the seasons which are longer than human lifetime.

This planet is 149 Light-years away from Earth, which revolve around the main star of a three star system in an unstable orbit. The Brightest star is massive than our Sun and 2 less massive stars revolve around this star and around themselves too.

2.Gliese 436b:

Some laws of physics fail here. This planet contain hot ice in solid form at temperature of 440°C.

Gliese 436b is located 30 light years away from earth, orbiting a red dwarf star at an orbit 15 times closer than that of mercury with sun.



3. J1407b:

J1407b is first exoplanet found with rings. It has rings 640 times larger than that of Saturn.

If we replace this planet with Saturn, it will make larger diameter than the full moon. Mass of this planet is 10 to 40 times larger than Jupiter, at a distance of 434 light years.

4.55 Cancri-e

55 Cancri-e is covered with diamond and graphite on its surface just like oceans on earth.

Large amount of Graphite and carbon are present here, along with high temperature converting them into Diamond.

5. The Earth:

We have seen many planets on which life can exist theoretically, But, at present only Our Great Earth support Life.

Do visit my blog for more such articles:
exitingspace.blogspot.com
-Tanmay Patil

QnA with Dr. Mahavir Sharma

Q1. Which celestial body do you find the most interesting in space and why?

I find the black holes to be the most intriguing. Singularities are a challenge to any physical theory. The physics that we know and its laws are at their limit when it comes to singularities. The black holes are the best example of singularities, and they are numerous too as we are now discovering via multiple methods, such as from X-ray observations and gravitational waves. Not only that but there is a mystery that still surrounds them because even after decades of research, the information that we have about them is either purely theoretical or through indirect measurements. They truly keep on testing the limits of our imagination, and I believe a lot remains to be discovered about them. They might even be holding the keys to understanding the beginning of our Universe.

Q2. Today, we have various theories on the ultimate fate of our universe. Which theory do you think is most likely to happen?

I think the different versions about the fate of the Universe are basically whatever are the possible outcomes from models, however we should then assess which outcomes are more probable. The current forefront of research in this regard has narrowed down the possible outcome of the fate of the Universe to that the Universe will keep on expanding forever. However, recently there has been some evidence that the expansion is accelerating.

Q3. Which topic do you find the most interesting for research in Astrophysics?

I find the formation of stars and galaxies particularly the most interesting. Galaxies are the building blocks of the Universe. Understanding how the galaxies form at the beginning and how they evolve subsequently remain the fundamental question in 21st century astrophysics. Moreover, the galaxies when they formed, produced a lot of UV photons that ionized the entire Universe. Similarly, inside the galaxies how first stars were formed, that also is a challenging problem. The star form from the cooled hydrogen gas, and cooling requires the presence of heavier elements. However, in the early Universe there were no heavier elements, but it was made up mostly of hydrogen and helium. Hence the formation of the first generation of stars in the early Universe remains an open problem.

Q4. The origin of ultra-massive black holes like Ton-618 is still a mystery, and there are many theories on it. What could be the most accurate theory according to you?

Black holes once created are like the sinks in the Universe and they keep on digesting anything that comes in their vicinity. As a consequence their weight grows. So, it looks like the existence of that highly massive black hole Ton-618 is most likely because it has consumed a lot of matter from its surrounding galaxy.

Q5. Rapid fire: which one is more destructive, neutron star merger or a supernova?

I think supernovae are more destructive because we talk in terms of energies, the supernovae generate 10^45 joules/s which is huge. You should think how much a neutron star merger generates in comparison?

Q6. Many Astrophysicists believe that the big bang was actually a sort of white hole, what do you think about that?

A hallmark of a good theory is that it is testable and can be verified to be true through experiments or measurements. Unfortunately at present we have very limited techniques; in fact we have no techniques at all to verify the theories about the big bang. So, to the belief that big-bang is a white-hole, if the mathematical model behind it is sound, even then I would say fine, it is a plausible hypothesis, but not more than a hypothesis.

Q7. What is your opinion on the search for the grand unified theory? Having researched on astrophysics, do you lean towards Einstein's relativity or do you feel, Quantum Mechanics is more likely to win the contest?

Einstein's relativity is arguably the most perfect theory ever created and most elegant as well. On the other hand, quantum mechanics is certainly interesting, it has got a charisma to it and it has many applications as well, however, if you go into deep mathematical foundations, it is not as perfect a theory as general relativity is.

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