
Astronomy &
Particle Physics Club
IIT Patna
APC
the BIG BANG BUZZ
Connecting Cosmos and You
2ND ISSUE
MARCH 2023

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MESSAGE FROM THE CLUB

Greetings!

We are members of the astronomy and particle physics club, and we are excited to share our passion for both astronomy and particle physics with you. Our club is dedicated to promoting an interest in both fields and educating people about the wonders of the universe at all levels of scale. We organize stargazing events and talks on astronomy, where members and the public can come together to observe the night sky and learn about the latest discoveries in astrophysics. In addition, we also plan to participate in research projects in particle physics, both independently and in collaboration with other institutions. We aim to contribute to our understanding of the fundamental particles and their interactions and push the boundaries of modern physics.

Our club is open to anyone who has an interest in astronomy and particle physics, regardless of their level of knowledge. Whether you're a beginner or an experienced researcher, we welcome you to join us and explore the wonders of the universe together.

Through our collective efforts, we aim to inspire and educate others about the universe and its mysteries and to promote diversity and inclusivity in the fields of astronomy and particle physics. Joining our club is a great way to get involved in these exciting areas of research and connect with like-minded individuals who share a passion for science.

So if you're interested in joining our club or attending one of our events, we encourage you to get in touch with us. We look forward to exploring the wonders of the universe together!

Best regards,
The Astronomy and Particle Physics Club

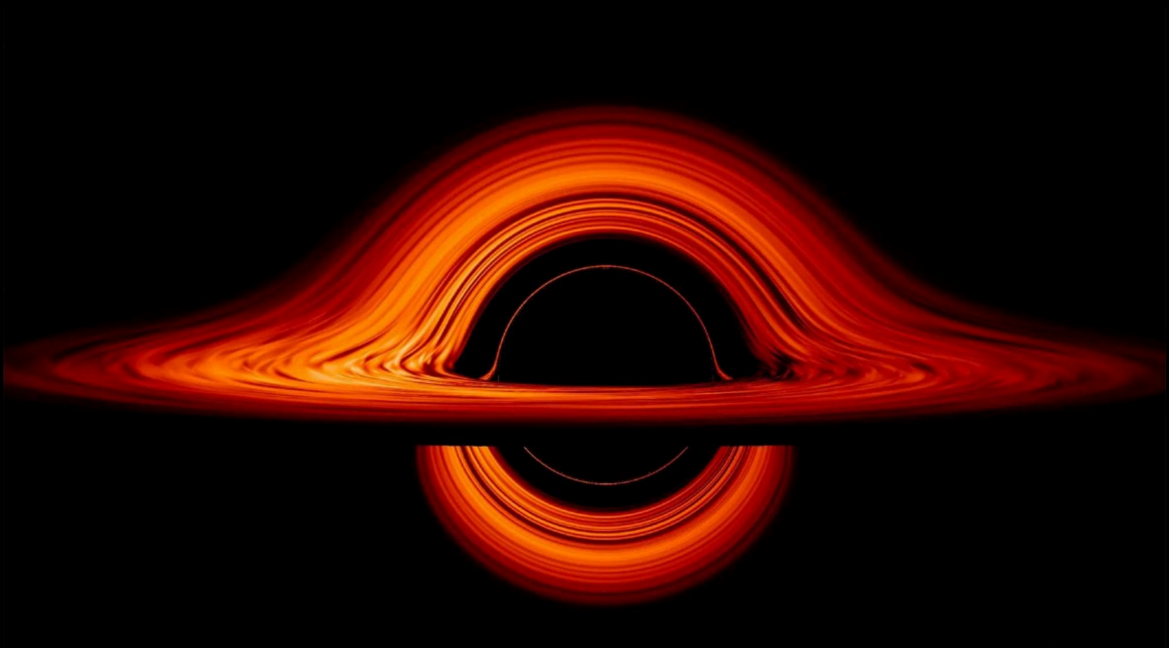


Image Credit : NASA's Goddard Space Flight Center

RINGS OF BLACK HOLE

-Suryansh Srivastava

Ever wonder why the blackhole has rings in place of a single ring !!!

It only happens when we are watching the black hole perpendicular to its ring's axis. Because of the large gravitational field, the light (which is not supposed to be visible) coming from the backside of the black hole gets bent and comes from the sides of the black hole. This new visualization of a black hole illustrates how its gravity distorts our view, warping its surroundings as if seen in a carnival mirror.

Viewed from the side, the disk looks brighter on the left than it does on the right. Glowing gas on the left side of the disk moves toward us so fast that the effects of Einstein's relativity give it a boost in brightness; the opposite happens on the right side, where gas moving away from us becomes slightly dimmer.

VAMPIRE STARS

-Amoy Ashesh

As fictional as they sound, Vampire Stars are a reality in the cosmos. Vampire Star is a kind of symbiotic star in close proximity to a bigger star and sucking mass and energy from its larger star.

Vampire Star acts the same way a supernatural vampire does: it will suck blood from its victim except its hydrogen and not blood. Eventually, the Vampire star will suck so much out of the victim that the victim will be destroyed or turned into a white dwarf star. It could also explode in a supernova destroying both stars in the process.

Vampire Stars often start as smaller stars, but as they draw hydrogen from the victim star, they become hotter and hence bluer. Blue Straggler is a star in a star cluster that looks hotter and younger than other stars because it's been siphoning hydrogen from its neighbours.

Image Credit: NASA and L. Hustak (STScI)

ZOMBIE STARS

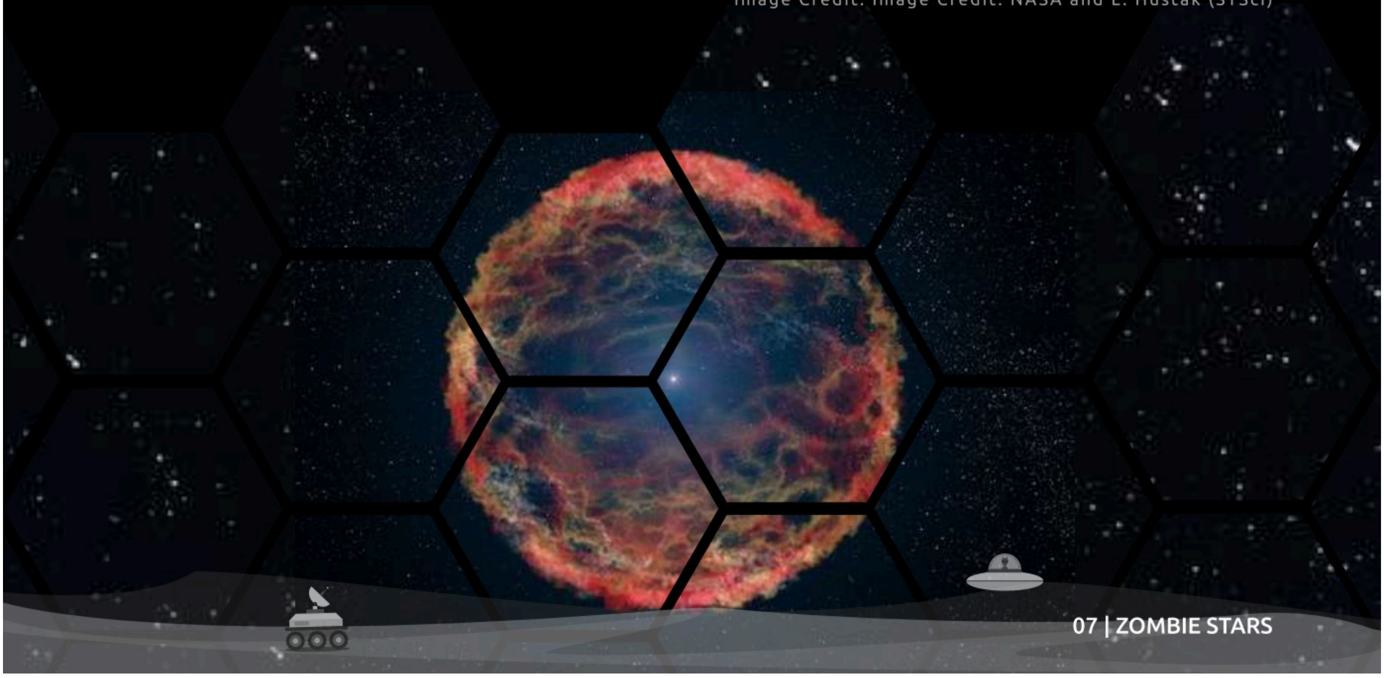
-Amoy Ashesh

Zombies - the living dead, are creatures that seem to disregard the inevitable nature of death to feed on the living.

Enough fiction; Zombie stars are the supernova remnant stars that do not explode and often end up becoming white dwarf stars. The zombie star can become a Vampire Star by consuming fuel and energy from a nearby star to revive itself.

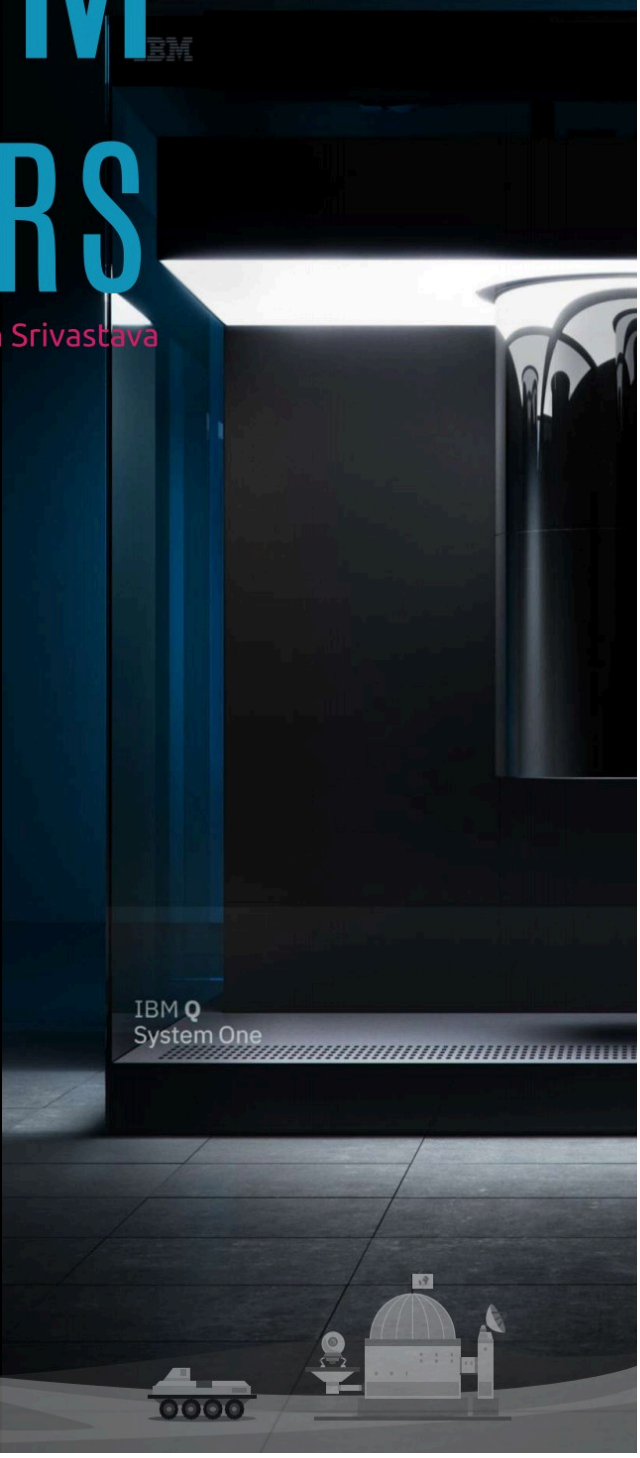
Zombie stars tend to appear in binary star systems. The Zombie star was once the bigger of the two stars but was consumed by the more massive star and shrunk to become a white dwarf. The star can come back from the dead even though its a dead white dwarf star. The Zombie Star can suck back hydrogen from its nearby Vampire star therefore becoming a vampire star itself. When the Zombie star gets roughly the size of a planet, it can go supernova and destroy the original vampire star.

Image Credit: Image Credit: NASA and L. Hustak (STScI)



QUANTUM COMPUTERS

-Suryansh Srivastava



Today's computers are too fast, easily affordable, can be fitted anywhere, are accurate, and can perform any task you want to do. Whether you want to play high graphics games or do school projects or share as a server, even few of them are capable of simulating black holes and galaxies. So, why do we need quantum computers or it's like we can make it so humans are making it? Let's find out...

Quantum Computers are computers that harness the phenomenon of quantum physics like interference, superposition, and entanglement to get the final result. They are faster than

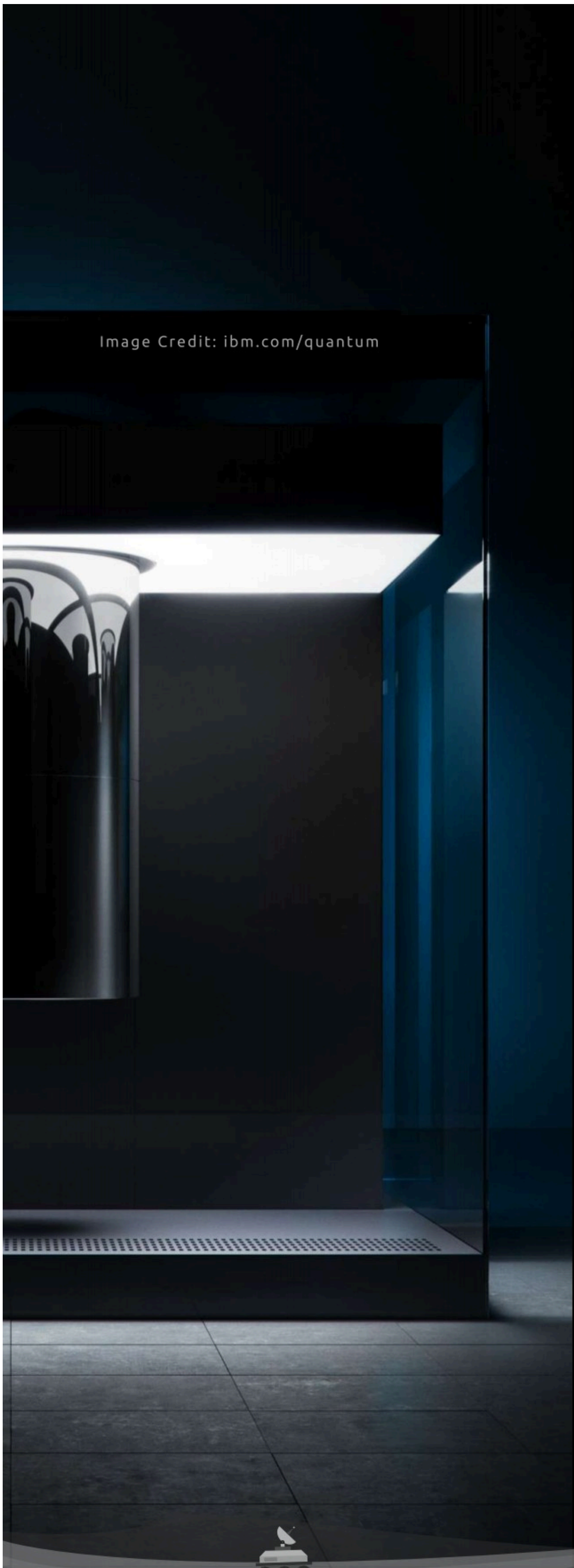


Image Credit: ibm.com/quantum

today's computers as you can think of them interpreting two bits at a single time. They create multidimensional spaces where the patterns linking individual data points emerge. A quantum computer uses qubits (CUE-bits) to run multidimensional quantum algorithms. But they need a very low-temperature environment to operate, this can be guessed by the fact that The operating temperature of the D-Wave 2000Q quantum computer is 0.015 Kelvin.

In 2019, Google reported that their 53-qubit quantum device "Sycamore" solved a task in a few minutes that would take today's most powerful supercomputers thousands of years. Furthermore, the Sa 30 qubit quantum computer can run trillions of operations per second.

Maybe quantum computers can help in making the ultimate theory of physics that can simulate everything in the universe.

MOON CRASHES

Here we are not going to discuss even if it's possible or not. We only explore the effects caused by the moon in the way of its crashing to earth. According to calculations made, it will take exactly one year to hit the earth.

The First Month (384,000 km to 200,000 km)

In this period, the moon gets a little bit brighter and the tides get higher causing the cities to fill with salty water every day.

The Second Month (200,000 km to 133,000 km)

The moon will cover two-thirds of the distance, the tides will get even higher, sea ports will become inoperable, the electrical power supply will stop and the countries will be left with the storage they had which includes food too.

The Third Month (133,000 km to 100,000 km)

The navigation and communication satellite will get disrupted.

The Fourth and Fifth Months (100,000 km to 60,000 km)

The high tides will grow about 100m high. The Earth itself will start to squeeze causing splashing of water on and off the surface.

INTO EARTH

-Suryansh Srivastava

The Sixth and Seventh Months (60,000 km to 40,000 km)

The moon squeezes up to 100 km over a matter of months.

The Eighth to Eleventh Month (40,000 km to 10,000 km)

The moon will start revolving faster than its rotation. The earth will face a lot of earthquakes and volcanic eruptions and the sky will appear almost red all the time.

The Final Month (10,000 km Remaining)

The Moon has reached the Roche Limit (a point where the earth's gravitational moon is stronger than the moon's own gravity), which leads to the disintegration of the moon forming a ring of the moon around the earth (almost the same as Saturn) and the ocean will start leaving land. The people who survived this apocalypse will see the brightest night ever along with meteor showers.

In a nutshell, the moon cannot crash into the earth. So, you are living on one (probably) of the safest planets in the universe.

Image Credit : Jackal1976 on DeviantArt

THE 'DARK'

The visible universe, from non-living objects to humans, planets to stars, galaxies to clusters, is made of electrons, protons, and neutrons. One of the most remarkable discoveries of the 20th century was that ordinary matter contributes to less than 5% of the universe's mass.

We encountered dark matter first in the 1930s, when Fritz Zwicky, a Swiss astronomer, observed that the rotational speed of the galaxies towards the edge of the Coma cluster was more than it should have been, as per the calculations done by considering the mass of the galaxies. But the theory started gaining popularity when Vera Rubin, a US astronomer, showed that in spiral galaxies, stars at the galaxy's edge rotate much faster than they should be, considering the mass of the stars. Without more matter being present, they should simply fly off into space due to the centrifugal force. Exactly five times the amount of visible matter is required for the galaxies to exist like that. So scientists started to realize that there is something at play that we can't see. So they named it "dark matter." It doesn't interact with

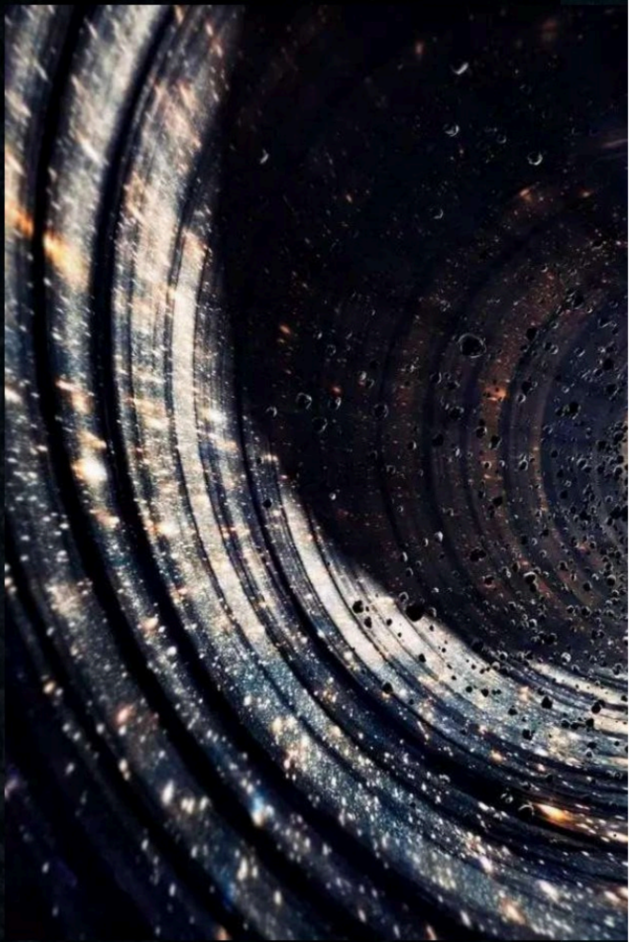


Image credit: Shutterstock

UNIVERSE

-Varun Thanneeru

Image credit: Getty Images

ordinary matter in any way except through gravity.
Scientists first came across "dark energy" when they observed the redshift of Ia Supernovas. Dark energy is even more strange and mysterious. They believe that around 68% of the universe is dark energy. Dark matter makes up about 27%. And everything we have ever known, the normal matter, is less than 5% of the universe. Think about it; maybe it shouldn't be called "normal" matter at all. We have many theories about what dark energy might be; the most popular one states that dark energy might be a property intrinsic to space. The energy that is more powerful than anything we know. Albert Einstein was one of the first few to realize that empty space is nothing. Empty space has energy.
"Empty space has more energy than everything else in the universe combined." Our theories on dark matter and dark energy are just that; theories. It proves that no matter how much we think we are on top of things, we are still very much apes with smartphones, on a tiny, fragile island in space, looking into the sky, wondering how our universe works.

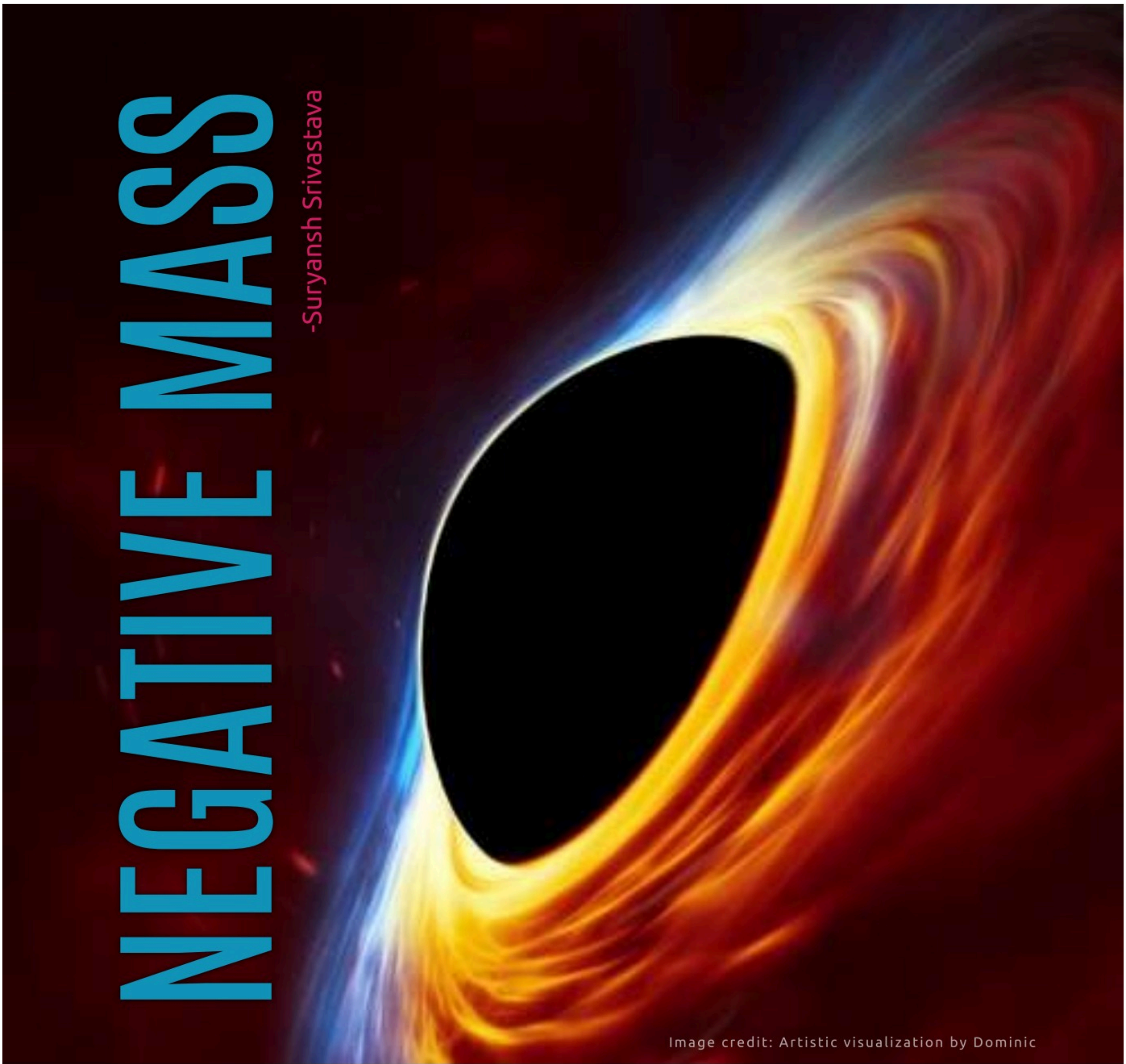


Image credit: Artistic visualization by Dominic

This seems like something out of our knowledge. How can a mass be negative, even if it is possible? Well, the answer is “Yes”. The best part of negative mass is; if we bring a positive mass near to it, it will repel that instead of attracting it. This property of negative mass is very useful in making zero-mass rockets (or infinite

Image credit: Artistic visualization by François Dorothé

acceleration) and stabilizing the wormhole, but how?

Well, here we are only exploring the concept of stabilization of wormholes. A wormhole is created by two blackholes meeting each other at their singularity forming a tunnel for space travel. But singularities are points of infinite densities. And they are surrounded by regions known as the event horizon, one-way barriers in the cosmos. If you cross a black hole's event horizon, you'll never escape. So the entrance should be away from the event horizon, but as soon as you enter such a wormhole tunnel the gravity gets fluctuated which further leads to the collapse of the tunnel into itself, creating just two black holes apart in space.

Here comes the use of negative mass, if there is a negative mass (or if we are able to put it) at the point of singularity we can make the wormhole tunnel always open as it will have a negative gravity impact which will repel every possible positive mass.

Feeling excited, aren't you? Well, as far as we know, matter with negative mass doesn't exist. We have no evidence for it, and if it did exist it would violate a lot of laws of the universe, like inertia and the conservation of momentum.

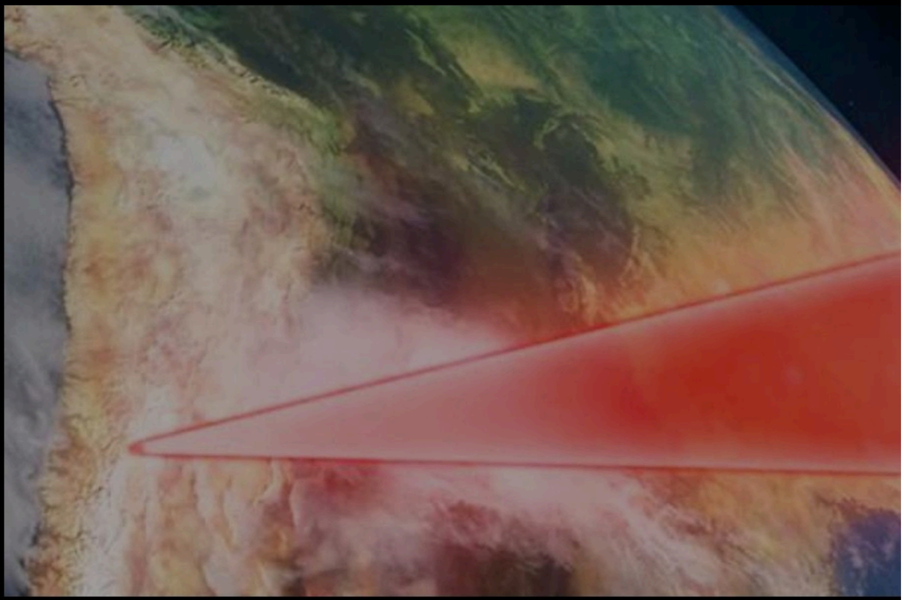
$$F = ma$$

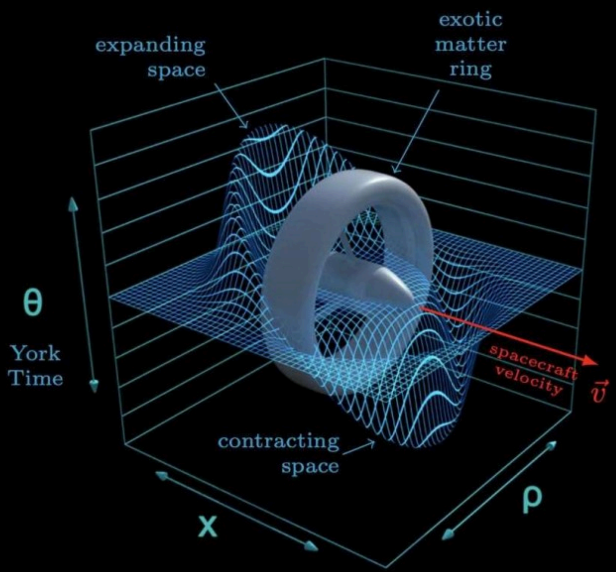
where $m<0$

INTERSTELLAR SPACESHIP

-Awantika Singh

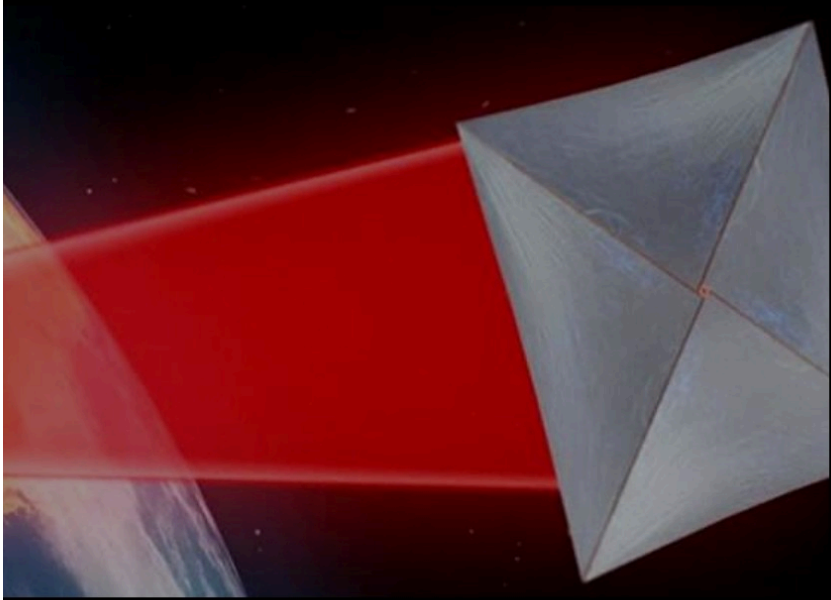
Star system! It fascinates most of us. Have you ever thought of visiting a different star system, one like our solar system? Yeah interstellar travel. Nowadays we do not have such aircraft which go beyond our limitations, our solar system, or our galaxy because of the vastness of our universe. Stars separations are in light years.





Even the nearest stars would take tens of thousands of years to reach using conventional spacecraft, such as the robotic probes being used now to explore the solar system. But if we're going to travel beyond our solar system, we're going to need something a little faster than that Laser-driven light sail spacecraft is the basis of the Breakthrough Starshot project that was announced by investor

Yuri Milner and physicist Stephen Hawking.



This mission is proposed to make a journey to Alpha Centauri, our nearest star system. This journey may include a flyby of Proxima Centauri b, an Earth-sized exoplanet, present in the habitable zone of its host star, Proxima Centauri.

The concept of this mission is launching a spacecraft named mothership, carrying a thousand tiny space probes to a high-altitude earth orbit. This tiny space probe is called a nano-spacecraft. The nano–spacecraft will carry data-gathering electronics on a one-way mission to Alpha Centauri systems. The mothership orbiting earth will launch a nano spacecraft.

A phased array of ground-based lasers would then focus a tremendously light beam at the spacecraft. It will accelerate the spacecraft to 20% speed of light within a minute. Once the nano-spacecraft arrives at the Alpha Centauri star system, it won't slow down. As it whizzes past the stars and planets, it will gather as much data as possible. With a laser beam of its own, the nano craft will send data back to earth. Job is done but it will not back to earth, it will go further.

The concepts behind this project have been studied by Philip Lubin, a professor of cosmology at the University of California, Santa Barbara, who says the biggest challenge remaining is to create sufficiently powerful lasers to drive the light sail spacecraft.

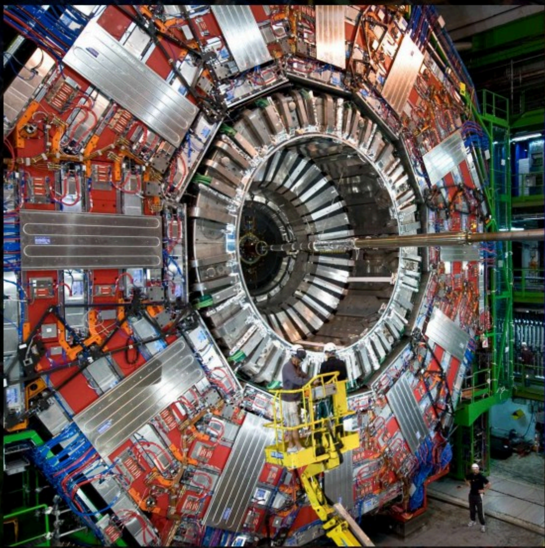


Image credit: Caltech

GOD PARTICLE

HIGGS BOSON

-Ayesha Khan

Discovery—In 2009 scientists from across the globe were eager for an update on the hottest race in particle physics, the search for the so-called God particle 'The Higgs Boson' thought to be responsible for giving many particles mass. It was a true race for glory with scientists competing to get their hands on the brand-new Large Hadron Collider (LHC). The LHC was built specifically for this search at the cost of 3 billion euros. But before the race had really begun it suffered a huge setback. Just a month after the LHC was switched on, an explosion occurred that critically damaged several accelerating magnets in the accelerator. The sprint at the start turned into a grueling marathon that lasted until 2012 with a thousand billion proton-proton collisions in the 27 km long accelerator but on the 4th of July CERN finally announced their success. It was a massive worldwide media sensation. Peter Higgs who gave the theory 50 years back was also present. It was after this, that on October 8, 2013, Peter Higgs and Francois Englert won the Nobel Prize in Physics for their work on the Higgs boson.

The elusive Higgs boson—the fundamental particle that gives mass to all other particles—had been found. After generations of work, the last puzzle piece was in place and the Standard Model of particle physics was complete.

Now the Higgs Boson sits alongside 60 other unique fundamental elementary particles that make up the standard model. The current model includes not only ordinary matter but also anti-matter with opposite charges which make up exotic composite particles and annihilate with the normal matter on contact. As far as we can tell the standard model is complete.

These 61 particles are enough to explain everything that happens or has ever happened in the history of the universe. Using this structure and further advancements in particle physics over the last 50 years, science is finally in a position to zoom out from the unimaginably microscopic to the unfathomably huge particles.

Existence of Higgs Field You and everything around you are made of particles. But when the universe began, no particles had mass, they all sped around at the speed of light. Stars, planets, and life could only emerge because particles gained their mass from a fundamental field associated with the Higgs boson known as the Higgs Field. The stronger a particle interacts with the Higgs field, the heavier the particle ends up being. Photons, for example, do not interact with this field and therefore have no mass. Yet other elementary particles, including electrons, quarks, and bosons, do interact and hence have a variety of masses. The existence of this mass-giving field was confirmed in 2012 when the Higgs boson particle was discovered at CERN.

Conclusion—In the words of Prof. Andre David "The day of discovery of Higgs boson will go down as one of the great days in the history of science. We now have this new tool and we can learn more about what nature is and how the universe works by using this tool".

So, what's next? What is the road map that will guide physicists to the next triumphs, from identifying dark matter to quantizing gravity, and perhaps providing insight into the deepest question of all—why is there something rather than nothing? What theories will light the way? What machines will we need to build to tether progress to reality?

These questions still remain unanswered. 10 years after the discovery of the Higgs boson, physicists still can't get enough of the 'God particle. The Higgs boson is a unique particle. It can interact with any particle with mass. Studying these interactions could be a key to further understanding our universe.

THE BIG BANG

The Beginning


Image credit: ALFRED PASIEKA/SCIENCE PHOTO LIBRARY

The big bang is a theory that explains how our universe began. It is the idea that the universe began as just a single point, infinitesimally small but infinitely dense.

The Big Bang is a misnomer because the universe started as a really small point and there were no explosions associated; it was just the event of enormous cosmic inflation when spacetime came into existence. It is still unclear as to what happened immediately after the big bang but scientists have a very clear prediction after 10^-43 seconds (known as Planck Epoch). It is hypothesized that the four fundamental forces had the same strength and were possibly even unified into one fundamental force, held together by perfect symmetry. Gradually, the fundamental forces came into existence and fundamental particles (quarks, electrons and neutrinos) started forming.

As everything expanded and took up more space, it cooled down. The tiny particles grouped together to form atoms. Then those atoms were grouped together. Over time, atoms came together to form stars and galaxies. The first stars created bigger atoms and groups of atoms. That led to more stars being born. At the same time, galaxies were crashing and grouping together. As new stars were being born and dying, then things like asteroids, comets, planets, and black holes formed!

THE BIG CRUNCH

Image credit: Artistic visualization by Lisa Kuennen

The Cyclic End

The Big Crunch theory narrates a perpetuous story; a story that has neither a beginning nor an end. If the universe has a large amount of dark energy, then the expansion of the universe could theoretically continue forever. If, however, the universe lacks the repulsive effect of dark energy, then gravity will eventually stop the expansion of the universe and it will start to contract until all the matter in the universe collapses to a final singularity, a mirror image of the Big Bang known as the "Big Crunch", somewhere in the region of a hundred billion years from now.

Models of a collapsing universe of this kind suggest that, at first, the universe would shrink more or less evenly, because, on a gross scale, matter is reasonably consistently distributed. At first, the rate of contraction would be slow, but the pace would gradually pick up. As the temperature begins to increase exponentially, stars would explode and vaporize, and eventually atoms and even nuclei would break apart in a reverse performance of the early stages after the Big Bang.

This model offers intriguing possibilities of an oscillating or cyclic universe (or "Big Bounce"), where the Big Crunch is succeeded by the Big Bang of a new universe, and so on, potentially ad infinitum.

THE BIG FREEZE

The Slow Death

Perhaps the most likely possibility, based on current knowledge, is a long, slow decline known as the "Big Freeze" (or the “Big Chill” or “Heat Death”).


Image credit: MIKE ZENG/QUANTA

If the universe continues expanding and gradually “runs down” to a state of zero thermodynamic free energy in which it is unable to sustain motion or life. Eventually, over a time scale of 10^14 (a hundred trillion) years or more, it would reach a state of maximum entropy at a temperature very close to absolute zero, where the universe simply becomes too cold to sustain life, and all that would remain are burned-out stars, cold dead planets and black holes.

What happens after that is even more speculative but, eventually, even the atoms making up the remaining matter would start to degrade and disintegrate, as protons and neutrons decay into positrons and electrons, which over time would collide and annihilate each other. Depending on the rate of expansion of the universe at that time, it is possible that some electrons and positrons may form bizarre atoms billions of light years in size, known as positronium, with the distant particles orbiting around each other so slowly it would take a million years for them to move a single centimetre. After perhaps 10^116 years, even the positronium will have collapsed and the particles annihilated each other.

THE BIG RIP

-Amoy Ashesh

Tragic Teardown

This theory proposes the most catastrophic ultimate end of our universe. If the acceleration caused by dark energy increases without, limit the dark energy eventually becomes so strong that it completely overwhelms the effects of the gravitational, electromagnetic and weak nuclear forces. This would result in galaxies, stars and eventually even atoms themselves being literally torn apart, with the universe as we know it ending dramatically in an unusual kind of gravitational singularity within the relatively short time horizon of just 35 - 50 billion years.

Galaxies would first be separated from each other about 200 million years before the Big Rip. About 60 million years before the Big Rip, galaxies would begin to disintegrate as gravity becomes too weak to hold them together. Planetary systems like the Solar System would become gravitationally unbound about three months before the Big Rip, and planets would fly off into the rapidly expanding universe. In the last minutes, stars and planets would be torn apart, and the now-dispersed atoms would be destroyed about 10^−19 seconds before the end. At the time the Big Rip occurs, even spacetime itself would be ripped apart and the scale factor would be infinity.

BLACK BODY RADIATION

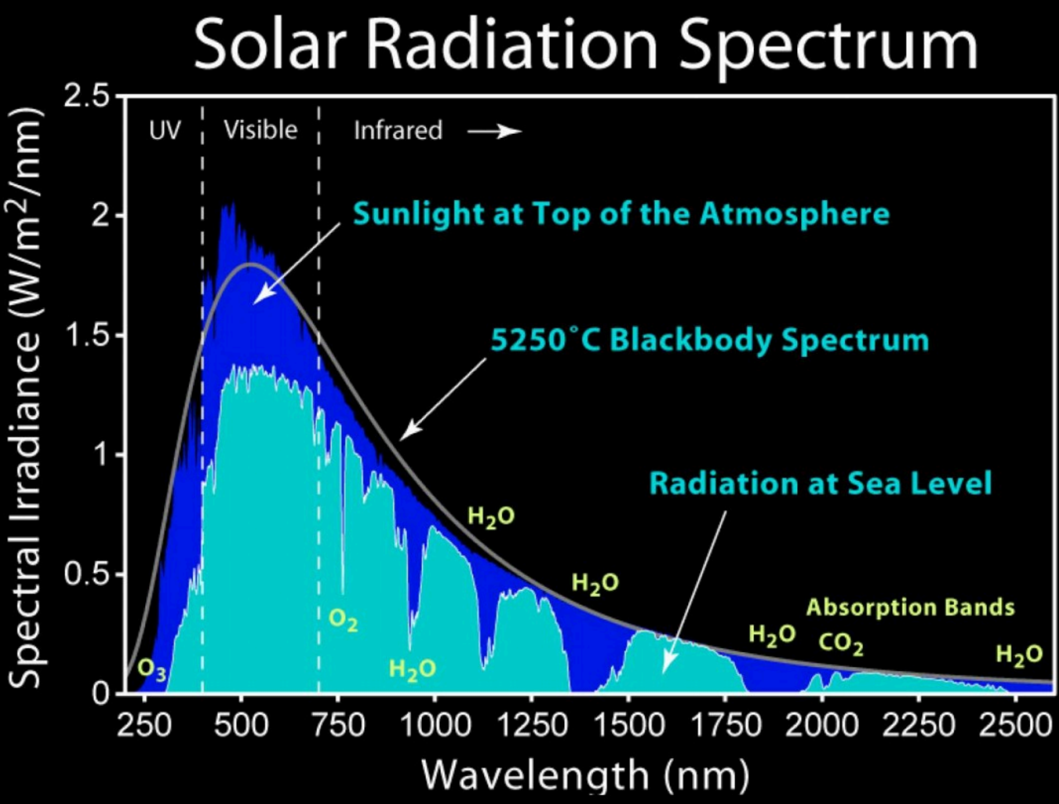
-Shilpa Kanjilal

We know that classical Newtonian mechanics dominated for a few centuries. Still, later some events finally exposed its limitations. One of the first things that suggested more to the universe than we had previously thought was the concept of black-body radiation.

Particular objects are called black bodies because they emit electromagnetic radiation of all wavelengths. The sun is an example of such an object. Suppose we can look at the distribution of the wavelengths of light we receive from the sun. In that case, we find that most of it is in the visible spectrum, but we also receive light on either side, in the UV portion, in infrared, and beyond. A hot piece of metal will also do this. Black bodies were studied at that time, noting that the distribution depends not on the material but on temperature and the particular wavelength emitted with maximum intensity peak shifting left as temperature increases.

The problem with the black-body spectrum was that classical electromagnetism could not account for it. Mathematical models attempting to produce these distributions could fit the data for longer wavelengths. Still, they couldn't predict the intensity profile to the left for the UV portion of the spectrum. This came to be known as the ultraviolet catastrophe.

Max Planck solved this problem by introducing a concept called quantization. We know from classical physics that heat is just kinetic energy transfer from one place to another. In the case of a piece of solid hot metal, that kinetic energy takes the form of atomic vibrations or oscillations.



These vibrations are what generate the light we see in the black-body spectrum. Planck proposed that the vibrational energies of these atoms and, by extension, the energies of the electromagnetic waves emitted by these atoms must be quantized, meaning that rather than being able to take on any value from a continuous series, they can only possess specific discrete values from a set of accepted values. In this way, he developed this expression for black-body radiation.

This was the first time that the concept of quantization had solved such a big problem in physics, but it wouldn't be the last. It was the first in a series of developments that would utterly transform the field of physics and, by extension, our perception of reality. While Planck's work solved one problem, it created another. Why is there quantization of energy? This marked the beginning of the quantum revolution.

ENTANGLEMENT

AND THE EPR PARADOX

-V. Tarun Vikas

The scientific community would have been familiar with Einstein's description of Quantum Entanglement being "spooky action at a distance", perhaps showing his displeasure towards it.

The story of the concept of entanglement can be traced back to a famous paper by Einstein, Podolsky and Rosen wherein they mentioned their thoughts on whether Quantum Mechanics is 'complete', through the landmark paper in 1935, named "Can Quantum Mechanical Description of Physical Reality Be Considered Complete?".

In it, they pondered upon a question as to whether the wave function description used to describe reality in quantum mechanics is complete or not. According to them, a theory can be said to be complete if there exists a counterpart in that theory which corresponds to every element of physical reality. Translated better, it says that a complete theory must be able to help us derive all physically relevant truths about the system (here, the quantum system), which uses the same theory for formulating it. Now, talking about physical reality, they said that if a physical quantity has an 'element' of physical reality, we can certainly predict the value of that physical quantity in a system without disturbing it. But they showed with an example, which involved physical quantities of momentum and position, that the momentum was easily predicted just with an application of the momentum operator on the system's state, but the position was not been able to 'predict'; it had to be measured. But this act of measurement affects the state itself, thus disturbing it. Not only is such a situation with position and momentum, but this is the same situation with those physical quantities whose operators do not 'commute,' i.e., AB does not equal BA, where A and B are two operators corresponding to the physical quantities they are referring to.

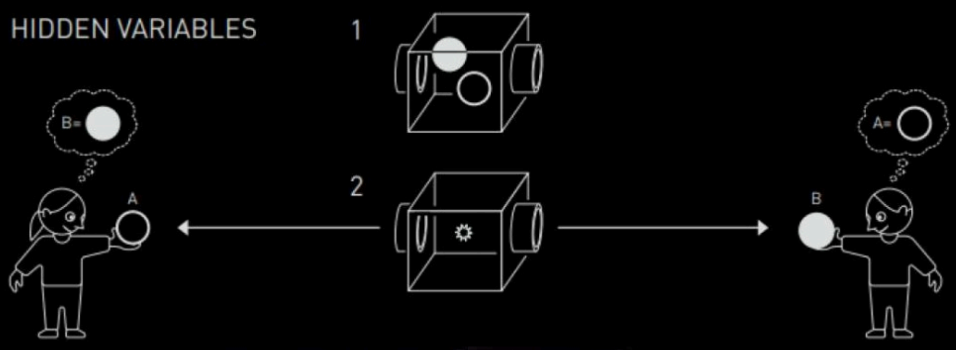
This made them conclude two things: either:

1) the description that the wavefunction-based theorems about quantum systems are NOT complete or 2) if the operators corresponding to physical quantities do NOT commute, they cannot exhibit the simultaneous reality of those two physical quantities; by 'simultaneous reality' they meant the phenomenon of realising the values of two different physical quantities for the same system, without affecting the system when measuring any physical quantity. As we can see from the above paragraph, 2) is asserted. But what about the first conclusion? Can such a description be 'complete'?

This is how they proceeded for the above question in the other part of the paper: Assume 1) to be false (use the wavefunction theorem and see what you would comment about 2)). The system taken here; a system of two particles is allowed to interact with each other for some time, and at a later time, they were separated; they were curious to study this two-particle system after being separated. They expressed the wavefunction of the combined state as the combination of the eigenfunctions of the operator A acting on the first particle, the coefficients of each of the eigenfunctions of these acting as the wavefunction of the second particle for a particular eigenfunction; thesesteps form essentially a process known as 'reduction of the wave packet'. But these 'coefficients'

Does colour exist when no one is watching?

Quantum mechanics' entangled pairs can be compared to a machine that throws out balls of opposite colours in opposite directions. When Bob catches a ball and sees that it is black, he immediately knows that Alice has caught a white one. In a theory that uses hidden variables, the balls had always contained hidden information about what colour to show. However, quantum mechanics says that the balls were grey until someone looked at them, when one randomly turned white and the other black. Bell inequalities show that there are experiments that can differentiate between these cases. Such experiments have proven that quantum mechanics' description is correct.



change if a different operator (say B) is acting on the first particle; we see that we are assigning two different wavefunctions to the same second particle after it interacts with the first particle, depending on the operator.
Note above that in the process of assigning the wavefunction to the second particle, we are NOT affecting it (since we were using the operators A and B on the first particle, and the second particle does not interact anymore with the first particle during this time). But does this happen even when the operators A and B do not commute? Could this violate 2)?

For this, they took an example of a wavefunction for a two-particle system; it was such that when the momentum operator was applied on the first particle, they were able to obtain an eigenvalue 'p' corresponding to the eigenfunction of the momentum operator for the first particle. The wavefunction of the second particle obtained through the process described previously was found to be an eigenfunction of the momentum operator (P; this is the momentum operator of the second particle), which assumes the eigenvalue '-p'. Similarly, in the case of applying the position operator on the first particle, its eigenfunction assumes the value 'x'. But here, it turns out; the second particle is described by the eigenfunction of the position operator (say Q; this is the position operator of the second

Nobel Prize Physics 2022 - Alain Aspect, John F. Clauser and Anton Zeilinger for experiments with entangled photons, establishing the violation of Bell inequalities and pioneering quantum information science:

In 1969 John Clauser was the first to demonstrate experimentally that two widely separated particles can be entangled. Later Alain Aspect in 1981 and Anton Zeilinger in 1997 conducted ground breaking experiments using entangled photons at a distance of 40 feet. These experiments proved that the quantum entanglement is a real principle and passes test after test.

particle), which assumes the eigenvalue 'x+x0', where x0 is some constant.
Notice above; the eigenvalues assumed by the second particle are related to that obtained for the first particle, for both the cases of momentum and position operators. Also, these operators do not commute as we know before; but do you notice that without affecting the second particle, we were able to predict the 'values' (which are, in fact, eigenvalues here) for the position and momentum of the second particle with certainty?
This violates 2). This could just mean that the assumption taken about 1) is false; that is, they concluded, the quantum mechanical description of reality given by the wavefunction is incomplete.
They felt that if an alternative description of reality existed which said that 'simultaneous reality' is defined to be where two physical quantities can be 'simultaneously' predicted/measured, it would say that since two different physical quantities cannot be predicted, they would not be 'simultaneously real'. This would mean the reality of the second particle depends on the measurement of the first particle, which does not disturb the second particle; no definition of reality, according to them, could allow this to happen. They believed, at this stage, that there should be an alternate description of physical reality, which is complete, not like the wave function. This series of thought experiments is better known as the 'EPR Paradox'. This paper, in fact, excited the entire physics community about the foundations of quantum mechanics itself. In a letter to Einstein by Schrodinger was first said to be when the term 'entanglement' was first used for this phenomenon described in this paper.
No weak points in the argument put forward by EPR (easy to refer to the trio like this!) were reportedly discovered until 1964 by John Bell, who said that the 'principle of locality', assumed to be used in this paper, is inconsistent with quantum mechanics. He showed an upper limit on the strength of the correlations through the famous Bell's inequalities that would come if this 'principle of locality' is assumed. He asserted that Quantum mechanics showed violations of these inequalities for certain entangles systems; Bell's work opened up possibilities of using correlations in the field of quantum communications, particularly in QKD protocols like BB84 and E91, and this phenomenon, according to me, gives 'beauty' to quantum mechanics as such.

BLACK HOLES
NOT BLACK AT ALL!

-Nellohit Karmakar

“Black Holes are where God divided by zero.”
- Albert Einstein

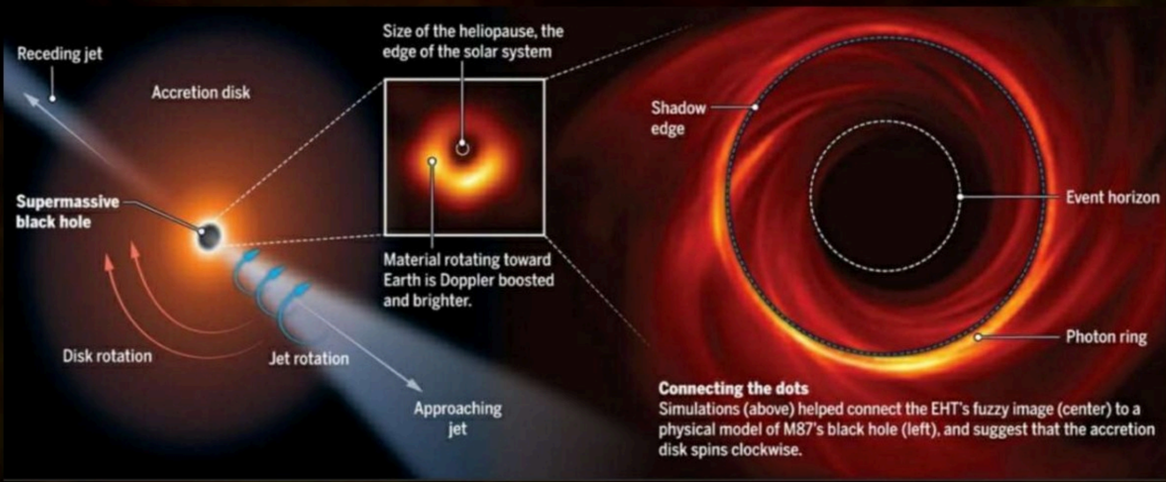
Black Holes are one of the most fascinating as well as most mysterious objects in our universe. It’s a region of spacetime where gravity is so strong that nothing – no particles or any electromagnetic radiation such as light (the fastest known entity of our universe) can escape from it. Black holes are considered an edge of space, a one-way exit door from our universe, nothing inside a black hole can ever communicate with our universe again.

How do they form?

Stars are an incredibly massive collection of mostly H-atom that collapsed from enormous gas cloud under their own gravity. In their core, nuclear fusion crushes H-atoms into He-atoms releasing a tremendous amount of energy. This energy in the form of radiation pushes against gravity and maintains a balance between the two forces, radiation and gravity. As long as there is fusion in the core a star remains stable. But for the stars having 10 or 20 times the mass of our sun, the heat and pressure at the core allow them to fuse heavier elements until they reach Iron. After this, the fusion process does not generate any energy. As a result balance between gravity and radiation suddenly breaks, the core collapses within a fraction of second and the star implodes into a tiny region of space and creates a Black Hole.

Types of Black Holes

Scientists have theorized different types of Black Holes where ‘Stellar’ and ‘Supermassive’ are most common. Stellar Black Holes form when massive stars die and collapse. They are roughly 10 to 20 times the mass of our sun and are scattered throughout the universe. There could be millions of Stellar Black Holes in the Milky Way alone. Supermassive Black Holes are giants by comparison, millions or billions of times more massive than our sun. Scientists believe that they exist at the centre of every large galaxy, including our own. ‘Sagittarius A’ is the supermassive Black Hole at the centre of our Milky Way has a mass of 4 million times our sun and the diameter of the distance between the Sun and Earth.

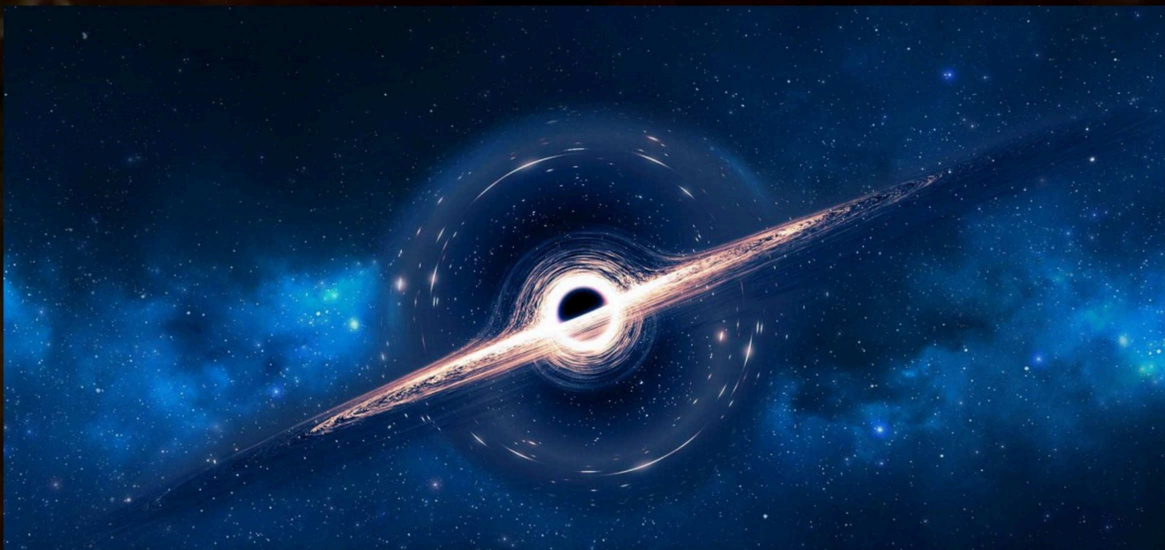


Connecting the dots
Simulations (above) helped connect the EHT's fuzzy image (center) to a physical model of M87's black hole (left), and suggest that the accretion disk spins clockwise.

How do we know that there is a black hole?

If you look directly at a Black Hole it looks like nothing. As Black Holes are invisible the only way to observe or study them is to observe their effect on nearby matter. When some object passes nearby a Black Hole, due to heavy distortion of the fabric of space it starts rotating outside the event horizon just as planets rotate around the sun. This matter can become incredibly hot as close orbits can speed this matter up to half the speed of light and due to friction and collision between the particles heat them to a billion degrees, making the space around the Black Holes incredibly bright and an accretion disk forms around the black hole. Another way is by detecting the gravitational waves produced due to ripples in the fabric of space created by a black hole. Einstein predicted this in his Theory of General Relativity.

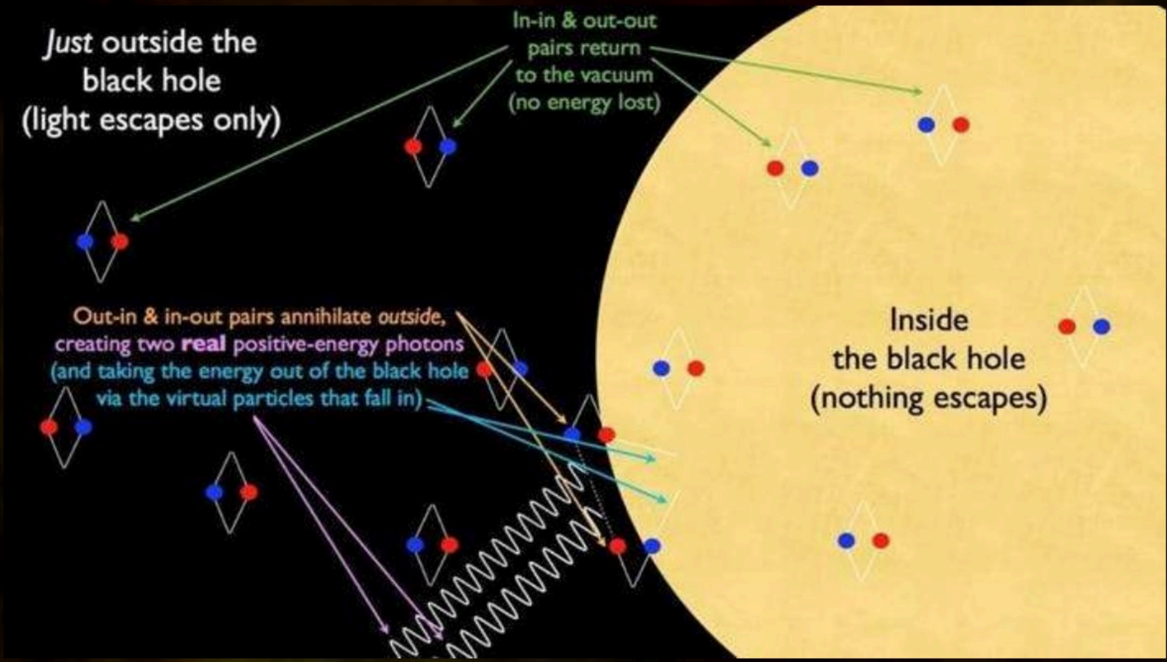
Consider a black hole of size rs (Schwarzschild radius) at a distance ro from another black hole, moving with velocity v. As the black holes spiral into each other they emit gravitational waves with a characteristic wavelength determined by the orbital period, $\lambda = 2\pi ro/v$. The first detection of a gravitational wave was made on 14 Sept. 2015 by LIGO (Laser Interferometer Gravitational-Wave Observatory). These gravitational waves are produced when two massive black holes collide and collapse into a single black hole. After the collapse, there was a difference between the total mass before and after the collision and the left mass converts into energy by the famous formula E=mc2 and scattered in the universe as a gravitational wave.



How does spacetime vary near a Black Hole?

As you get closer to a black hole, the flow of time slows down compared to the time far from the hole. Near the Black hole, the slowing of time is extreme. From the view of an observer outside the Black hole, time stops. For example, an object falling into a black hole seems to be frozen in time at the edge of the hole.Near an event horizon, you would see your image in any direction as light also orbiting black holes. Straight ahead would the back of your own head as light from your back travels around the black hole to your eyes. While you watch the universe above you speed up, those far away will watch you in slow motion. If you fly away from a black hole, you might find thousands of years passed for the rest of the universe, a time travel to the future.

For a Schwarzschild black hole, the space-time interval becomes, $ds2 = \{1/(1-rs/r)\} dr2 – (1- rs/r)c2dt2$ - (1) rs= Schwarzschild radius. Very far from event horizon the Schwarzschild interval becomes old Minkowski's interval, $ds2 = dr2 - c2dt2$; and space and time are nice separated. But when $r<rs$, then both the brackets in Eqn. (1) becomes negative so dr is negative and dt is positive. Now there is only way to maintain this casual progression is to fall inward. Space is falling inwards towards the singularity. So, space behaves as time-like and time behaves like space-like.



Hawking Radiation

Hawking radiation from black holes is surely the most sticking prediction of gravitational physics of the last few decades. Quantum Mechanically, a black hole can radiate like black body at a characteristic temperature T. We can actually determine the temperature of a black hole.

From the Schwarzschild solution of Einstein Field equations,

ds2= {1 –(2GM/r)} dt2 - {1 –(2GM/ r)}-1dr2 – r2dθ2- r2 Sin2θ dφ2

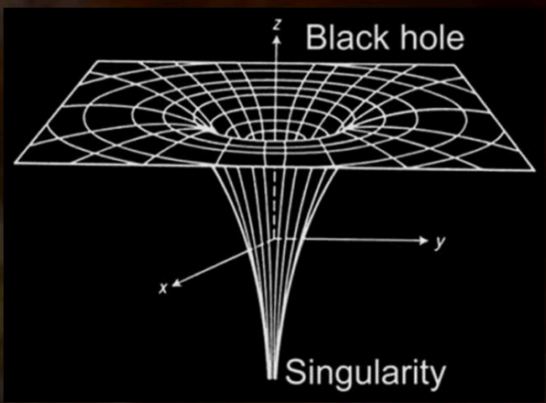
From above equation we can obtain Hawking temperature,

T= hc3/16п2GM.

Due to radiating energy like black body the mass of the black hole decreases in time and the horizon radius becomes smaller and smaller, until it's totally disappears at the end of the evaporation process. The space of black hole filled with particles and their antiparticles comes into existence and annihilating each other again. When this happens at the edge of a black hole one of them drawn inside and other will escape and become a real particle. As a result Black hole losing energy. This happens incredibly slowly at first and gets faster as the size decreases. At the last second of life Black hole radiate with the energy of billions nuclear bombs in a huge explosion.

Singularity

The singularity at the centre of a Black Hole is the point at which gravity is so intense that spacetime breaks down catastrophically. It is the point where space and time come to stop. At the singularity, all laws of physics break down. However, any observer who remained outside the black hole would not be affected by this failure of predictability because neither light nor any other signal can reach them from the singularity.



Event Horizon

It is the boundary defining the region of space around a Black Hole from where nothing can escape –not even light. The Schwarzschild radius is a physical parameter in the Schwarzschild solution to Einstein's Field equations that corresponds to the radius defining the event horizon of a Schwarzschild black hole (non-rotating black hole).

The Schwarzschild radius,
rs = 2GM/c2
where, G = Gravitational Constant = 6.674 x 10-11N m2Kg-2
c = speed of light in free space = 3 x 108 m/s

If once any object crosses the event horizon then to escape from that region it should have a speed greater than light (c, limit of the universe from Einstein's theory of Special Relativity) which is impossible. No one exactly knows what's going inside, scientists only predict some possibilities with current theories.

AP TIMES

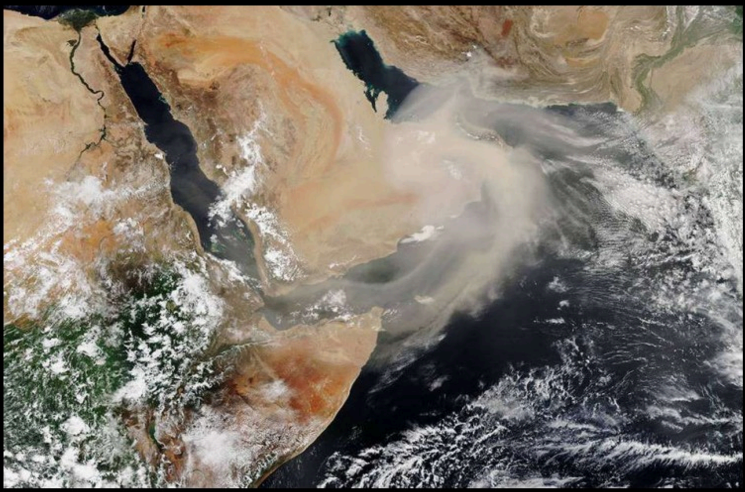
Astronauts Return from Six-Month Mission

From left to right, ESA (European Space Agency) astronaut Matthais Maurer, NASA astronauts Tom Marshburn, Raja Chari, and Kayla Barron
Credits: NASA/Aubrey Gemignani

After about six months aboard the International Space Station, the astronauts of NASA's SpaceX Crew-3 mission has come home. The four crew members – NASA astronauts Kayla Barron, Raja Chari (seen above), and Tom Marshburn, and ESA (European Space Agency) astronaut Matthias Maurer – traveled back to Earth inside SpaceX's Dragon Endurance spacecraft, splashing down off the coast of Florida at 12:43 a.m. EDT (4:43 UTC) on Friday, May 6.

During their time aboard the orbiting laboratory, the Crew-3 astronauts contributed to hundreds of scientific investigations and technology demonstrations, including growing chiles, studying cotton, and performing the first archaeological study on the station. This valuable research helps to prepare humans for future space exploration missions while generating numerous innovations and benefits for humanity on Earth.

NASA's New Minor Dust Dectector Headed to Space Station



Dust swirls over the Arabian Peninsula in this image captured by the Suomi NPP satellite in July 2018. NASA's upcoming Earth Surface Mineral Dust Source Investigation (EMIT) will help scientists better understand the role of airborne dust in heating and cooling the atmosphere.
Credits: NASA Earth Observatory

Each year, strong winds carry more than a billion metric tons – or the weight of 10,000 aircraft carriers – of mineral dust from Earth's deserts into the atmosphere. While scientists know that dust affects the environment and climate, they don't have enough data to determine what those effects are or maybe in the future – at least not yet.
NASA's Earth Surface Mineral Dust Source Investigation (EMIT) mission will help to fill those knowledge gaps. EMIT is scheduled to launch from NASA's Kennedy Space Center in Florida on June 10, 2022, as part of SpaceX's 25th commercial resupply services mission for NASA.

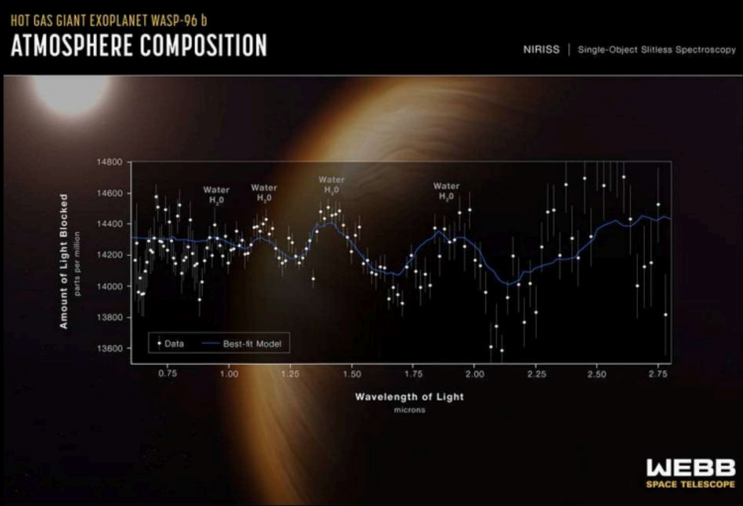
NASA Reveals Webb Telescope's First Images of the Unseen Universe

The world got its first look at the full capabilities of the telescope, an international collaboration between NASA, the European Space Agency, and the Canadian Space Agency, when the full set of its first full-color images and spectroscopic data were unveiled during a live broadcast on Tuesday, July 12.

See the first images from the biggest, most powerful space telescope ever made:

Credits: NASA, ESA, CSA, and STScI

Webb's First Deep Field – Webb has produced the deepest and sharpest infrared image of the distant universe to date. This image shows the galaxy cluster SMACS 0723 as it appeared 4.6 billion years ago, with many more galaxies in front of and behind the cluster. This slice of the vast universe covers a patch of sky approximately the size of a grain of sand held at arm's length by someone on the ground.



Credits: NASA, ESA, CSA, and STScI

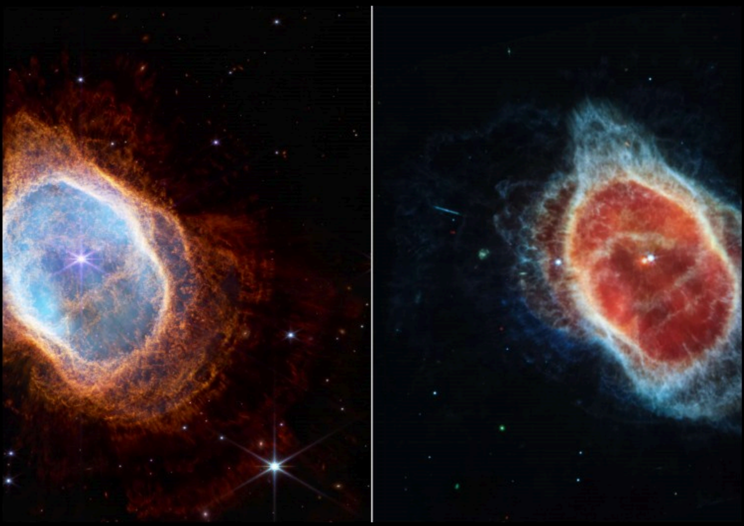
Steamy Atmosphere – Webb captured the distinct signature of water, along with evidence for clouds and haze, in the atmosphere surrounding WASP-96 b. Observation of this hot, Jupiter-like exoplanet demonstrates Webb's ability to analyze atmospheres more than a thousand light-years away, marking a huge leap forward in the quest to characterize potentially habitable planets beyond Earth.

Credits: NASA, ESA, CSA, and STScI

A Galactic Quintet – This enormous mosaic of Stephan's Quintet, a visual grouping of five galaxies, is Webb's largest image to date. Containing over 150 million pixels, the image shows never-before-seen details in this galaxy group – sparkling clusters of young stars, sweeping tails of gas, and huge shock waves as one of the galaxies, NGC 7318B, smashes through the cluster.

Credits: NASA, ESA, CSA, and STScI

Cosmic Cliffs – This landscape of "mountains" and "valleys" speckled with glittering stars is actually the edge of a nearby, young, star-forming region called NGC 3324 in the Carina Nebula. Captured in infrared light, this image reveals for the first time previously invisible areas of star birth.



Credits: NASA, ESA, CSA, and STScI

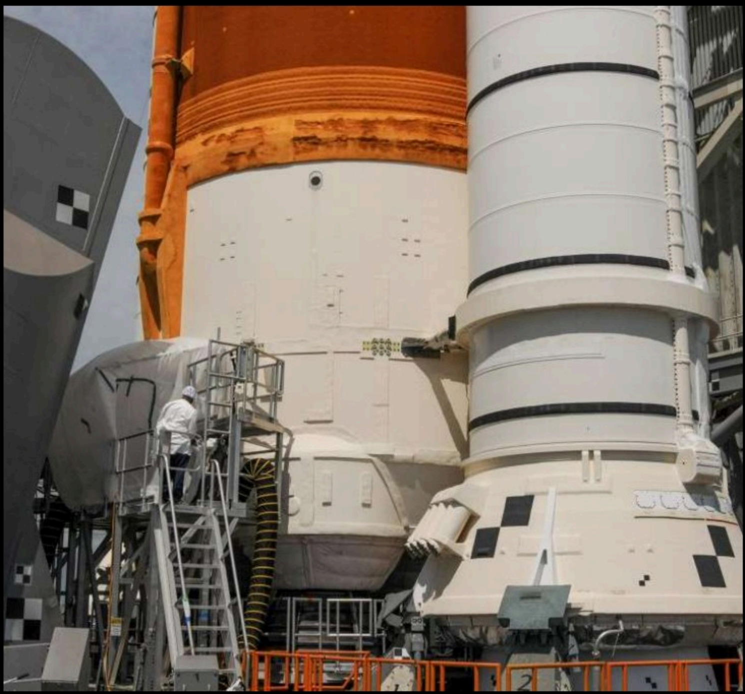
Last Performance of a Dying Star – NGC 3132, known informally as the Southern Ring Nebula, is a planetary nebula - clouds of gas and dust expelled by a dying low-mass star- about 2,500 light-years away. There are actually two stars at the center of this image.

Repairs Continue as NASA Prepares for Next Artemis I Launch Opportunity

Officials stopped the Sept. 3 launch countdown after discovering a hydrogen leak in a quick disconnect, an interface between the hydrogen fuel feed line on the mobile launcher and the Space Launch System (SLS) rocket. Engineers are making progress repairing the area, and NASA is preserving options for the next launch opportunity as early as Friday, Sept. 23.

Although Artemis I will not have human crew members aboard, senior leadership stressed the importance of thoroughly testing and understanding the systems to ensure the safety of future astronauts who will rely on the SLS, the Orion spacecraft, and the ground systems at Kennedy Space Center for later Artemis missions.

In order to replace the seal on the quick disconnect, technicians have set up a tent-like enclosure around the work area that protects the hardware from the weather and other environmental conditions. After the repair work is completed, teams will test the seal under the same conditions it will experience during launch and evaluate plans for the next launch attempt.



DART MISSION

Illustration of DART, from behind the NEXT-C ion engine
Credits: NASA/Johns Hopkins APL

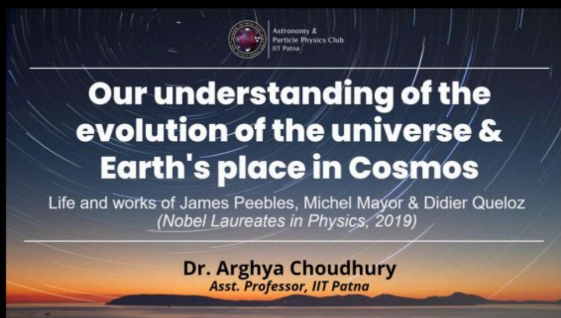
NASA's Double Asteroid Redirection Test (DART), the world's first mission to test technology for defending Earth against potential asteroid or comet hazards, will impact its target asteroid—which poses no threat to Earth—at 7:14 p.m. EDT on Monday, Sept. 26. DART's target is the binary near-Earth asteroid Didymos and its moonlet, Dimorphos. Launched in November 2021, the mission will see if intentionally crashing a spacecraft into an asteroid is an effective way to change its course, should an Earth-threatening asteroid be discovered in the future.

KNOW YOUR CLUB

GUEST LECTURE SESSION

We kickstarted the journey for the new term with the guest lecture series. For our first talk held on 27th August 2021, we had invited Dr. Arghya Choudhry, Assistant Professor in Physics Department, IIT Patna. He delivered a lecture on “Our understanding of the evolution of the universe and Earth’s place in Cosmos” and also threw light on the Life and Works of James Peebles, Michel Mayor & Didier Queloz (Nobel Laureates in Physics, 2019). The talk first started with a very catchy video portraying the theme of The Big Bang Theory. This was enough to keep the viewers hooked for the next 100 minutes. The talk was divided into two parts.

The talk focused on the work of James Pebbles. It also covered a brief introduction to the topics: Big Bang Theory, Cosmic Microwave Background, Dark Matter, Dark Energy, and the quantitative story of how it has shaped the physics of this modern era. This talk also gave a brief introduction to Physical Cosmology which made the audience more curious and excited about the field.

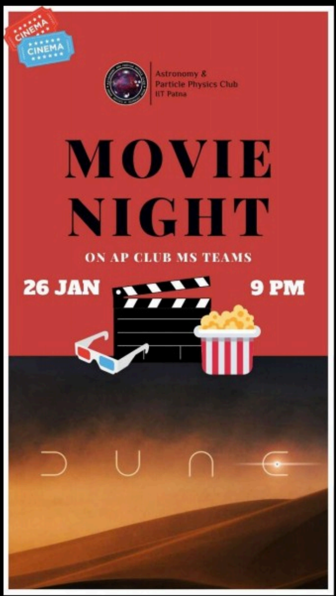


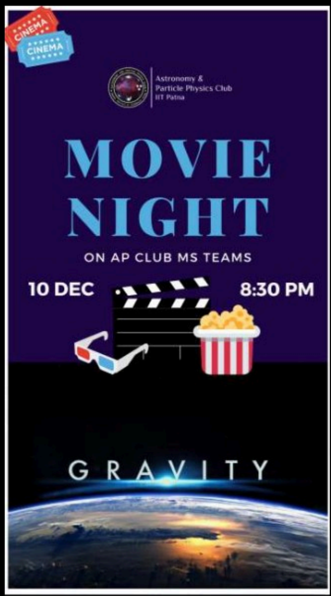
SOCIAL MEDIA OUTREACH

AP Club to has a wide social media base so that we can connect with more physics and astronomy lovers and introduce them to this fraternity.

MOVIE NIGHTS

Bored with your daily life? Here we come as a relief. Let your mind be lost in science and technology. We will watch the movie, discuss the topic and try to explore the possibility behind it.





NIGHT OBSERVATIONAL SESSIONS

Are you interested in stalking planets? Here we have a new device to help you out. Yes you read it correctly, lets explore the universe with a lot of learning some finer details about telescope and its usage.

OTHER EVENTS AND SESSIONS

We organize events for everyone - be it an astrophile or an enthusiast. Keep an eye out for exciting events if you are a knowledge-seeker, a stellar-explorer, a stargazer or a person with an inquisitive mindset.

Our Recommendations

Podcasts

Listen Here!

Space

A collection of radio documentary programmes broadcast on the BBC World Service, with one thing in common – space.

Space Time

Recognized worldwide as one of the best and most thoroughly researched programs on Astronomy, Technology, Space, and Science News.

Listen Here!

Listen Here!

Astronomy Cast

Take a fact-based journey through the cosmos. Discussions on astronomical topics ranging from planets to cosmology bring the questions of an avid astronomy lover direct to an astronomer.

Movies and Shows

Watch Here!

Particle Fever

IMDb : 7.4 / 10

Particle Fever follows the inside story of six brilliant scientists seeking to unravel the mysteries of the universe, documenting the successes and setbacks in the planet's most significant and inspiring scientific breakthrough.

Rocket Boys

IMDb : 8.9 / 10

Rocket Boys is the story of Independent India's formative years in the field of science. It chronicles the illustrious life of three great men responsible for launching India's space and nuclear programmes respectively: Dr Homi J. Bhabha, the architect of India's Nuclear Programme, Dr. Vikram Sarabhai, and Dr. A.P.J Abdul Kalam, the pioneer of modern Indian aerospace and nuclear technology. A story of friendship, sacrifice and great determination; its emblematic of the journey of our country as it emerges into a new, post-war world.

Watch Here!

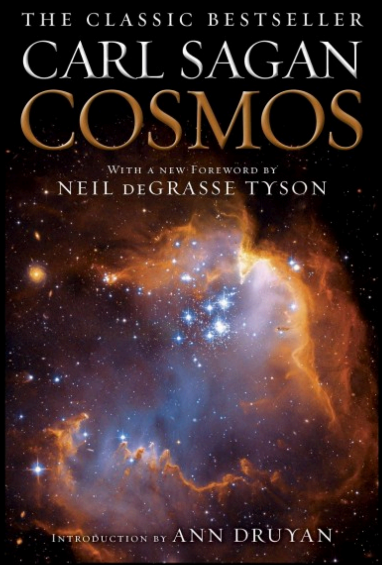
Watch Here!

Cosmos

IMDb : 9.1 / 10

The show is a follow-up to the 1980 television series Cosmos: A Personal Voyage, which was presented by Carl Sagan and is considered a milestone for scientific documentaries. This series was developed to bring back the foundation of science to network television.

Books

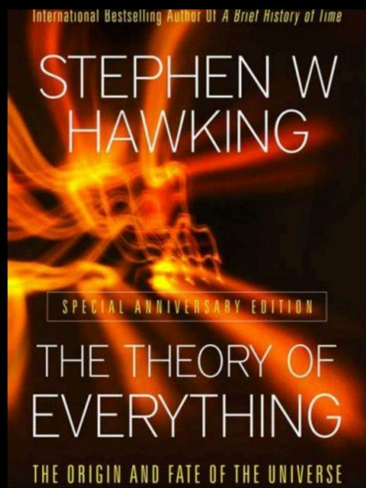


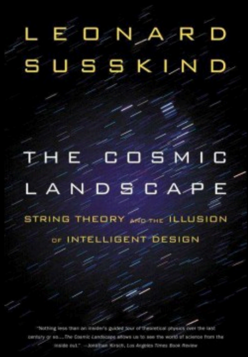
Get it Here!

A bestselling science book of all time, Cosmos is a clear-eyed view of our jewel blue planet inhabited by a life form that is just beginning to discover its own identity and venture into space. The fourteen billion years of cosmic evolution that have transformed matter into consciousness are traced, with topics ranging from the origin of life to spacecraft missions, death of the Sun, evolution of galaxies and the individuals who helped shape modern science.

Stephen Hawking is widely believed to be one of the world's greatest minds: a brilliant theoretical physicist whose work helped to reconfigure models of the universe and to redefine what's in it. Hawking begins with a history of ideas about the universe, from Aristotle's determination that the Earth is round to Hubble's discovery, over 2000 years later, that the universe is expanding. Using that as a launching pad, he explores the reaches of modern physics, including theories on the origin of the universe (e.g., the big bang), the nature of black holes, and space-time.

Get it Here!

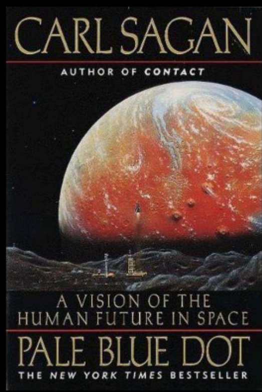




Get it Here!

Physicist Susskind is a founder of string theory, and his first popular work will be of utmost significance to science readers. They will be challenged throughout by Susskind's ideas, of which strings are but a part; his driving curiosity is to discover why the laws of physics are what they are and so finely poised to permit life. Susskind discusses how slight alterations of physical values would destroy atoms and, hence, life. Deeming unscientific any proposition of a supernatural agency in setting the physical dials so exactly, Susskind advances a radical concept he calls the "landscape."

Future generations will look back on our epoch as the time when the human race finally broke into a radically new frontier—space. In Pale Blue Dot, Sagan traces the spellbinding history of our launch into the cosmos and assesses the future that looms before us as we move out into our own solar system and on to distant galaxies beyond. The exploration and eventual settlement of other worlds is neither a fantasy nor luxury, insists Sagan, but rather a necessary condition for the survival of the human race.



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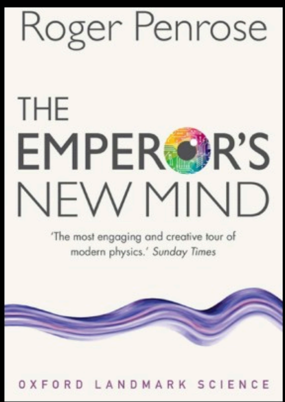

Get it Here!

For many decades, the proponents of `artificial intelligence' have maintained that computers will soon be able to do everything that a human can do. In his bestselling work of popular science, Sir Roger Penrose takes us on a fascinating tour through the basic principles of physics, cosmology, mathematics, and philosophy to show that human thinking can never be emulated by a machine.

Oxford Landmark Science books are 'must-read' classics of modern science writing which have crystallized big ideas, and shaped the way we think.

OUR TEAM

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PRAJYOT RAMTEKE

CHIEF CONTENT GUIDE
PRIYANSHI SINGH

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AYESHA KHAN

AWANTIKA SINGH
NISHANT KUMAR


SCAN ME