QUANTA

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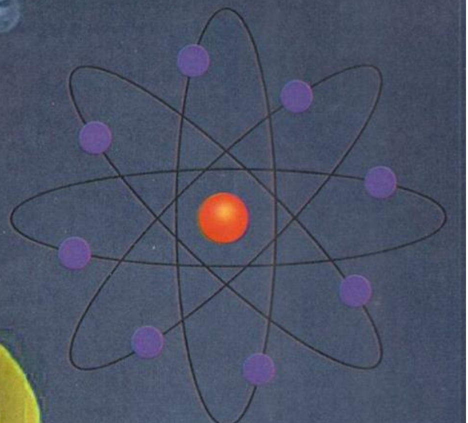

Editor
Gwmshart Basumatary

DEPARTMENTAL ACTIVITIES

QUANTA

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गोरायुंनि मावख' :: बिजनी सोलोंसालिमा

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Message

*It is indeed a great pleasure for me to know that Bijni College Physics Department is going to bring out the 9th issue of annual departmental magazine "**QUANTA**" for the session 2024-25 shortly.*

Wishing all concerned in achieving a grand success, I sincerely feel that the publication would enable the upcoming writers to express their talent pertaining to literary skill.

With best wishes.

(Dr. Birhash Giri Basumatary)
Principal,
Bijni College, Bijni

Principal
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From the Editor

Newton's second law is a quantitative description of the changes that a force can produce on the motion of a body. It states that the time rate of change of the momentum of a body is equal in both magnitude and direction to the force imposed on it. The momentum of a body is equal to the product of its mass and its velocity. Momentum, like velocity, is a vector quantity, having both magnitude and direction. A force applied to a body can change the magnitude of the momentum or its direction or both. Newton's second law is one of the most important in all of physics. For a body whose mass m is constant, it can be written in the form F = ma, where F (force) and a (acceleration) are both vector quantities. If a body has net force acting on it, it is accelerated in accordance with the equation. Conversely, if a body is not accelerated, there is no net force acting on it.

Our department has a custom of publishing annual departmental magazine every year, it is hereby my great honour and pleasure to present the annual departmental magazine QUANTA for the year 2024-2025.

I would like to extend my sincere and special thanks to our professors for helping me with their valuable advices in publishing this magazine .I also thank my college, the editorial board members and cover designers in making this publication a grand success. This magazine is an effort to nature the inner talents of students and helping them again confidence.

I beg your pardon for any mistake in this publication.

-Editor, Quanta: 9th Issue
Gwmshart Basumatary

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Unveiling the Cosmos: Exploring the Universe's Origins, Structure, and Mysteries

Gwmshart Basumatary B.Sc. 6th Semester, Physics Department, Bijni College

Abstract

The universe is a vast and mysterious expanse that has fascinated humanity for centuries. This study explores its origins, structure, and the fundamental forces that shape it. From the Big Bang to the role of dark matter and dark energy, we examine the evolution of the cosmos. Key astronomical discoveries, including black holes and cosmic expansion, shed light on the universe's complexities. Despite advancements, many mysteries remain, driving ongoing scientific exploration. Understanding the cosmos not only expands our knowledge but also deepens our appreciation of our place in the universe.

Keywords: Big Bang theory, Cosmic inflation, Dark matter, Dark energy

Introduction

Cosmology, the study of the universe's grand narrative, seeks to unravel the origins, structure, and fate of the cosmos. From the explosive birth of the Big Bang to the enigmatic dark energy driving cosmic acceleration, this article journeys through key discoveries and enduring mysteries in our quest to understand the universe.

Objective:

- ivestegate the big bang and cosmic inflatation.
- study the dark matter and dark energy to undestand their role in cosmic evolution.
- study cosmic microwave background and cosmic web.
- study multiverse and string theory.
- study about future prospects.

Methodology

In this article some resource taken from books and some from internet.

Discussion

The Big Bang and Cosmic Inflation: The Big Bang theory posits that the universe began as a hot, dense singularity approximately 13.8 billion years ago, expanding and cooling over time. Contrary to a traditional explosion, this was an expansion of space itself. Key evidence includes the abundance of light elements (hydrogen, helium) formed during Big Bang nucleosynthesis and the discovery of the Cosmic Microwave Background (CMB) radiation—a relic glow from 380,000 years post-Big Bang when atoms formed and photons roamed freely.

In the 1980s, the inflationary model was proposed to address puzzles like the universe's uniformity (horizon problem) and flat geometry. Inflation suggests a rapid exponential expansion within the first fraction of a second, smoothing irregularities and seeding future cosmic structures.

Dark Matter and Dark Energy: The Invisible Cosmos : Visible matter constitutes just 5% of the universe. The remainder is dark matter (27%) and dark energy (68%). Dark matter, inferred from galaxy rotation curves and gravitational lensing in clusters like the Bullet Cluster, provides the gravitational scaffolding for galaxy formation. Yet, its particle nature remains elusive, with experiments like LUX and XENON1T hunting for Weakly Interacting Massive Particles (WIMPs).

Dark energy, discovered in 1998 via Type Ia supernovae observations, drives the universe's accelerated expansion. This mysterious energy, possibly a property of space itself (cosmological constant), challenges our understanding of fundamental physics.

Cosmic Microwave Background: The CMB, discovered by Penzias and Wilson in 1965, offers a snapshot of the early universe. Tiny temperature fluctuations (anisotropies) mapped by missions like Planck reveal density variations that seeded galaxies and clusters. Polarization patterns in the CMB also provide clues about inflationary gravitational waves, a potential window into quantum gravity.

The Cosmic Web : The universe's matter is woven into a vast network of filaments and voids, the cosmic web. Dark matter's gravity guided this structure, with galaxies forming at intersections. Surveys like the Sloan Digital Sky Survey (SDSS) chart this web, while supercomputer simulations, such as the Millennium Simulation, model its evolution, offering insights into dark matter dynamics and galaxy formation.

Theoretical Frontiers: Multiverse and String Theory: Beyond observable realms lie speculative theories. Eternal inflation suggests a multiverse—a mosaic of bubble universes with varying physical laws. String theory's "landscape" of possible vacuum states complements this idea. While empirically untested, these concepts push the boundaries of cosmology, challenging our perception of reality.

Future Prospects: Next-generation tools promise breakthroughs. The James Webb Space Telescope peers into the epoch of first galaxies, while the Euclid satellite and Vera Rubin Observatory probe dark energy's influence. The Dark Energy Spectroscopic Instrument (DESI) maps galaxy distributions, and neutrino detectors explore the role of these elusive particles in cosmic evolution. Meanwhile, resolving the Hubble tension—a discrepancy in expansion rate measurements—may hint at new physics.

Conclusion

Cosmology intertwines observation, theory, and imagination, revealing a universe far stranger than once imagined. As we stand on the brink of new discoveries, each cosmic clue—from the CMB's whisper to dark energy's push—invites us to ponder our place in the vast cosmic tapestry, driving humanity's timeless quest to comprehend the cosmos.

ISRO's_SpaDeX_Mission

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Introduction

The Space Docking Experiment (SpaDeX) is a cost-effective technology demonstrator mission by ISRO, designed to showcase in-space docking capabilities using two small spacecraft launched aboard a PSLV. This critical technology plays a key role in India's long-term space ambitions, including future lunar missions: sample return missions, and the development of the Bharatiya Antariksh Station (BAS). In-space docking is essential for missions requiring multiple rocket launches to achieve a shared objective. On 19 January 2025 ISRO successfully completed docking of two small satellite and become fourth nation in the world to master space docking technology.

Objectives

1. To discuss about the ISRO's_SpaDeX_Mission
2. To highlight the technological operation of docking system

Methodology

Data for writing this article has been collected from various sources of internet.

Discussion

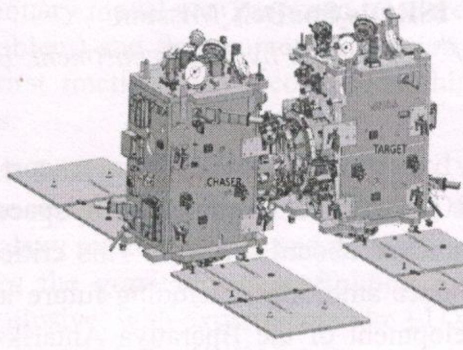
The Indian Space Research Organisation's (ISRO) pioneering SpaDeX mission will deploy two small spacecraft—each weighing approximately 220 kg—aboard the PSLV-C60 rocket. Launched simultaneously into a 470 km circular low-Earth orbit inclined at 55°, the satellites will operate within a 66-day local time cycle, setting the stage for a meticulously choreographed orbital dance.

Orbit Insertion and Initial Separation

The PSLV-C60's precision will impart a slight relative velocity between the Target (SDX02) and Chaser (SDX01) spacecraft during separation. This strategic maneuver allows the Target to drift 10–20 km ahead of the Chaser within 24 hours. To stabilize the configuration, the Target will then use its onboard propulsion system to neutralize the velocity difference, establishing a controlled 20 km gap—a phase termed "Far Rendezvous."

Phased Approach and Docking Sequence

From this starting point, the Chaser will execute a series of incremental closing maneuvers. By intentionally creating and compensating for small velocity differentials, it will progressively narrow the distance to the Target: first to 5 km, then 1.5 km, 500 m, 225 m, 15 m, and finally 3 m. Each phase validates autonomous navigation and guidance systems critical for safe proximity operations. The culmination is the docking and rigidization of the two spacecraft, forming a single composite unit.



Post-Docking Experiments and Undocking

Once securely docked, the mission will demonstrate cross-satellite electric power transfer—a leap forward for applications like in-space robotics and modular orbital infrastructure. Following this test, the pair will undock, separating to begin independent operations. Both spacecraft will then activate their payloads, which are designed to function for up to two years, contributing to ISRO's broader goals of advancing long-duration orbital technologies.

Spacecraft_development

The SpaDeX mission's twin spacecraft, Chaser (SDX01) and Target (SDX02), were developed by ISRO's URSC with contributions from multiple centers. Integrated and tested at M/s Ananth Technologies, they passed rigorous checks. ISRO's ISTRAC will manage operations using a global network.

Conclusion

The SpaDeX mission represents a significant milestone in India's space exploration efforts, successfully demonstrating the critical technologies of rendezvous and docking between two small spacecraft in low-Earth orbit. This achievement not only showcases ISRO's growing capabilities but also lays the groundwork for future endeavors such as satellite servicing,space station operations, and complex interplanetary missions. The successful execution of SpaDeX underscores India's commitment to advancing its position in the global space community.

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Quantum Revolution

Bikram Chetry B.Sc. 6th Semester, Physics Department, Bijni College

Introduction

Quantum mechanics, the fundamental theory in physics that provides a description of the physical properties of nature at the scale of atoms and subatomic particles, has revolutionized our understanding of the universe. Unlike classical physics, which deals with macroscopic objects, quantum mechanics operates on principles that often defy our everyday experiences.

Objective

1.To study the birth of quantum mechanics and its key principle

2. Application and challenges in future.

Methodology The collection of data in this article are taken from some book and different type of website.

Discussion

The Birth of Quantum Mechanics : The inception of quantum mechanics dates back to the early 20th century, when classical physics failed to explain certain phenomena. Max Planck's solution to the black-body radiation problem in 1900 marked the beginning of quantum theory. Planck proposed that energy is quantized, meaning it can only be emitted or absorbed in discrete amounts called quanta.

Key Principles of Quantum Mechanics:

1. Wave-Particle Duality: One of the most intriguing aspects of quantum mechanics is the concept of wave-particle duality. Particles such as electrons exhibit both wave-like and particle-like properties. This duality was first demonstrated by the double-slit experiment, where electrons create an interference pattern typical of waves.

2. Uncertainty Principle: Formulated by Werner Heisenberg, the uncertainty principle states that it is impossible to simultaneously know the exact position and momentum of a particle. This principle highlights the intrinsic limitations in measuring quantum systems.

3. Superposition: Quantum superposition allows particles to exist in multiple states at once until they are measured. For example, an electron in a quantum system can be in a superposition of spin-up and spin-down states.

4. Entanglement: Quantum entanglement is a phenomenon where particles become interconnected, such that the state of one particle instantaneously influences the state of

another, no matter the distance between them. This "spooky action at a distance," as Einstein called it, has been experimentally validated and is a cornerstone of quantum information science.

Applications of Quantum Mechanics: Quantum mechanics has led to numerous technological advancements and theoretical insights:

1. Quantum Computing: Leveraging the principles of superposition and entanglement, quantum computers promise to solve complex problems that are intractable for classical computers.

2. Semiconductor Technology: The development of transistors and integrated circuits, which are the backbone of modern electronics, relies heavily on quantum mechanics.

3. Medical Imaging: Techniques such as MRI (Magnetic Resonance Imaging) are based on quantum mechanical principles.

Challenges and Future Directions

Despite its successes, quantum mechanics presents several challenges. The interpretation of quantum mechanics remains a topic of debate among physicists. Various interpretations, such as the Copenhagen interpretation, many-worlds interpretation, and pilot-wave theory, offer different perspectives on the nature of quantum reality.

Future research aims to unify quantum mechanics with general relativity, Einstein's theory of gravitation, to form a complete theory of quantum gravity. This endeavor is crucial for understanding the universe at the Planck scale, where quantum effects and gravitational forces are both significant.

Conclusion

Quantum mechanics has profoundly transformed our understanding of the physical world. Its principles, though often counterintuitive, have led to groundbreaking technologies and deepened our comprehension of the universe's fundamental nature. As research continues, the mysteries of quantum mechanics promise to unlock even more profound insights into the fabric of reality.

The Cosmic Web of Magnetism: Unveiling the Universe's Hidden Force

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Introduction

The universe is a tapestry of forces, among which magnetism plays a enigmatic yet pivotal role. From the protective sheath around Earth to the colossal structures of galaxies, magnetic fields permeate the cosmos, influencing everything from star birth to cosmic ray trajectories. This article explores the origins, extent, and implications of these magnetic fields, shedding light on one of astronomy's most intriguing puzzles.

Objective

- To study the cosmic magnetism
- To study the Origins: From Primordial Seeds to Galactic Dynamos
- To study Intergalactic Magnetic Fields: The Cosmic Frontier
- To study the Implications: Shaping the Universe:
- To study the Current Research and Future Prospects:

Methodology: The collection of data in this article are taken from some book and different type of website.

Discussion

Cosmic Magnetism: A Universal Phenomenon

Magnetic fields are ubiquitous, observed in planets, stars, and galaxies. Earth's dynamo-generated field shields life from solar winds, while the Sun's magnetic activity drives space weather. Galactic fields, though weaker (microgauss), stretch across light-years, shaping star-forming regions. Beyond galaxies, recent studies suggest even the vast intergalactic voids—once thought inert—may host faint magnetic fields, detected via polarized light from distant quasars and synchrotron radiation from high-energy electrons.

Origins: From Primordial Seeds to Galactic Dynamos

The genesis of cosmic magnetism remains debated. Two primary theories emerge:

1. Primordial Origins: Magnetic fields may have arisen in the early universe's plasma, post-Big Bang. Quantum fluctuations during inflation or phase transitions could have seeded weak fields, later amplified by cosmic structures.

2. Astrophysical Dynamos: Galactic fields might originate from the Biermann battery effect, where pressure and density gradients in early plasma generate seed fields. These are then amplified by turbulent dynamos in rotating galaxies, converting kinetic energy into magnetic energy.

Intergalactic Magnetic Fields: The Cosmic Frontier

Intergalactic magnetic fields (IGMFs), though elusive, are theorized to exist in the cosmic web—filaments connecting galaxy clusters. Detecting IGMFs involves:

- Faraday Rotation: Measu`ring polarization twists in light as it traverses magnetized plasma.

- Gamma-Ray Observation: High-energy photons from blazars interact with IGMFs, creating detectable particle cascades.

- CMB Studies: Polarization patterns in the Cosmic Microwave Background may hold imprints of early magnetic activity.

Recent simulations suggest IGMFs could originate from galactic outflows or active galactic nuclei, ejecting magnetized material into intergalactic space. However, primordial origins remain plausible, with some models proposing fields as weak as 10^{-19} Gauss in voids.

Implications: Shaping the Universe

Cosmic magnetism influences:

1. Star Formation: Magnetic pressure regulates gas collapse in molecular clouds.

2. Galactic Evolution: Fields channel interstellar medium flows, affecting spiral arm structures.

3. Cosmic Rays: Magnetic fields deflect these particles, complicating tracing their origins.

4. Large-Scale Structure: IGMFs might suppress gas collapse in filaments, subtly shaping the cosmic web.

Current Research and Future Prospects:

Cutting-edge projects aim to unravel magnetic mysteries:

1.Square Kilometer Array (SKA): This radio telescope will map galactic and intergalactic fields with unprecedented precision.

2.CMB Experiments: Missions like LiteBIRD seek primordial magnetic signatures in polarization data.

3.Numerical Simulations: Advanced models, such as those using the IllustrisTNG framework, track magnetic evolution from the universe's infancy.Recent breakthroughs include the Event Horizon Telescope's imaging of magnetic fields near black holes, offering clues on jet formation and galactic-scale field dynamics.

Conclusion

Magnetic fields are a cornerstone of cosmic evolution, yet their origins and large-scale roles remain enigmatic. As observational techniques and simulations advance, we edge closer to deciphering this magnetic puzzle, revealing how invisible forces sculpt the visible universe. The journey to understand cosmic magnetism not only illuminates the past but also guides our exploration of the universe's deepest secrets.

Basic Physics Formula and Their Daily Life Application

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Abstract

Physics is an essential part of our daily lives, governing everything from motion and energy to electricity and pressure. This article explores fundamental physics formulas, such as Newton's laws of motion, work, power, kinetic energy, Ohm's law, gravity, density, speed, momentum, and pressure, highlighting their real-world applications. By simplifying complex concepts and providing practical examples, the article aims to enhance scientific awareness and demonstrate how physics influences everyday activities, from driving a car to using household appliances. Through explanation, and validation, this article serves as an educational resource for students, educators, and science enthusiasts, fostering a deeper understanding of physics in daily life.

Introduction

Physics is not just a subject confined to textbooks and classrooms—it is the foundation of the universe itself. From the motion of celestial bodies to the smallest particles within an atom, physics governs everything around us. It is present in the way we walk, the electricity that powers our homes, the vehicles we travel in, and even the way we communicate using mobile phones and the internet. Without physics, the modern world as we know it would not exist.

Many people perceive physics as a complex and abstract field, filled with daunting equations and theories. However, at its core, physics is simply the study of how things work. Whether you are switching on a light, boiling water, riding a bicycle, or playing a sport, you are unknowingly applying the principles of physics. Understanding basic physics formulas not only enhances our knowledge but also helps us make informed decisions in daily life. For instance, knowing how momentum works can explain why a heavy truck takes longer to stop than a bicycle, or how energy conservation plays a role in reducing electricity bills.

Here we are going to break down some of the most fundamental physics formulas and their real-life applications. By connecting science to everyday experiences, we can develop a deeper appreciation for the role physics plays in our lives. Whether you are a student, a curious learner, or simply someone who enjoys understanding the world better, these concepts will show you that physics is not just a subject—it is a way of understanding and interacting with the world around us.

Let's explore some essential physics formulas and their practical significance in our daily routines.

Objectives

1. To Explain the Role of Physics in Daily Life.
2. To Introduce Basic Physics Formulas.

Methodology: This article was developed through extensive research, selection of fundamental physics concepts, simplification of theories, use of real-life examples, and validation of information to ensure accuracy and practical relevance.

Discussion

Newton's Second Law of Motion

Newton's Second Law of Motion states that the force acting on an object is equal to the product of its mass and acceleration. Mathematically, it is expressed as:

$F = ma$

Where F = Force (in Newton's, N),m = Mass of the object (in kilograms, kg), a = Acceleration (in meters per second squared, m/s^2)
This law explains how the motion of an object changes when a force is applied to it. The greater the force, the greater the acceleration. Similarly, a heavier object requires more force to accelerate than a lighter one.
Real-Life Example:
Pushing a Shopping Cart: If you push an empty cart, it moves easily. But if the cart is full, it requires more force to achieve the same acceleration.

Driving a Car:
Pressing the accelerator increases the force on the car, making it speed up (increase acceleration). A heavier car (more mass) requires more force to accelerate than a lighter one.
This law is fundamental in understanding motion, from simple activities like walking to complex systems like rocket launches.
Work Done:
Newton's Second Law explains how force affects motion, but how do we measure the effect of force over a distance? That's where the concept of work comes in.
Formula: W = Fdcosɵ
Where, W = Work done (in Joules, J),F= Force applied (in Newton's, N),d= Distance moved by the object (in meters, m),ɵ = Angle between the force and direction of movement
Work is done when a force is applied to an object and the object moves in the direction of the force. If there is no movement, no work is done even if force is applied.
Real-Life Example:
Lifting a Bag: When you lift a grocery bag from the floor, you apply a force upward, and since the bag moves in the same direction, work is done.

Pushing a Car: If you push a car but it doesn't move, no work is done, even though you are applying force.

Cycling Uphill vs. Flat Ground: More work is needed to cycle uphill because you are moving against gravity, requiring more force.
This concept helps us understand energy transfer in physical activities, machines, and engineering applications.
Power:
Now that we understand work, the next important concept is power, which tells us how fast work is done. Power is the rate at which work is performed or energy is transferred.
Formula: P = W/t
Where, P = Power (in Watts, W), W = Work done (in Joules, J), t = Time taken (in seconds, s)
Power measures how quickly work is done. If two people do the same amount of work, but one does it faster, that person has more power.
Real-Life Example:
Running vs. Walking Up Stairs: If two people climb the same set of stairs, but one runs and the other walks, the runner exerts more power because they do the same work in less time.
Light Bulbs: A 100-watt bulb consumes energy faster than a 60-watt bulb, making it brighter.

Car Engines: A sports car has a more powerful engine than a regular car, allowing it to accelerate faster.

Understanding power helps in designing electrical appliances, engines, and even improving human efficiency in physical activities.

Kinetic Energy:

Now that we have covered work and power, let's talk about energy—the ability to do work. One of the most important forms of energy in physics is kinetic energy, which is the energy of motion.

Formula: $KE = 1/2mv^2$

Where, k = Kinetic Energy (in Joules, J), m= Mass of the object (in kilograms, kg), v= Velocity of the object (in meters per second, m/s), Kinetic energy depends on both mass and velocity. This means:

The faster an object moves, the more kinetic energy it has. A heavier object moving at the same speed as a lighter one has more kinetic energy.

Real-Life Example:

Moving Vehicles: A speeding car has more kinetic energy than a slow-moving car. That's why accidents at high speeds are more dangerous.

Cycling Downhill: When you ride a bicycle downhill, your speed increases, and so does your kinetic energy.

A Falling Object: If you drop a ball, its kinetic energy increases as it falls because its speed increases.

Kinetic energy plays a crucial role in transportation, sports, and even safety measures like seatbelts and airbags in cars.

Ohm's Law: Electricity is a fundamental part of daily life, and one of the most important laws in electrical physics is Ohm's Law, which describes the relationship between voltage, current, and resistance in an electrical circuit.

Formula: $V = IR$

Where ,V= Voltage (in Volts, V), I= Current (in Amperes, A), R= Resistance (in Ohms, Ω)

This formula means that if voltage increases, current increases (if resistance stays the same). If resistance increases, current decreases (if voltage stays the same).

Real-Life Example:

Household Appliances: A high-power appliance like a heater has low resistance, allowing more current to flow.

Phone Charging: A higher voltage charger (like a fast charger) provides more current to charge your phone faster.

Light Bulbs: A 100-watt bulb has lower resistance than a 40-watt bulb, so it allows more current to flow and shines brighter.

Ohm's Law helps in designing electrical circuits, choosing the right appliances, and ensuring electrical safety in homes and industries

Gravitational Force:

Gravity is one of the most fundamental forces in the universe. It is the reason why objects fall to the ground and why planets stay in orbit around the sun. Newton's Law of Universal Gravitation explains how gravity works between two objects.

Formula: $F = Gm_1m_2/r^2$

Where, F= Gravitational force (in Newton's, N), G = Gravitational constant (Nm^2/kg^2)

m_1 and m_2 = Masses of the two objects (in kilograms, kg) and r= Distance between the centers of the two objects (in meters, m)
The larger the masses of the objects, the stronger the gravitational force between them.
The farther apart the objects are, the weaker the gravitational force.
Real-Life Example:
Falling Objects: When you drop something, gravity pulls it toward the Earth.
Tides in the Ocean: The moon's gravity pulls on Earth's oceans, causing high and low tides.
Weight Differences on Other Planets: Your weight on the moon is less than on Earth because the moon's gravitational force is weaker.
Gravity is essential for life on Earth, keeping us grounded, influencing weather patterns, and playing a key role in space exploration.
Density:
Density is a measure of how much mass is packed into a given volume. It helps explain why some objects float while others sink.
Formula: rho = m/v where, (rho) = Density (in kg/m³), m= Mass of the object (in kilograms, kg), v = Volume of the object (in cubic meters, m³)
If an object has high density, it means more mass is packed into a smaller space.
If an object has low density, it means the mass is spread out over a larger space.
Real-Life Example:

- Why Ice Floats on Water: Ice has a lower density than liquid water, so it floats.
- Ships Floating on Water: A steel ship is heavy, but its shape ensures that its overall density is lower than that of water, allowing it to float.
- Cooking Oil and Water: Oil is less dense than water, so it floats on top when mixed.

Density is important in engineering, cooking, material selection, and understanding natural phenomena like buoyancy and fluid behavior
Speed and Velocity:
Speed and velocity describe how fast an object moves. While speed is just the rate of motion, velocity also considers direction.
Formula: $v = c/t$

- v = Speed or velocity (in meters per second, m/s)
- d = Distance traveled (in meters, m)
- t = Time taken (in seconds, s)

Speed is how fast something moves, without considering direction.
Velocity is speed with direction (e.g., 60 km/h east).
Real-Life Example:

- **Driving a Car:** The speedometer shows how fast the car is moving (speed), but if you say you're driving north at 60 km/h, that's velocity.
- Athlete Running a Race: A sprinter running 100 meters in 10 seconds has a speed of 10 m/s.
- Airplanes and Weather Reports: Pilots and meteorologists use velocity to describe wind speed and direction.

Speed and velocity are essential in transportation, sports, aviation, and tracking the motion of objects in physics
Momentum:
Momentum is the measure of an object's motion and depends on both its mass and velocity. It helps explain why some objects are harder to stop than others.

Formula: $p = mv$, p = Momentum (in kg,m/s), m= Mass of the object (in kilograms, kg), v = Velocity of the object (in meters per second, m/s)
An object with more mass or higher velocity has greater momentum. A moving truck has more momentum than a bicycle moving at the same speed because of its larger mass.
Momentum is conserved in a closed system, meaning the total momentum before and after an event remains the same.
Real-Life Example:

- Car Collisions: A heavy truck moving at high speed has more momentum, making it harder to stop in an accident.
- Sports: A fast-moving football is harder to stop than a slow-moving one because of its momentum.
- Rocket Launches: Rockets use high-speed exhaust gases to gain momentum and lift off into space.

Momentum is crucial in understanding motion, vehicle safety, sports physics, and even space travel.
Pressure:
Pressure is the amount of force applied over a certain area. It helps explain why sharp objects cut better and why deep-sea divers experience more force underwater.
Formula: $P = F/A$
Here, P = Pressure (in Pascals, Pa), F= Force applied (in Newtons, N) and A = Area over which the force is applied (in square meters, m^2)
More force on the same area increases pressure. A smaller area with the same force increases pressure (e.g., a sharp knife cuts better than a blunt one).
Real-Life Example:

- Walking on Snow: Snowshoes spread your weight over a larger area, reducing pressure and preventing you from sinking.
- Nails and Pins: A nail has a sharp tip to concentrate force on a small area, increasing pressure and making it easier to driv…

These were some of the most fundamental physics formulas used in daily life. However, physics has many more important concepts that influence our world, such as thermodynamics, electromagnetism, and quantum mechanics.
Conclusion:
Physics is everywhere—from the motion of a car to the electricity in our homes. Understanding these basic formulas helps us appreciate how the world works and allows us to make smarter decisions in daily life. Whether it's understanding why a heavy truck takes longer to stop, why a balloon rises, or how electricity flows in our gadgets, physics provides the answers.
By applying these concepts, we not only gain knowledge but also develop problem-solving skills that are useful in engineering, medicine, sports, and technology. So the next time you drive a car, turn on a light, or play a sport, remember that physics is at work!

Chandrayaan -3 Mission

Radhe Shyam Das B.Sc. 6th Semester, Physics Department, Bijni College

Chandrayaan-3 is India's third lunar mission launched by ISRO. The Aim was to achieve a successful soft landing on the Moon's South Pole. A testament to India's growing technological and scientific capabilities in space exploration.

Objectives of Chandrayaan-3 are:

1. Soft landing on the lunar surface.
2. Study of the Moon's South Pole region.
3. Conduct scientific experiments on lunar soil composition and temperature.
4. Strengthen India's position in global space exploration.

Discussion:

Key Benefits for India

1. Technological Advancements:-Indigenous development of soft landing technology, Improved propulsion systems and navigation.
2. Scientific Discoveries:-Analysis of lunar soil and surface composition Detection of potential water-ice deposits.
3. Boost to Space Industry:-Growth of indigenous manufacturing in space technology, Increased involvement of private players and start-ups.
4. Educational and Inspirational Impact:-Encouragement for students in STEM fields, Awareness of space exploration initiatives.
5. Economic and Industrial Growth:-Increased investments and job creation in the space sector
6. National Prestige and Global Recognition:-Enhanced India's position as a leading space-faring nation, Strengthened international collaborations.
7. Strategic and Geopolitical Impact:-Strengthening India's space defense capabilities, Contribution to space diplomacy.

Conclusion:

Chandrayaan-3 represents a milestone in India's space journey.Its success brings technological, scientific, and economic benefits. A source of national pride and a foundation for future space exploration missions.

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Discovery of Supersolid

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Introduction

A supersolid is a state of matter that combines the rigid structure of a solid with the frictionless flow of a superfluid. Theoretical predictions of supersolidity date back to the 1960s, but experimental confirmation remained elusive until recent breakthroughs. Researchers have now observed supersolids in ultracold atomic gases, marking a major advancement in condensed matter physics and quantum mechanics.

Objectives

The main goals of supersolid research are:

1. Confirming Supersolidity – Demonstrating the coexistence of solid and superfluid properties.
2. Understanding Quantum Effects – Investigating the role of Bose-Einstein condensates (BECs) in supersolidity.
3. Observing Quantum Vortices – Detecting superfluid vortices within a crystalline structure.
4. Exploring Applications – Assessing potential uses in quantum materials and technology.

Discussion

A supersolid is a paradoxical state where atoms form a rigid crystalline structure while simultaneously flowing without resistance. This behavior defies classical physics and is governed by quantum mechanics. Supersolidity requires extreme conditions, such as temperatures close to absolute zero, where atoms behave as a collective quantum state.

Experimental Discovery

Early Attempts and Theoretical Background

The idea of supersolidity was first proposed in the 1960s in relation to solid helium. However, early experiments failed to produce conclusive results. The breakthrough came in 2019, when three independent research teams—Stuttgart, Florence, and Innsbruck—successfully created supersolids in ultracold quantum gases using dipolar atoms.

Breakthrough in 2024: Detecting Quantized Vortices

In 2024, scientists at the University of Innsbruck provided direct evidence of superfluidity in a supersolid by detecting quantized vortices—tiny whirlpools of fluid motion. Using precise magnetic field manipulations, they induced and observed these vortices within a supersolid made of erbium atoms, confirming its superfluid nature.

How Supersolids Work

1. Bose-Einstein Condensates (BECs): Atoms are cooled near absolute zero, forming a single quantum state.
2. Long-Range Interactions: Dipolar atoms interact via both attractive and repulsive forces, creating a self-organized density wave.

3. Coexistence of Solid and Superfluid Properties: Atoms form a regular pattern (solid) while also flowing without viscosity (superfluid).

Key Observations

- Crystalline Structure: Atoms arranged in an ordered pattern.
- Superfluid Flow: Frictionless movement within the structure.
- Quantized Vortices: Proof of superfluid behavior.

Challenges and Future Research

- Extreme Conditions: Supersolids require temperatures near absolute zero.
- Precise Control: Small disturbances can disrupt supersolid states.
- Potential Applications: Research continues into applications for quantum materials and future technologies.

Conclusion

The discovery of supersolids confirms a long-standing theoretical prediction and opens new avenues in quantum physics. By demonstrating a phase that merges solid and superfluid properties, this research paves the way for future advancements in quantum technology, superconductors, and fundamental physics. Continued exploration of supersolids could lead to breakthroughs in quantum computing and advanced materials.

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The First Image of a Black Hole

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Introduction

In April 2019, the world witnessed a groundbreaking achievement in the field of astronomy—the first-ever image of a black hole. This image, captured by the Event Horizon Telescope (EHT) collaboration, was not just a triumph of technology and innovation but also an incredible leap forward in our understanding of the universe. The photograph showed the shadow of a supermassive black hole at the center of the galaxy M87, located about 55 million light-years away from Earth. This achievement marked the culmination of decades of research and collaboration by scientists from around the world.

Understanding Black Holes

.: Before delving into the significance of the first black hole image, it's essential to understand what black holes are and why they have fascinated scientists for over a century. A black hole is a region of space where gravity is so intense that nothing, not even light, can escape from it. The "surface" of a black hole is known as the event horizon—the boundary beyond which nothing can return. Black holes are formed when massive stars collapse under their own gravity, creating an infinitely dense point known as a singularity. These objects are invisible to conventional telescopes because light cannot escape them.

The concept of black holes was first theorized by Albert Einstein's theory of general relativity in 1915, and it wasn't until the 1960s that the term "black hole" was coined by physicist John Archibald Wheeler. For many years, black holes remained an abstract theoretical concept with no direct observational evidence. Scientists could only infer their existence based on their gravitational effects on nearby stars and galaxies.

The Event Horizon Telescope

.: The image of the black hole was made possible by the Event Horizon Telescope (EHT), an international collaboration of over 200 scientists and engineers from various institutions across the globe. The EHT is not a single telescope but a network of radio telescopes spread across different continents, functioning as a single Earth-sized telescope. This global array of telescopes, known as a very long baseline interferometer (VLBI), allowed scientists to capture extremely detailed and high-resolution images of distant cosmic objects.

The EHT uses a technique called interferometry, which combines data from multiple radio telescopes to simulate a telescope the size of the Earth. By synchronizing these telescopes, astronomers can capture sharper images and detect radio waves emitted by objects that would otherwise be too distant or faint to observe. The EHT network includes facilities in locations such as Antarctica, Chile, Spain, the United States, and more, ensuring that the data gathered is comprehensive and precise.

The First Image: M87's Supermassive Black Hole

The black hole whose image was captured resides at the center of the galaxy M87, a supergiant elliptical galaxy in the Virgo Cluster. This black hole, known as M87 (M87 star), is about 6.5 billion times more massive than our Sun and has a diameter of approximately 40 billion kilometers, roughly equivalent to the size of our solar system. This makes M87 one of the largest known black holes in the universe.

The image shows a bright ring of light encircling a dark center—the "shadow" of the black hole. The ring is formed by gas and dust being heated to extreme temperatures as they spiral toward the event horizon. This process, known as accretion, emits intense radiation, which is what the EHT captured. The dark center represents the event horizon, where gravity is so strong that not even light can escape.

This image confirmed the long-standing theoretical predictions about the nature of black holes and provided a visual representation of a phenomenon that was once purely theoretical. The data gathered from the EHT's observations also provided key insights into the behavior of matter and energy near the event horizon, helping scientists better understand the fundamental laws of physics, particularly the interplay between gravity, space, and time.

The Significance of the Image

The release of the first image of a black hole was not just a technical achievement; it also had profound implications for the field of astrophysics. It provided concrete evidence of the existence of black holes, which had been theorized for decades but never directly observed. It also provided valuable data to test Einstein's general theory of relativity under extreme conditions. The image showed that the behavior of light and matter near a black hole aligns closely with predictions made by general relativity, further validating this fundamental theory.

In addition to advancing our understanding of black holes, the image also opened new avenues for future research. The EHT team continues to study the data gathered from M87 and has set its sights on capturing images of other black holes, including the one at the center of our Milky Way galaxy, known as Sagittarius A. These future images will help refine our understanding of black hole formation, growth, and the role they play in the evolution of galaxies.

Conclusion

The first image of a black hole was a milestone in both science and human achievement. It marked a new era in our ability to observe the universe at its most extreme, providing a glimpse into the heart of one of the most mysterious and powerful phenomena in space. The success of the EHT project is a testament to the power of global collaboration, technological innovation, and human curiosity. As we continue to explore the cosmos, the image of M87 will remain a symbol of how far we've come in unraveling the mysteries of the universe, and it will inspire future generations of scientists to reach even further into the unknown.

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NISAR (A Revolutionary Earth-Observing Mission)

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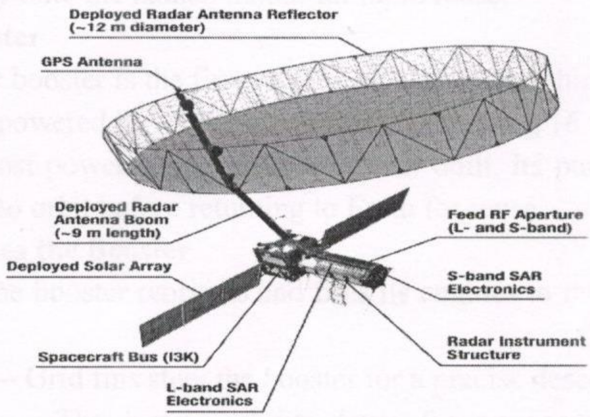
The NASA-ISRO Synthetic Aperture Radar (NISAR) mission is a joint project between NASA and ISRO to co-develop and launch a dual-frequency synthetic aperture radar on an Earth observation satellite in 2025. The satellite will be the first radar imaging satellite to use dual frequencies. It will be used for remote sensing, to observe and understand natural processes on Earth.

The main objectives of NISAR are :

- To Monitor Natural Hazards : NISAR aims to monitor and study natural hazards such as earthquakes, landslides, and volcanic eruptions. The satellite's radar imaging capabilities will help scientists understand the causes and consequences of these events.
- To Track Environmental Changes : NISAR will track environmental changes such as deforestation, glacier melting, and sea-level rise. The satellite's data will help scientists understand the impacts of climate change and develop strategies for mitigating its effects.
- To Study Earth's Ecosystems : NISAR will study Earth's ecosystems, including forests, oceans, and land surfaces. The satellite's radar imaging capabilities will provide insights into ecosystem processes, such as biomass production, soil moisture, and ocean currents.



NASA-ISRO Synthetic Aperture Radar (NISAR) is a collaborative Earth observation mission between NASA and the Indian Space Research Organisation (ISRO). Scheduled for launch in 2024, NISAR will be the first radar imaging satellite to use dual L-band and S-band synthetic aperture radar (SAR) technology, allowing it to capture high-resolution images of Earth's surface regardless of weather or daylight conditions. The mission aims to monitor land surface changes, track natural disasters like earthquakes, landslides, and floods, and improve our understanding of climate change by studying ice sheet dynamics and forest biomass.

NISAR's advanced radar system will enable scientists to collect precise data on ecosystem disturbances, agricultural productivity, and coastal processes. The satellite's ability to provide frequent and consistent observations will enhance disaster response and resource management globally. By combining NASA's expertise in L-band radar with ISRO's S-band radar capabilities, NISAR represents a significant step in international cooperation for Earth science and sustainability. Conclusion: NISAR represents a major milestone in global Earth observation efforts. With its advanced radar imaging technology, it promises to improve disaster preparedness, climate change monitoring, and resource management. The collaboration between NASA and ISRO highlights the significance of international cooperation in space exploration, paving the way for future missions that can further our understanding of Earth's dynamic processes.

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Mechazilla Has Caught the Super Heavy Booster

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On October 13, 2024, SpaceX made history by successfully catching the Super Heavy booster with its Mechazilla system during Starship's fifth test flight. This breakthrough represents a major step toward full rocket reusability, drastically reducing the cost and time required for space missions. By eliminating the need for ocean landings and complex recovery operations, SpaceX has demonstrated an innovative approach to next-generation spaceflight.

The primary goals of this achievement include:

- Improving Reusability – Enabling rapid booster turnaround for future launches.
- Reducing Costs – Eliminating the need for costly landing legs and ocean recovery operations.
- Increasing Payload Capacity – Allowing for larger cargo loads by removing landing gear.
- Enhancing Landing Precision – Using an automated, high-precision catch system.
- Pioneering Deep-Space Exploration – Creating a sustainable launch system for Mars and Moon missions.

Understanding Mechazilla

Mechazilla is a robotic catch system mounted on the Starbase launch tower. Instead of relying on traditional landings, it catches the Super Heavy booster mid-air using two massive mechanical arms, nicknamed "chopsticks." These arms support the booster, securing it safely onto the launch mount for rapid reuse.

The Super Heavy Booster

The Super Heavy booster is the first stage of SpaceX's Starship system. It is 230 feet (70 meters) tall and powered by 33 Raptor engines, generating 16 million pounds of thrust—making it the most powerful rocket booster ever built. Its purpose is to propel Starship's upper stage into orbit before returning to Earth for reuse.

How Mechazilla Catches the Booster

1. Boost-Back Burn – The booster reorients and fires its engines to return to the launch site.
2. Aerodynamic Control – Grid fins steer the booster for a precise descent.
3. Final Landing Burn – The booster slows down for an accurate approach to Mechazilla.
4. Catching the Booster – The chopstick arms close around the booster, securing it mid-air.
5. Repositioning – The arms gently lower the booster onto the launch mount for immediate reuse.

Technical Breakdown

- Grid Fins – Four titanium grid fins provide fine control during descent.

- Chopstick Arms – Massive mechanical arms move using hydraulic actuators to grip the booster.
- Flight Computers – AI-driven guidance systems ensure a precise landing.
- Raptor Engines – Methane-powered engines dynamically adjust thrust for controlled descent.

Challenges & Solutions

1. Precision Navigation

The booster must align perfectly with the chopstick arms. This is achieved using GPS, AI, and real-time telemetry.

2. Structural Durability

The arms must withstand extreme forces. SpaceX engineered them using high-strength steel and hydraulic dampers to absorb impact forces.

3. Timing & Synchronization

The system must operate within seconds for a successful catch. Advanced software automation ensures perfect coordination between descent and arm movements.

Conclusion:

The successful capture of the Super Heavy booster by Mechazilla represents a major milestone for spaceflight technology. By eliminating ocean landings and reducing refurbishment time, this system will significantly lower launch costs while increasing mission frequency. More importantly, Mechazilla is a critical step toward SpaceX's vision of interplanetary travel, making missions to the Moon and Mars more feasible. This revolutionary advancement proves that fully reusable rockets are not only possible but essential for the future of space exploration.

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OPTICS

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Optics is a branch of physics that deals with the determination of behavior and the properties of light, along with its interaction with the matter and also with the instruments which are used to detect it. The study of light in the area of physics is known as optics. Ray optics is also called geometrical optics. It is a branch of science that describes light proportion in terms of ''rays''. Light and its properties:- Light is a form of energy that is in the form of an electromagnetic wave and is almost energy where around us. The visible light has wavelengths measuring between 400-700 nanometers. The sum is the primary source of light by which plans utilize this to produce their energy. In physics, the terms light also refers to electromagnetic radiation of different kinds of wavelengths, whether it is visible to the naked eye or not.

Speed of light:- the rate at which the light travels in free space is called the speed of light. For example, light travels 30% slower in water when compared to vacuum.

Refraction:- the bending of light when it passes from one medium to another is called refraction. This property of refraction is used in a number of devices like microscopes, magnifying lenses,corrective

Lenses and so on. In his property when the light is transmitted through a medium , polarization of electrons takes place which in term reduces the speed of light, thus changing the direction of light.

Dispersion :- It is a property of light where the white light splits into its constituent colours. Dispersion

Can be observed in the form of a prism. The other properties of light include diffraction and interference.

Total internal reflection:- When a beam of light strikes the water , a part of the light is reflected and some part of the light is reflected. This phenomenon is called as total internal reflection.

Reflection :- reflection is one of the primary properties of light. Reflection is nothing but the images you see in the mirrors. Reflection is defined as the change in direction of light at an interface in between two deferent media so that the wave-front returns into a medium from which it was originated . the typical example s for reflection of light include sound waves and water wave.

Application of optics :-

The properties of optics are applied in various field of physics:-

- The refraction phenomenon is applied in the case of lenses (concave and convex) for the purpose of forming an image of the object.
- Geometrical ooptics is used in studies of how the image form in an optical system.
- It is used in the therapeutical and surgeries of the human tissues.

The Planet, I Want To Visit (Mars)

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Introduction

For centuries, Mars has captivated the human imagination. Often called the Red Planet, it has been a subject of myths, science fiction, and real scientific inquiry. Unlike distant exoplanets, Mars is within our reach, making it the most realistic destination for human exploration and colonization. In this article, I will explore why Mars is the planet I want to visit, the scientific significance of the journey, and the challenges of living on the Red Planet.

Discussion

Why Choose Mars?

1. A Step Toward Interplanetary Civilization:- Mars represents humanity's next frontier. If we can successfully establish a presence there, it would be a major step toward becoming an interplanetary species. This could ensure human survival in case of catastrophic events on Earth.

2. A Planet Rich in History and Science :- Mars has a fascinating geological history. Scientists believe it once had rivers, lakes, and possibly an ocean. Studying its terrain could reveal how planets evolve and whether life once existed beyond Earth.

3. Potential for Human Settlement :- Unlike other planets in our solar system, Mars has some conditions that make it more habitable:

• It has a day length of 24.6 hours, similar to Earth.

• There is evidence of water ice beneath its surface.

• It has carbon dioxide, which could be used for oxygen production.

These factors make Mars the most promising candidate for a second home for humanity.

3 Target Audience This article is for space enthusiasts, future astronauts, scientists, and anyone interested in human space exploration. Whether you are a student dreaming of becoming an astronaut, a scientist searching for extraterrestrial life, or a sci-fi lover imagining a Martian colony, this article will take you on a journey to Mars.

Scientific Facts About Mars :-

1. Location and Distance:- Mars is the fourth planet from the Sun and the second smallest in our solar system. It is about 225 million km (140 million miles) away from Earth, depending on its position in orbit.

2. Atmosphere and Climate Mars has a thin atmosphere, mostly composed of carbon dioxide (95.3%), with very little oxygen. The lack of a dense atmosphere means:

• Temperatures are extreme, ranging from-140°C (-220°F) at night to 20°C (68°F) during the day.

• There is no liquid water on the surface, but evidence of underground water exists.

• Dust storms can last for weeks, covering the entire planet.

3. Gravity and Surface Conditions :-Mars has 38% of Earth's gravity, meaning you would weigh much less than on Earth. This could have long-term effects on human muscles and bones. Its surface is rocky and covered in iron oxide, giving it a reddish color. It has the tallest volcano in the solar system, Olympus Mons, and a canyon system (Valles Marineris) that dwarfs the Grand Canyon.

4. Possibility of Life:- Scientists believe that microbial life might have existed on Mars in the past. Recent discoveries of organic molecules and methane variations suggest that Mars could still support some form of life underground.

The Journey to Mars

1. Current Space Travel Limitations

With current technology, a mission to Mars takes about 6 to 9 months. Some of the challenges include:

• Radiation exposure from cosmic rays and solar storms.

• Psychological effects of long-duration space travel.

• Limited resources, requiring astronauts to be self-sufficient.

2. Future Technologies for Faster Travel:- To make travel to Mars safer and faster, scientists are working on:

• Nuclear thermal propulsion, which could cut travel time in half

. • Plasma engines, which could provide continuous thrust for long journeys.

• SpaceX's Starship, a fully reusable spacecraft designed for Mars missions.

3. The First Human Mission :-

NASA and private companies like SpaceX plan to send humans to Mars within the next two decades. The goal is to set up a permanent base, test in-situ resource utilization (ISRU), and eventually terraform the planet for long-term habitation.

Challenges of Living on Mars

1. Surviving in a Harsh Environment

Mars is cold, dry, and has a thin atmosphere. To survive, astronauts will need:

• Protective suits to withstand radiation and low pressure.

• Water recycling systems to conserve resources.

2. Sustaining Life with Limited Resources

Mars has no supermarkets or fresh water supply. Future settlers will need to:

• Grow food in Martian soil, possibly using hydroponics or greenhouses.

• Extract water from underground ice.

• Generate oxygen from the atmosphere using technologies like MOXIE (Mars Oxygen In-Situ Resource Utilization Experiment).

3. Adapting to Low Gravity

Long-term exposure to lower gravity could weaken human muscles and bones. Astronauts may need:

• Artificial gravity solutions, such as rotating habitats.

• Regular exercise to maintain muscle and bone strength.

4. Communication Delays

. Since Mars is millions of kilometers away, communication with Earth has a delay of 5 to 20 minutes. This means astronauts must operate independently, relying on AI and automated systems.

Future of Mars Exploration

1. Colonizing Mars

Experts predict that within 50 to 100 years, we could have selfsustaining colonies on Mars. This could lead to:

• The first Martian cities, built underground or in domes.

• Terraforming projects to make the atmosphere more Earth-like.

• New industries, such as mining and scientific research.

2. The Search for Martian Life

Future missions will continue exploring Mars for signs of microbial life. If life is found, it could change our understanding of biology and the potential for life elsewhere in the universe.

3. Space Tourism

One day, traveling to Mars might not be just for astronauts. Private companies may offer trips for adventurous tourists, making Mars a destination for exploration and adventure.

Conclusion:

Mars is the planet I most want to visit because it represents the future of human space exploration. While it poses many challenges, it also offers endless possibilities for discovery, settlement, and even the survival of our species. Whether as a scientist searching for life, an engineer building the first Mars colony, or a dreamer looking toward the stars, Mars holds a special place in our future. As technology advances, the dream of walking on the Red Planet is becoming more realistic than ever.

QUANTUM ENTANGLEMENT

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Introduction:

Quantum entanglement is the phenomenon of a group of particles being generated, interacting, or sharing spatial proximity in a manner such that the quantum state of each particle of the group cannot be described independently of the state of the others, including when the particles are separated by a large distance. The topic of quantum entanglement is at the heart of the disparity between classical physics and quantum physics: entanglement is a primary feature of quantum mechanics not present in classical mechanics.

Measurements of physical properties such as position, momentum, spin, and polarization performed on entangled particles can, in some cases, be found to be perfectly correlated. For example, if a pair of entangled particles is generated such that their total spin is known to be zero, and one particle is found to have clockwise spin on a first axis, then the spin of the other particle, measured on the same axis, is found to be anticlockwise. However, this behaviour gives rise to seemingly paradoxical effects: any measurement of a particle's properties results in an apparent and irreversible wave function collapse of that particle and changes the original quantum state. With entangled particles, such measurements affect the entangled system as a whole.

Such phenomena were the subject of a 1935 paper by Albert Einstein, Boris Podolsky, and Nathan Rosen,and several papers by Erwin Schrödinger shortly thereafter,describing what came to be known as the EPR paradox. Einstein and others considered such behaviour impossible, as it violated the local realism view of causality (Einstein referring to it as "spooky action at a distance")and argued that the accepted formulation of quantum mechanics must therefore be incomplete.

Discussion:

Existing in multiple states at once:

To truly understand the spookiness of quantum entanglement, it is important to first understand quantum superposition. Quantum superposition is the idea that particles exist in multiple states at once. When a measurement is performed, it is as if the particle selects one of the states in the superposition.

For example, many particles have an attribute called spin that is measured either as "up" or "down" for a given orientation of the analyzer. But until you measure the spin of a particle, it simultaneously exists in a superposition of spin up and spin down.

There is a probability attached to each state, and it is possible to predict the average outcome from many measurements. The likelihood of a single measurement being up or down depends on these probabilities, but is itself unpredictable.

Though very weird, the mathematics and a vast number of experiments have shown that quantum mechanics correctly describes physical reality.

Two entangled particles:

Albert Einstein, Boris Podolsky and Nathan Rosen pointed out an apparent problem with quantum entanglement in 1935 that prompted Einstein to describe quantum entanglement as 'spooky action at a distance.' The spookiness of quantum entanglement emerges from the reality of quantum superposition, and was clear to the founding fathers of quantum mechanics who developed the theory in the 1920s and 1930s.

To create entangled particles you essentially break a system into two, where the sum of the parts is known. For example, you can split a particle with spin of zero into two particles that necessarily will have opposite spins so that their sum is zero.

In 1935, Albert Einstein, Boris Podolsky and Nathan Rosen published a paper that describes a thought experiment designed to illustrate a seeming absurdity of quantum entanglement that challenged a foundational law of the universe.

A simplified version of this thought experiment, attributed to David Bohm, considers the decay of a particle called the pi meson. When this particle decays, it produces an electron and a positron that have opposite spin and are moving away from each other. Therefore, if the electron spin is measured to be up, then the measured spin of the positron could only be down, and vice versa. This is true even if the particles are billions of miles apart.

This would be fine if the measurement of the electron spin were always up and the measured spin of the positron were always down. But because of quantum mechanics, the spin of each particle is both part up and part down until it is measured. Only when the measurement occurs does the quantum state of the spin "collapse" into either up or down – instantaneously collapsing the other particle into the opposite spin. This seems to suggest that the particles communicate with each other through some means that moves faster than the speed of light. But according to the laws of physics, nothing can travel faster than the speed of light. Surely the measured state of one particle cannot instantaneously determine the state of another particle at the far end of the universe?

Physicists, including Einstein, proposed a number of alternative interpretations of quantum entanglement in the 1930s. They theorized there was some unknown property – dubbed hidden variables – that determined the state of a particle before measurement. But at the time, physicists did not have the technology nor a definition of a clear measurement that could test whether quantum theory needed to be modified to include hidden variables.

John Bell, an Irish physicist, came up with the means to test the reality of whether quantum entanglement relied on hidden variables.

Disproving a theory:

It took until the 1960s before there were any clues to an answer. John Bell, a brilliant Irish physicist who did not live to receive the Nobel Prize, devised a scheme to test whether the notion of hidden variables made sense.

Bell produced an equation now known as Bell's inequality that is always correct – and only correct – for hidden variable theories, and not always for quantum mechanics. Thus, if Bell's equation was found not to be satisfied in a real-world experiment, local hidden variable theories can be ruled out as an explanation for quantum entanglement.The experiments of the 2022 Nobel laureates, particularly those of Alain Aspect, were the first tests of the Bell inequality. The experiments used entangled photons, rather than pairs of an electron and a positron, as in many thought experiments. The results conclusively ruled out the existence of hidden variables, a mysterious attribute that would predetermine the states of entangled particles. Collectively, these and many follow-up experiments have vindicated quantum mechanics. Objects can be correlated over large distances in ways that physics before quantum mechanics can not explain.

Importantly, there is also no conflict with special relativity, which forbids faster-than-light communication. The fact that measurements over vast distances are correlated does not imply that information is transmitted between the particles. Two parties far apart performing measurements on entangled particles cannot use the phenomenon to pass along information faster than the speed of light.Today, physicists continue to research quantum entanglement and investigate potential practical applications. Although quantum mechanics can predict the probability of a measurement with incredible accuracy, many researchers remain skeptical that it provides a complete description of reality. One thing is certain, though. Much remains to be said about the mysterious world of quantum mechanics.

Quantum Entanglement – a new era for deep space communication

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Abstract

In 2022 three physicist named Alain Aspect, John Clauser and Anton Zeilinger got Nobel Prize in Physics. The field was Quantum Entanglement. It is a phenomenon that occurs between particles or quanta, not between large objects.Everything is entangled as that interacts. Interaction results in entanglement. It is the connection between particles that's are may be at large distance. It is an emergent property. The scientists generated particles that's areentangled from the special kind of crystal and kept the two at different location. Then they measured the spin direction of both and found that the pair was correlated. The main important thing is that if the state of one particle is known then the state of other can be predicted. This miracle can be used for deep space exploration.

Objectives:

1. To get the idea of quantum entanglement.

2. To explain how it can be used in deep space communication.

Key words: Entanglement, space communication.

Introduction: Though it looks like new but certainly it is not .Einstein the great scientist , one of the first pioneers of quantum theory , wrote a paper on it. He thought that entanglement was the property and could be used to prove the incompleteness of quantum theory. But next it was proved wrong.

In experiment the researchers observed the entangled particles from different angles. The output characteristics depends on the viewing angle.

In 1967 first time the experimental evidence of entanglement came.physicist Carl Kocher(Oregon state university) in his experiment on calcium atom found entanglement in pairs of photon that emitted from calcium .This experiment is considered as the first demonstration of quantum entanglement.

Discussion: Quantum refers to small particles as electron, proton, photon etc. The field of quantum mechanics was developed in 1920 and Erwin Schrodinger showed with equation that quantum particles exist in quantum superposition. Now what is quantum superposition? It is a fundamental aspect of the quantum particles. Quantum particles can exist more than one state. It can be said that any state of a particle is the sum of other quantum states and when observed only one of the superposed states observable.Simply it is the ability of quantum system to be in multiple states at the same time until it is measured.

We can state the Young double slit experiment where light waves passes through two slits at the same time interfere and produce Dark and Bright spot on the screen. Same way when the same experiment is done for a single electron or photon particle then same result is observed. So, It can be said that Photon or electron exist in a superposition of passing through both the slits. So, the particles interfere with itself and at a time produce interference pattern. Electron and photon both have the property of wave and particle. From this strange reality of quantum superposition the thought of quantum entanglement developed by Einstein, Nathan Rosen and Boris Podolsky in 1935. But Einstein said it as a spooky.

Entangled particles are created at a same event. Example photons are created with the collision of positron and electron. This two photons travels in opposite directions. As the two produce in a same event they are entangled. Simply the quantum entanglement is – let A and B two particles , initially of the same system, so entangled particles, when the state of A of changed then the state of B also changed instantly(Einstein said it spooky).

In quantum entanglement the entangled particles are correlated regardless the distance between them. The state of one particle instantly affects the state of other .So the information can be transmitted between the particles. And this property can be used in deep space communication.

Today the scientists are facing a big problem in deep space communication .The main obstacle is the distance and for this there are other discrepancy arises. Latency(time delay) occurs for reaching signal to their destination and for this several challenges appease in scientific operation. Another problem arises due to interference that takes place with communicating waves (generally radio waves) which makes difficulty to connect with the spacecraft in remote space to explore. Signal degradation which occurs due to collision with other particles in the space and get weaker, is another problem. Spacecraft find it difficult to receive and analyze. All these can be solved through proper use of quantum entanglement. It can communicate without any delay whatever be the distance as here the main communicating media are the entangled particles. Entangled particles become connected in such a way that the state of particle is instantly correlated with the state of other particles.

If one of the entangled particles in earth and other at deep space, and the earth placed particle is manipulated then the other particle which one in space will responds immediately whatever be the distance. For communication the entangled particles are used as quantum bits which are the fundamental units of quantum information. Now by encoding information into states of the entangled particles, and manipulating the particles the data can be transmitted.

But there are some technical problems.

1. One major problem is the environmental crisis can harm the correlation of the particles. Scientists are working to develop techniques to preserve the entanglement.

2. The 2nd problem is security. The communication through entangled particles does not guarantee confidentiality. For this additional cryptographic protocols are required.

As the entangled particles responds immediately to each other`s state modification, so, it can revolutionize the space exploration with secure and instantaneous way by manipulating one of the entangled particles in earth and other which is in the spacecraft responds immediately. For Entangled particles ,every property from speed to spin of each particles are connected.

Conclusion: The more research in this field will ensure future secured communication.

Another prospect of quantum entanglement is the more exploration of outer space with unprecedented data collection and then analyzing.More research in this field will open the new window and unravel the mysteries of the universe.

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Sunita Williams' Historic Return: A Nine-Month Struggle in Space

Syed Jawahar Hussain,Assistant Professor,Department of Physics, Bijni College.

Abstract

On June 5, 2024, NASA astronaut Sunita Williams, along with her crewmate Butch Wilmore, launched on Boeing's first crewed mission of the Starliner. Originally scheduled as a brief eight-day mission to the International Space Station (ISS), the mission was eventually extended to about nine months due to technical issues. Following a deep valley of troubleshooting, Starliner safely returned the two astronauts to Earth on March 18, 2025. Williams was greeted as a hero upon her return, and particularly in India, where millions continue to celebrate her success given her Gujarati ancestry. Following a long stay in microgravity, Williams now faces the challenges of post-mission health challenges that developed from her time in microgravity.

Keywords: Sunita Williams, NASA, Boeing Starliner, ISS, Space Exploration, Microgravity Effects, Astronaut Recovery

Introduction:NASA's Commercial Crew Program hoped the Boeing Starliner mission would represent a historic moment intended to offer replacement transportation for the ISS. Unfortunately, the spacecraft experienced a variety of unforeseen technical issues resulting in extensive delays and, as a consequence, the astronauts, Sunita Williams and Butch Wilmore, had to extend their mission well beyond or greatly exceeding expectations. Williams and Wilmore spent nearly 286 days in space, which tested both the reliability of the Starliner mission and the endurance of the astronauts. This article will consider the significance of the mission, the challenges that occurred through the process, the larger effects of Williams' return on India, and the space community as a whole.

Williams and Wilmore flew from Cape Canaveral, Florida, on June 5, 2024, on the Boeing Starliner, a big test for Boeing, which marked the first crewed flight of the spacecraft. The mission aimed to assess the performance and capability of the spacecraft as a whole in human spaceflight, but technical issues prolonged the time spent in orbit, and They ended up staying on the ISS for nearly 9 months. Despite all these setbacks, the crew kept on performing scientific experiments, doing spacewalks, and doing necessary maintenance activities aboard the ISS. NASA labored day and night to enhance the propulsion and software problems of the Starliner. NASA certified the spacecraft for flight in March 2025 - adapting to all the fixes.

Challenges:

1. <u>Health Problems Caused by Microgravity</u>

The deterioration of physical health due to microgravity is one of the biggest challenges in long-duration missions. After landing, Williams appeared to have lost weight, had some muscle atrophy, and had some possible decrease in bone density. Medical professionals have indicated that post-flight rehabilitation is critically important in readjusting her body back to Earth's gravity.

2. Psychological and Emotional Strain

One can only imagine how mentally grueling it must be to be away from Earth for nearly a year. Williams and Wilmore endured extensive isolation, prolonged uncertainty of their return, and the psychological weight of having no way home. However, Williams' fortitude and ability to draw upon her prior missions on the ISS helped keep both hers and Wilmore's morale up.

3. Technical Failures of Starliner

Boeing intended the Starliner mission to be a huge leap forward in the future of safe and reliable commercial spaceflight, yet hurdles and glib neglect nullified those advances and caused real concerns about the long-term flight viability of the vehicle. NASA, SpaceX, and Boeing will analyze both the problems and the bungled sequencing of the problems to help ensure subsequent missions return home safely.

Discussion: Williams' return has ignited discussions in India and in the global space community itself. Indian-origin astronauts have always produced a sense of pride among the people. Kalpana Chawla, an Indian-origin astronaut, is a figure of particular pride whose essence continues to inspire young minds. Students at Tagore Baal Niketan School in Karnal, Haryana, where Kalpana received her education, celebrated Williams' safe return from space, citing how "Even if he is from America, he is still from Indian descent." This illustrates the deep sense of connection people feel with the work being done in outer space.India's Chief of the Indian Space Research Organisation (ISRO), V Narayanan, welcomed the mission from outer space and called it an incredible accomplishment, and recognized NASA, SpaceX, and the United States of America's commitment to space exploration. Narayanan expressed that India is interested in Williams joining a future space mission team and is open for collaboration. Williams joining a future mission may signify a growing collaboration between ISRO and NASA regarding a future Gaganyaan human spaceflight program.

Conclusion: Sunita Williams' nine-month experience in space underscores the unpredictable reality of spaceflights and the courage required of astronauts. Her return constitutes an event of historical significance to NASA, Boeing, and India, continuing to resonate with millions who share her heritage. As she recuperates from the post-mission experience, her contributions will be valuable in creating space medicine innovations, astronaut training, and ventures further into deep space.

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4. India Today

PROFILE
DEPARTMENT OF PHYSICS
BIJNI COLLEGE, BIJNI

HISTORY OF THE DEPARTMENT

The department came into being in 1994 with the establishment of the science stream in the college. The permission was obtained from Gauhati University on 21-01-1997. The final Govt concurrence and permanent affiliation were granted on 22-02-2001 and 13-08-2009 respectively. The major course in the department was introduced from the session 2004-2005 and obtained permission from G.U on 09-06-2009. The science stream of the college was provincialised by Govt. Of Assam w.e.f 01-01-2013. The college was affiliated under Bodoland University from the session 2020-21.

Academic Programme Offered

- B.Sc. (Regular and Minor Courses)
- B.Sc.(Honours and Major Courses)
- B.Sc. (SEC)
- Subject in HS Courses

Teacher –Student Ratio: 1:30
(Session: 2023-2024)

PRESENT FACULTY STATUS OF THE DEPARTMENT

Jayshri Narzary, Assistant Professor & Head of Department
Qualification: M. Sc., B. Ed. NET
Specialisation: Electronics
Research Interest: Condensed Matter Physics

Sanjita Ray, Assistant Professor
Qualification: M. Sc., M. Phil
Specialisation: Particle Physics
Research Interest: Astrophysics

Syed Jawahar Hussain, Assistant Professor
Qualification: M. Sc., M. Phil
Specialisation: Non Linear Optics & Spectroscopy
Research Interest: Quantum Mechanics

LABORATORY ASSISTANT

Rabiram Muchahary
Qualification: B.A.

VARIOUS ACHIEVEMENTS SINCE 2017-2018

Publications

- ❖Number of Research Articles in Edited Books ::12
- ❖Number of research articles in Peer Reviewed Journals: 3
- ❖Number of Research articles seminar/Conference Proceedings : 11
- ❖Number of Annual Departmental Magazine , 'Quanta' publications : 7
- ❖Number of Wall Magazine, 'The Image' publications: 8

MOU

- ❖Number of MOU with other Institution: 01
- ❖Number of activities under MOU: 02

WEBINAR /SEMINAR

- ❖ International Webinar on " Geospatial Technologies and Emerging Opportunities"
- ❖International Webinar on Environmental Risk: Issues, Management & Sustainable Development
- ❖Interactive Talk on Environmental Awareness and Sustainable Development

OUTREACH

- ❖ Extension Activity Program organized by the Department: 02

LABORATORY FACILITIES OF THE DEPARTMENT

- ➢Experimental Laboratory: For UG Honours / Major & Regular/ Minor Students
- ➢Dark Room: For Optical Experiments
- ➢Physics Computer Lab: For UG Honours / Major Students

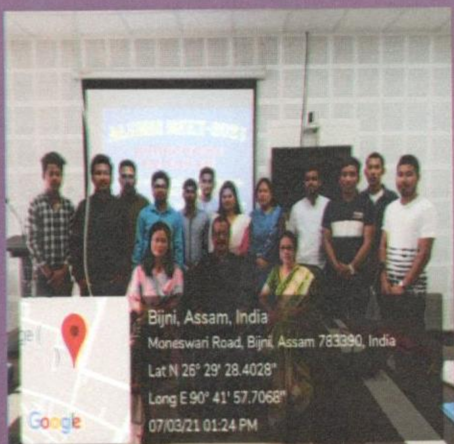
Result of Department Since 2018-2019

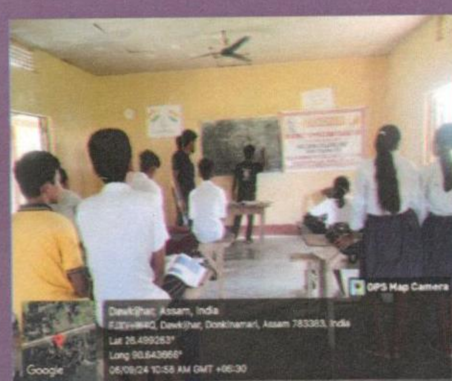
Session	Appeared	Passed	Pass %
2017-2018	15	9	60
2018-2019	7	6	85.7
2019-2020	11	10	90.9
2020-2021	5	5	100
2021-2022	6	4	66.6
2022-2023	11	9	82
2023-2024	4	3	75

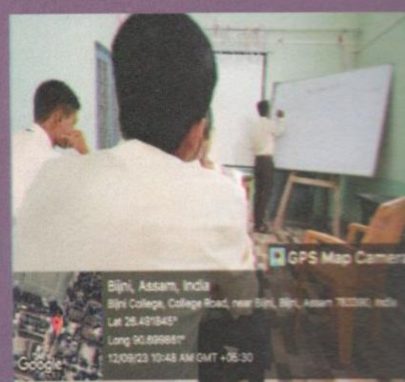
Placement & Progression to HE of the Department Since 2018-2019

Session	Placement	Progression to HE
2017-2018	1	5
2018-2019	4	4
2019-2020	4	3
2020-2021	3	1
2021-2022	8	4
2022-2023	2	2
2023-2024	2	2

PHOTO GALLERY OF DIFFERENT ACTIVITIES OF THE DEPARTMENT DURING LAST FIVE YEARS







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STUDENTS OF PHYSICS DEPARTMENT WITH FACULTY MEMBERS