A periodic E-magazine of
DEPARTMENT OF PHYSICS

HANDIQUE GIRLS' COLLEGE

LUMEN

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MESSAGE FROM THE PRINCIPAL



It gives me immense pleasure to present LUMEN – The Physics E-Magazine, Issue 01 (2026), published by the Department of Physics, Handique Girls' College.

Physics is not just a subject of equations, theories and experiments; it is a way of understanding the universe and discovering the principles that shape our everyday lives. From the mysteries of the cosmos and the fascinating world of quantum mechanics to artificial intelligence, supercomputing sustainable energy and space exploration, physics continues to expand the boundaries of human knowledge and innovation.

This magazine is a commendable initiative that reflects the intellectual curiosity, scientific temperament and creative potential of our students and faculty members. The diverse range of articles demonstrates an enthusiasm for exploring beyond the prescribed curriculum, connecting scientific concepts with contemporary developments, and communicating knowledge in an engaging manner. I am particularly delighted to see the inclusion of emerging areas of research, the role of women in physics and the applications of science in addressing global challenges. I firmly believe that educational institutions must nurture a culture of inquiry, critical thinking, innovation and lifelong learning. Such academic initiatives give students valuable opportunities to develop their ideas, express their perspectives, and appreciate the relevance of scientific knowledge in building a better future.

I sincerely appreciate the efforts of the Department of Physics, the editorial team, faculty contributors and student authors whose dedication and collaborative spirit have made this publication possible. I hope LUMEN will continue to grow as a vibrant platform for scientific exploration and creative expression in the years ahead. May this magazine inspire our young minds to remain curious, question the unexplored and pursue knowledge with confidence, commitment and imagination.

My best wishes to the entire team for the success of this initial issue.

Dr. Ranjit Sarma
Principal: Handique Girls' College
Guwahati, Assam

MESSAGE FROM THE HEAD



It gives me great pleasure to present the E-Magazine of the Department of Physics. This publication is a reflection of the curiosity, creativity, and academic spirit that defines our department. It serves as a platform for sharing knowledge, innovative ideas, and scientific insights among our faculty, students, and alumni.

I am delighted to see the enthusiastic participation and valuable contributions from all involved. Such collective efforts not only enrich our academic environment but also inspire a culture of inquiry and excellence.

I sincerely appreciate the dedication of the editorial team for their hard work in bringing out this magazine. I hope this initiative continues to grow and motivates everyone to explore, learn, and contribute to the ever-evolving field of physics.
Wishing all readers an engaging and enlightening experience.

Dr. Uday Sankar Senapati
Head Of The Department

STUDENT EDITORIAL BOARD

"Behind every page lies a thought, behind every word a vision, and behind every creation, a team that believes in the power of ideas."



DIMPI KALITA
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MESSAGE FROM THE EDITORIAL TEAM



It gives us immense pleasure to present this edition of Lumen, our departmental magazine. More than just a collection of articles and photographs, it is a reflection of the creativity, ideas, and collective efforts of our students and faculty members.

Putting this edition together has been a rewarding experience, made possible by the valuable guidance of our teachers and the enthusiastic contributions of everyone involved. We extend our heartfelt gratitude to all who have helped bring this magazine to life.

We hope Lumen inspires curiosity, celebrates creativity, and encourages the spirit of exploration.

Happy reading!

— The Editorial Team

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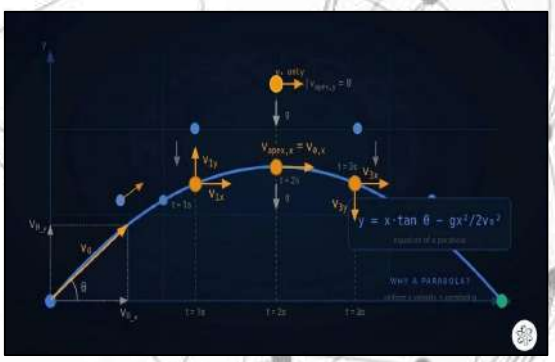
FEATURE ARTICLE:-01

PROJECTILE MOTION-
THE PHYSICS BEHIND SPACE LAUNCHES

BY:- ADITI DAS, UG SEM I

Have you ever wondered how a rocket escapes Earth's surface and carries satellites into space? Or how a satellite continues moving around Earth without falling straight back to the ground? Behind these fascinating achievements lies the beauty of physics. One of the fundamental concepts that helps us understand such motion is projectile motion. What seems like a simple curved path followed by a ball thrown into the air has a much deeper connection with space science and modern technology. It shows how the basic laws of motion can help us understand some of the greatest achievements in space exploration.

From Everyday Motion to Space Exploration Projectile motion describes the motion of an object projected into the air under the influence of gravity. It follows a curved path called a trajectory Its horizontal velocity remains constant (neglecting air resistance), while its vertical velocity changes due to gravity



Interestingly, the same basic principles that explain a ball thrown into the air also introduce us to the science behind space launches.

How Does a Rocket Reach Space?

A rocket does not simply travel upwards; it must achieve the correct speed and direction to enter orbit. Initially, it rises vertically and gradually tilts towards the horizontal direction to gain sufficient sideways velocity. Here is something fascinating: satellites do not escape Earth's gravity completely. Instead, gravity continuously pulls them towards Earth, while their high horizontal speed keeps them moving around the planet. A satellite in low Earth orbit travels at approximately 7.8 km/s. Unlike an ordinary projectile, a rocket is powered by its engines, and its actual trajectory involves complex forces and changing velocities.

Conclusion

From a ball thrown into the air to a satellite orbiting Earth, physics connects simple observations with extraordinary technological achievements. Projectile motion provides the foundation for understanding rocket trajectories and space exploration. What begins as a simple study of motion opens the door to understanding some of humanity's greatest achievements in space science.

FEATURE ARTICLE:- 02

Elastic Rebound Theory
How stored energy beneath the Earth's surface is suddenly released

BY:- ANANYA DAS, UG SEM V

Earthquake are among the most powerful natural phenomena, caused by the sudden release of energy within the Earth's crust. One of the most important theories explaining how earthquakes occur is the Elastic Rebound Theory, proposed by Harry Fielding Reid after his study of the 1906 San Francisco earthquake along the San Andreas Fault.

THE IDEA BEHIND ELASTIC REBOUND:

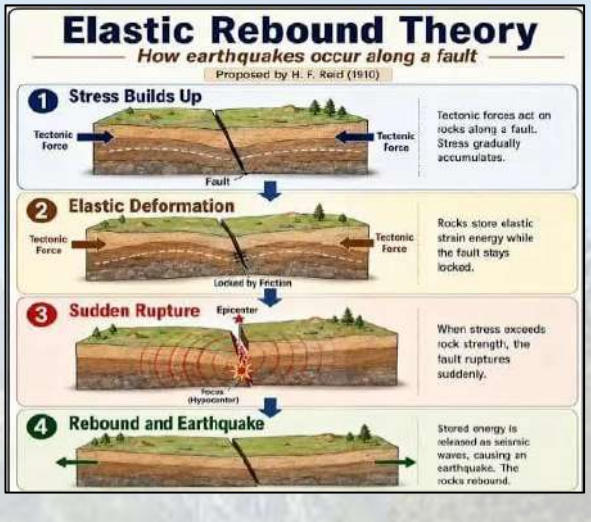
The Elastic Rebound Theory is based on a simple but powerful idea: rocks in the Earth's crust behave elastically when subjected to stress. Due to tectonic forces, rocks on either side of a fault are slowly deformed over time.

As this stress builds up, the rocks bend and store potential energy without immediately breaking. However, once the stress exceeds their strength, they suddenly fracture or slip along the fault. This abrupt release of stored energy generates seismic waves, which we experience as an earthquake. After the break, the rocks partially return, or "rebound," to a less deformed state.

HOW AN EARTHQUAKE DEVELOPS

The process of elastic rebound can be understood as a gradual cycle. Initially, rocks exist in a stable, under formed condition. As tectonic plates move, stress accumulates and causes elastic deformation, storing energy within the rocks.

When the elastic limit is exceeded, rupture occurs, leading to a sudden slip along the fault—this is the moment of the earthquake. The rocks then rebound, releasing energy in the form of seismic waves, heat, and permanent deformation.



WHAT THE THEORY EXPLAINS

This theory helps explain several important characteristics of earthquakes. It clarifies why earthquakes occur suddenly, even though stress builds up slowly over long periods of time. It also explains why earthquakes tend to repeat in the same regions, as stress begins to accumulate again after each event.

In addition, it helps us understand fault movements and the generation of different types of seismic waves, including P-waves, S-waves, and surface waves.

FEATURE ARTICLE:-03

Water In Zero Gravity

When gravity fades, surface tension takes over

BY:- SATAKSHI CHAKRABORTY, UG SEM V

Footage from the International Space Station often shows astronauts playing with a floating blob of water. Instead of flowing downward or spreading into a puddle, the liquid hovers in mid-air as a shimmering, almost perfect sphere. This raises an intriguing question, how does water behave in the absence of gravity?

GRAVITY AND ITS ABSENCE

On Earth, gravity dominates how liquids behave. Water settles, spreads, and droplets flatten under their own weight. In orbit, however, everything is in continuous free fall, so the net downward force becomes very small. This condition, called microgravity, does not mean gravity is absent—it is simply offset by motion.



THE DOMINANACE OF SURFACE TENSION

When gravity is no longer dominant, surface tension takes over. Water molecules attract each other through hydrogen bonding.

Inside a droplet, forces balance in all directions, but surface molecules experience a net inward pull. This makes the surface behave like a stretched elastic skin, minimizing its area.

For a fixed volume, the shape with the least surface area is a sphere. This is why water forms floating balls in microgravity.

STRANGE WATER BEHAVIOUR

In microgravity, water can cling to surfaces and crawl along them due to Capillary Action—allowing liquids to move without pumps, purely through surface forces!

THE PHYSICS BEHIND THE SHAPE

We describe surface tension with the symbol γ which is defined as force per unit length along the surface,

$$F\ \gamma\ = L$$

For water, γ is about 0.072 N/m at room temperature, which is strong enough to pull small droplets into spherical shapes even on Earth. For a spherical droplet, the balance between surface tension and internal pressure is given by the Young–Laplace equation:

$$2\gamma\ \ \Delta P\ = R$$

where ΔP is the pressure difference between the inside and outside of the droplet, γ is the surface tension, and R is the radius.

FEATURE ARTICLE:-04

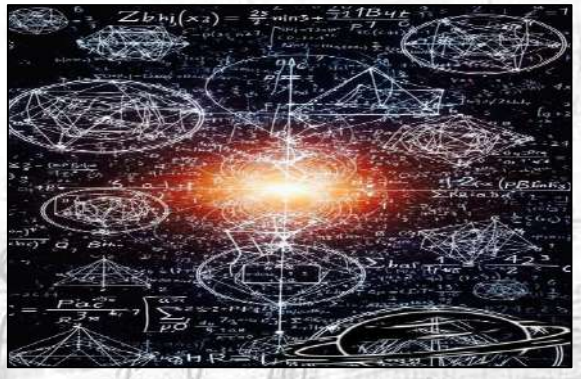
THE HIDDEN CHAOS OF PHYSICS

BY:- DIMPI KALITA, PG SEM I

"A tiny movement. A tiny change. A completely different future."

Imagine a butterfly opening its wings in a quiet forest. Nothing dramatic happens—no thunder, no dark clouds, no sudden storm. Yet this tiny movement has become one of the most fascinating metaphors in physics: the Butterfly Effect.

But can a butterfly really cause a storm?



The answer is more interesting than a simple yes or no. The Butterfly Effect comes from chaos theory, particularly the idea of sensitive dependence on initial conditions. In the 1960s, meteorologist and mathematician Edward Lorenz discovered that a tiny change in the starting conditions of a weather calculation could eventually produce a completely different prediction. At first, the difference might be almost invisible. But as the system evolves, that tiny difference can grow enormously. In physics, chaos does not simply mean disorder.

A chaotic system can follow precise physical laws and still become extremely difficult to predict over time.

Weather is a perfect example. Temperature, pressure, humidity, wind, oceans and many other factors interact continuously. A tiny difference in the initial state can eventually lead to a completely different weather pattern. This is why long-term weather prediction becomes increasingly difficult.

One mathematical example of chaos is the logistic map:

$$x_{n+1} = r\,x_n\,(1 - x_n)$$

For certain values of r, two almost identical starting values can eventually produce very different results.

For example:

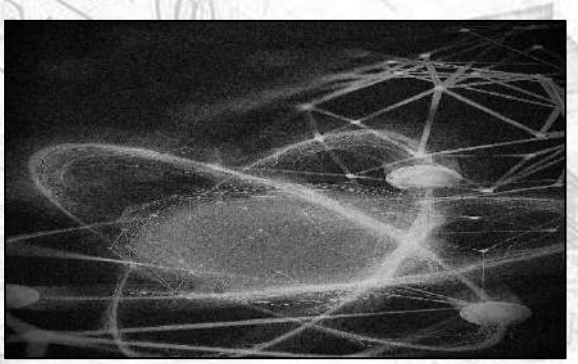
$x_0 = 0.400000$ and

$x_0 = 0.400001$

begin almost identically, but after many iterations their paths can separate dramatically.

This is the mathematical heart of the Butterfly Effect.

A butterfly does not have enough energy to create a hurricane. The atmosphere already contains enormous energy from solar heating, pressure differences, Earth's rotation and other processes.



The butterfly is a metaphor for a tiny disturbance in a sensitive system.

The real idea is:

A tiny difference in the beginning can sometimes produce a huge difference in the future

And chaos is not limited to weather. It can appear in turbulence, fluid motion, electrical circuits, orbital dynamics, combustion and many other systems.

The Butterfly Effect is ultimately about sensitivity, prediction and the limits of our knowledge. Nature can follow simple physical laws and still produce extraordinarily complicated behaviour. Sometimes, we don't need complicated rules to create complexity—we only need time, interaction and sensitivity to initial conditions.

So the next time you see a butterfly quietly moving its wings, don't ask whether it will create a storm. Just think for a while

What tiny changes around us are already shaping futures we cannot yet see?

FEATURE ARTICLE:-05

Mathematics of Harmony:
Wave Physics, Fine-Tuning, and Patterns in Nature

BY:- LIZA TALUKDAR, UG SEM III

Physics reveals that nature is not random chaos but a system governed by precise mathematical laws. From the motion of galaxies to the vibration of a string, from the formation of stars to the geometric patterns created by sound, the universe displays remarkable order. This harmony is not accidental, it emerges from equations, constants, and fundamental physical principles.

The same mathematics that governs cosmic evolution also explains the beautiful patterns formed by vibrations in matter. This connection between fine-tuning, wave physics, and natural geometry shows that mathematics is not merely a tool of description; it is the very language of the universe.

FINE TUNING OF THE UNIVERSE

Modern physics is built upon certain fundamental constants whose values determine the structure of reality. These include the gravitational constant, the speed of light, Planck's constant, and the fine-structure constant. Even a small change in these values could make the universe drastically different.

The Anthropic Principle discusses this idea by suggesting that the universe appears suitable for life because only such a universe can produce observers capable of questioning it.

One important equation is Newton's law of gravitation,

$F=G\ M1M2/R2$

If the value of G were significantly larger, stars would burn too rapidly. If smaller, stars might not form at all.

Another important constant is the fine-structure constant: $\alpha \approx 1/137$. This dimensionless number controls electromagnetic interactions. If its value changed slightly, stable atoms and chemistry would not exist.

WAVE PHYSICS AND RESONANCE

One of the most fundamental concepts in physics is the wave. Sound, light, water ripples, and even quantum particles can be described using wave behavior.

Another important phenomenon is resonance. When an external force matches the natural frequency of a system, the amplitude of vibration increases significantly. This is why a singer can break glass or why bridges must be designed carefully against oscillations.

Standing waves are formed when two waves of equal frequency travel in opposite directions. They create nodes (points of no vibration) and antinodes (points of maximum vibration) These standing waves are the foundation of cymatic patterns.

Cymatics is the study of visible sound vibrations. It demonstrates how sound frequencies can produce geometric patterns in physical matter.

The early experiments of Ernst Chladni used metal plates covered with sand. When the plate was vibrated using a violin bow, the sand moved away from vibrating regions and settled along nodal lines, forming beautiful symmetrical shapes called Chladni patterns.

Different frequencies produced different designs:

Low frequency → simple patterns High frequency → complex geometry

PATTERN IN NATURE

The same mathematical principles behind cymatics appear throughout nature. Examples include:

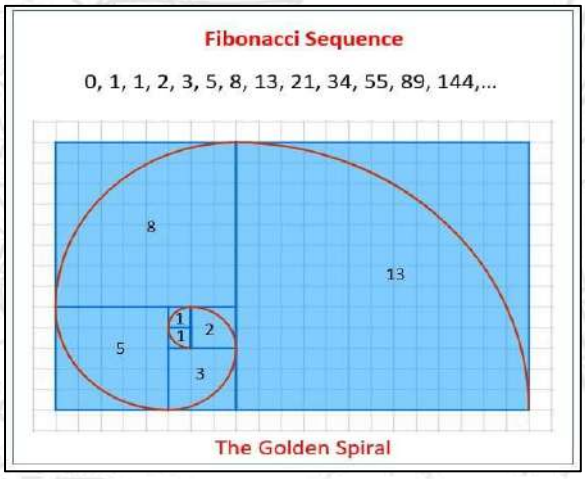
Sunflowers and Pinecones: Their spiral arrangements often follow Fibonacci sequences and the golden ratio.

Crystal Structures: Atoms arrange themselves in repeating symmetrical lattices due to energy minimization.

These examples show that nature prefers efficiency, balance, and symmetry qualities that mathematics naturally describes.

CONCLUSION

From the precise constants that allow stars to exist to the visible geometry of vibrating sound, the universe reveals a deep physical and mathematical harmony. The Anthropic Principle explains how fine-tuned physical laws make life possible, while Cymatics demonstrates how wave physics transforms vibration into form.



FEATURE ARTICLE:-06

QUANTUM BATTERIES: THE FUTURE OF ENERGY STORAGE

BY:- JUGANTIKA DEKA, UG SEM I

Imagine a battery that uses the mysterious principles of quantum mechanics to store and transfer energy. What sounds like science fiction may become an important part of future technology. Known as a quantum battery, this emerging concept is attracting considerable attention from physicists around the world.

Unlike conventional batteries, which store energy through chemical reactions, quantum batteries operate using quantum systems such as atoms, molecules and other microscopic particles. They utilise extraordinary quantum properties, particularly superposition and entanglement, to explore new ways of storing and transferring energy.

One of the most fascinating aspects of quantum batteries is their potential for extremely fast charging. In ordinary batteries, increasing the size of a battery does not necessarily make its charging process proportionally faster. However, theoretical research suggests that quantum interactions can provide a collective charging advantage, potentially allowing larger quantum systems to absorb energy more rapidly.

A remarkable development took place in March 2026, when scientists from Australia's national science agency, CSIRO, along with researchers from RMIT University and the University of Melbourne, demonstrated a proof-of-concept quantum battery capable of completing the charging, energy storage and discharging cycle. The experimental device used an organic microcavity and laser light to investigate quantum energy storage at room temperature.

Despite these promising developments, quantum batteries are still in their experimental stages. Scientists face several challenges, including maintaining stored energy for longer periods, reducing energy losses and developing reliable systems that can be scaled for practical applications.



In the future, this technology could contribute to advanced quantum devices, specialised energy systems and innovative methods of energy transfer. Researchers are also investigating how quantum energy storage might influence the development of next-generation technologies. Quantum batteries represent a fascinating meeting point between quantum mechanics and energy science.

Although they are not yet ready to replace conventional batteries, they offer a new perspective on how energy can be controlled at the microscopic level. Perhaps the future of energy will not depend only on how much we can store, but also on how intelligently and efficiently we can store it.

FEATURE ARTICLE:-07

QUANTUM CRYPTOGRAPHY: PHYSICS-BASED SECURITY IN THE DIGITAL ERA

BY:-NIBEDITA BASUMATARY, UG SEM I

Modern cyber security relies on public-key infrastructure like RSA and Elliptic Curve Cryptography, which base their security on mathematical complexity. However, fault-tolerant quantum computers executing Shor's algorithm threaten to break classical encryption in minutes, creating an urgent vulnerability known as "Harvest Now, Decrypt Later". Quantum Key Distribution (QKD) addresses this existential threat by securing communications through fundamental physical laws rather than computational hardness.

The security of QKD rests on three principles of quantum mechanics: Superposition, Heisenberg's Uncertainty Principle, and the No-Cloning Theorem. Information is encoded into non-orthogonal quantum states, such as photon polarization. Because an unknown quantum state cannot be duplicated without alteration, any intercept-resend attack by an eavesdropper ("Eve") collapses the photon & apos;s wave function. This measurement introduces physical noise and elevates the Quantum Bit Error Rate (QBER) above a detectable threshold, signaling the system to abort the compromised key exchange.

In protocols such as BB84, communicating parties ("Alice" and "Bob") exchange polarized light pulses and compare measurement bases over a classical channel. Once verified through privacy amplification, the unhackable key encrypts high-value data.

Deploying QKD across global networks presents distinct technical challenges. Terrestrial optical fibers suffer exponential signal attenuation, restricting direct transmission to roughly 100 to 200 kilometers. To span intercontinental distances without vulnerable trusted relays, satellite-based quantum channels leverage low atmospheric absorption in free space.

Because QKD hardware requires dedicated physical infrastructure and does not inherently authenticate endpoints, modern cyber-defence strategies favour a hybrid model. Combining hardware-based QKD key distribution with lattice-based Post-Quantum Cryptography (PQC) for software authentication delivers a resilient, future-proof security framework against quantum-era cyber threats.



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FEATURE ARTICLE:-08

Schrödinger's Cat: Alive, Dead, or Both?

BY:- K NILAKSHI SINGHA, UG SEM III

It is a famous thought experiment by Erwin Schrödinger.

Imagine a cat trapped in a sealed box with a vial of poison and a single unstable radioactive atom. If the atom decays, the poison is released and the cat dies. If it does not, the cat remains alive. According to quantum physics, until the box is opened and observed, both possibilities exist at once, i.e., the cat is simultaneously alive and dead. It sounds absurd, and honestly, it is meant to. Schrödinger proposed this idea in 1935 to highlight how strange quantum mechanics can be.

REALITY'S BIG MAYBE

This kind of quantum weirdness works well for tiny particles like atoms, but applying it to something as large as a cat feels ridiculous. That is exactly the point. The thought experiment exposes the measurement problem: "Why does observing a system force it to settle into one definite outcome?" In the quantum world, systems can exist in multiple states at once, but in everyday life, we never see such behavior.

MODERN IMPORTANCE

This paradox sparked major developments in physics. It led to the development of decoherence theory and inspired experiments with "cat states" in laboratories. Today, these ideas power quantum technologies, especially quantum computers, where superposition allows systems to perform calculations that classical computers cannot.

FUN FACT

A quantum bit, or qubit, can exist as 0 and 1 simultaneously, unlike a classical bit which must be only one state at a time.

CONCLUSION

Schrödinger's Cat remains one of the most powerful illustrations of quantum mechanics. It challenges our everyday understanding of reality and reminds us that nature behaves very differently at the smallest scales. Though the paradox does not provide all the answers, it opened the door to technologies that are transforming the future.

FEATURE ARTICLE:-09

QUANTUM FIELD THEORY

BY:- UTSHA SENGUPTA, PG SEM I

Introduction

Have you ever wondered what everything around us is made of? From the stars in the sky to the tiny particles that make up our bodies, everything in the universe is made up of matter and energy. For a long time, scientists believed that the smallest building blocks of matter were tiny particles, just like very small pieces of a puzzle. But as science developed, physicists discovered that the world at the smallest scales is much more interesting than we could imagine. This led to the development of a fascinating branch of physics known as Quantum Field Theory (QFT).

Quantum Field Theory is one of the most important ideas in modern physics. It helps us understand how tiny particles behave, how they interact with one another, and how forces work at the fundamental level. In simple words, it combines two major ideas of physics: quantum mechanics and special relativity.

What Exactly Is Quantum Field Theory?

To understand Quantum Field Theory, we first need to understand what a field is. We are already familiar with some types of fields in physics. For example, the Earth has a gravitational field around it, and a magnet produces a magnetic field. A field is something that has a value at every point in space and time.

Quantum Field Theory takes this idea a step further. According to this theory, the universe is filled with different quantum fields. What we call particles, such as electrons and photons, are actually small excitations or disturbances in these fields.

For example, imagine a calm pond. When you throw a small stone into it, ripples begin to form on the surface. The water is still there, but the disturbance travels across it. In a somewhat similar way, a particle can be understood as an excitation of a field that exists throughout space.

So, instead of thinking of an electron as simply a tiny solid object, Quantum Field Theory describes it as an excitation of the electron field. Similarly, a photon is an excitation of the electromagnetic field.

How Is It Different from Classical Physics?

In classical physics, we generally describe objects as having definite positions, velocities and paths. For example, if we throw a ball, we can calculate its motion using Newton's laws.

However, at the atomic and subatomic levels, things do not behave in the same way. Quantum mechanics tells us that particles can show wave-like behaviour and that we can only predict the probabilities of certain outcomes.

Quantum Field Theory combines these quantum ideas with Einstein's special theory of relativity. This combination is necessary because particles at very high energies can be created and destroyed. Unlike ordinary objects, elementary particles are not always fixed in number.

For instance, when particles collide at very high energies, new particles can be produced, provided the necessary conservation laws are satisfied. Quantum Field Theory gives us a mathematical framework to understand these processes.

Particles and Their Interactions

One of the most interesting features of Quantum Field Theory is that it explains how particles interact with each other.

We know that nature has four fundamental forces: gravitational, electromagnetic, strong nuclear and weak nuclear forces. Quantum Field Theory successfully describes three of these four forces: electromagnetic, strong nuclear and weak nuclear interactions.

For example, the electromagnetic interaction between charged particles is explained through the exchange of photons. Photons are the particles associated with the electromagnetic field.

Similarly, the strong nuclear force, which holds quarks together inside protons and neutrons, is described by a theory called Quantum Chromodynamics (QCD). It involves particles called gluons.

Another important theory is Quantum Electrodynamics (QED), which explains how light and matter interact. It is considered one of the most successful and accurately tested theories in physics.

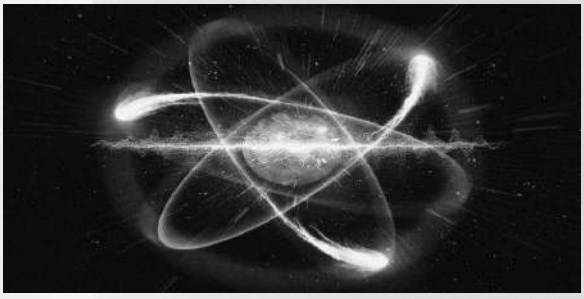
Why Is Quantum Field Theory Important?

Quantum Field Theory is not just an abstract mathematical idea. It plays a very important role in our understanding of the universe.One of its greatest achievements is the development of the Standard Model of Particle Physics. The Standard Model describes the fundamental particles known to us and explains how they interact through three fundamental forces.

It includes particles such as electrons, quarks, neutrinos, photons and gluons. It also includes the Higgs boson, which is associated with the Higgs field. The Higgs field plays an important role in explaining why many elementary particles have mass.

The discovery of the Higgs boson at CERN in 2012 was a major achievement and provided strong experimental support for an important part of the Standard Model.

Quantum Field Theory also helps scientists understand what happens inside particle accelerators, where particles are made to collide at extremely high energies to study their fundamental properties.

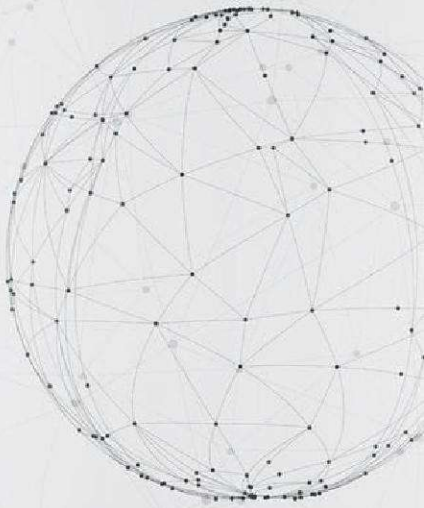


Is Quantum Field Theory the Complete Theory of Everything?

Although Quantum Field Theory has been extremely successful, it does not explain everything. One of its biggest limitations is that it has not yet been successfully combined with Einstein's general theory of relativity, which describes gravity and the large-scale structure of the universe.

General relativity works very well for understanding planets, stars, galaxies and black holes, while Quantum Field Theory works extremely well at the microscopic level. Bringing these two descriptions together remains one of the biggest challenges in modern theoretical physics.

Scientists are still working towards a theory of quantum gravity that could explain both the quantum world and gravity within a single consistent framework



FEATURE ARTICLE:-10

Shrunk to the Atomic World: A Journey Inside Matter

BY:- UDITA BAISHYA, UG SEM V

Imagine shrinking yourself smaller and smaller until even dust particles look like giant rocks. At this unimaginable scale, you enter the atomic world, i.e., the hidden structure inside all matter.

In everyday life, everything around us appears solid. However, when seen at atomic scale, this idea of "solid" begins to disappear. The atoms that make up objects are not tightly packed, but are separated by large distances compared to their size.

WHAT IS INSIDE AN ATOM?

At the center of every atom is a very small and dense region called the nucleus. It contains positively charged protons and neutrons. Almost all the mass of the atom is concentrated in this tiny space. Despite being extremely small, the nucleus is the core of atomic structure. Surrounding the nucleus are electrons. This electrons do not follow fixed paths. Instead, they exist in regions called orbitals, which represent areas of probability. This means we cannot know the exact position of an electron at a given time, only where it is likely to be found.

Because of this behavior, the atomic world is governed by probability rather than certainty. Things are not fixed or predictable in the same way as in our daily experience.

At the quantum level, particles behave in unusual ways. Electrons can jump between energy levels instantly without moving through the space in between. They also show wave-particle duality, meaning they can behave both like particles and like waves depending on how they are observed.

DID YOU KNOW?

If the nucleus of an atom were the size of a marble, the electrons would be much farther away, showing how much empty space exists inside matter.

WHAT DOES THIS TEACH US?

This shows that the atomic world is very different from the world we experience everyday. It is not fully solid, stable, or predictable. Instead, it is dynamic, uncertain and governed by the laws of quantum physics. And atoms are mostly empty space, held together by invisible forces that shape the structure of matter itself.



FEATURE ARTICLE:-11

Green Nanotechnology for Sustainable Energy

BY:- DR. UDAY SANKAR SENAPATI, HEAD OF THE DEPARTMENT

Green nanotechnology is an emerging field that combines nanoscience with the principles of sustainability to develop environmentally friendly materials and processes. It aims to minimize ecological impact while enhancing efficiency, particularly in the domain of sustainable energy.

By manipulating materials at the nanoscale (1–100 nm), scientists can significantly improve the performance of energy systems such as solar cells, batteries, fuel cells, and hydrogen production technologies.

HARNESSING SOLAR ENERGY

One of the most important applications of green nanotechnology is in solar energy. Nanomaterials such as quantum dots, titanium dioxide nanoparticles, and perovskites are used to increase the efficiency of photovoltaic cells.

These materials provide higher surface area, tunable optical properties, and improved light absorption, allowing solar panels to convert more sunlight into electricity while reducing material usage.

CLEAN HYDROGEN ENERGY

Another promising area is hydrogen energy production. Green nanotechnology enables efficient water splitting using nanocatalysts such as metal oxides and noble metal nanoparticles. These catalysts reduce the energy required for hydrogen generation, making it a cleaner and more viable alternative fuel. Nanomaterials are also used in fuel cells to improve their efficiency and durability.

SUSTAINABLE MATERIALS AND METHODS

Green nanotechnology also focuses on eco-friendly synthesis methods. Plant extracts, microorganisms, and other biological systems are used to produce nanoparticles, avoiding toxic chemicals and reducing energy consumption. This approach aligns with the principles of green chemistry and helps minimize environmental hazards.

CHALLENGES AND LIMITATIONS

Despite its advantages, several challenges remain. These include the potential toxicity of nanomaterials, high production costs, and issues related to large-scale implementation. Careful design, lifecycle analysis, and proper regulation are essential to ensure safe and sustainable use of these technologies.

SMALL SACLE, BIG IMPACT

A nanometer is one-billionth of a meter, so small that thousands could fit across a single human hair.

FEATURE ARTICLE NO:- 12

DEATH OF A STAR:THE MAKING OF SUPERNOVA

BY:- NIRJARA KASHYAP, UG SEM I

Every star has a lifetime, and even the brightest stars are destined to fade. But some stars do not disappear quietly. Instead, they end their lives in one of the most powerful and spectacular events in the universe — a supernova. These extraordinary stellar explosions mark the dramatic end of a star's life and play a crucial role in shaping the cosmos.

A supernova occurs when a star undergoes a catastrophic explosion, releasing an enormous amount of energy and briefly outshining entire galaxies. One of the most fascinating types is the core-collapse supernova, which occurs in massive stars with masses several times greater than that of our Sun.

Throughout its lifetime, a massive star maintains a delicate balance between two opposing forces: gravity, which pulls matter inward, and the outward pressure generated by nuclear fusion in its core. As the star ages, it fuses increasingly heavier elements, eventually producing iron. Unlike lighter elements, iron fusion does not release energy. Consequently, the core can no longer generate enough pressure to resist gravity. However, not all supernovae occur through core collapse.

Type Ia supernovae, for instance, involve the thermonuclear destruction of a white dwarf, making them fundamentally different from the explosions of massive stars.

Beyond their spectacular appearance, supernovae are essential to the evolution of the universe. They distribute elements such as oxygen, silicon, calcium and iron into interstellar space. These elements eventually become part of new stars, planets and even living organisms. In a sense, the materials that make up our world were forged in the hearts of ancient stars.

A star's death, therefore, is far more than a celestial spectacle. It is a fundamental process through which the universe recycles matter, creates new elements and continues its endless cycle of cosmic evolution.



Fig- Supernova 1993J

FEATURE ARTICLE-13

Rogue Planets: The Universe's Silent Wanderers

BY:-RICHA ROY, UG SEM III

What if there are worlds in the universe that have no sun to rise for them? No light, no warmth, only endless darkness. Do such planets really exist, drifting alone without a home? Surprisingly, the answer is yes. These mysterious worlds are known as rogue planets, planets that do not orbit any star. Unlike the familiar planets of our solar system, they travel silently through the vast emptiness of space, isolated.

WHAT ARE ROGUE PLANETS ?

Rogue planets are planetary bodies that wander freely through the galaxy instead of orbiting a star. All other planets in our solar system, depend on the Sun for light and energy. Rogue planets, however, exist in complete darkness. Because they do not reflect starlight, detecting them is extremely difficult. Scientists often rely on indirect techniques, such as gravitational microlensing or faint infrared radiation, to identify their presence.



1107-7626 in Chamelion Constellation

Even today, many rogue planets remain hidden, suggesting that there could be billions of them in our galaxy alone.

HOW DO THEY FORM ?

The origins of rogue planets are both violent and fascinating. One common explanation is that they are born within planetary systems but later thrown out. In the early stages of a solar system, gravitational forces between planets can become chaotic. Massive planets can disrupt the orbits of smaller ones, eventually ejecting them into deep space. Another possibility is that some rogue planets form independently. They may arise from collapsing clouds of gas and dust, like how stars form. However, they fail to gain enough mass to ignite nuclear fusion, leaving them as cold, starless objects drifting through space.

LIFE IN ROGUE PLANETS:-

Life on a rogue planet would be incredibly harsh. Without a nearby star, temperatures drop to extreme levels, and the surface remains in permanent darkness. However, scientists suggest that not all hope for life is lost. If they possess thick atmospheres or subsurface oceans beneath layers of ice, there is a small possibility that life could exist in hidden environments.

FEATURE ARTICLE:-14

Birth of Wormholes:
The Universe's Mind boggling Mystery

BY:- SUBRATA KALITA, UG SEM III

The story of wormholes does not begin in science fiction films; rather, it originates from the groundbreaking work of Albert Einstein and his theory of gravity, known as the General Theory of Relativity. In 1935, Einstein, along with physicist Nathan Rosen, was exploring the mysteries of space-time when they encountered a fascinating possibility. Their equations suggested that it might be possible to connect two distant points in the universe through a hidden bridge-an idea now referred to as a wormhole.

GENERAL RELATIVITY AND WARMHOLES

To better understand this concept, imagine space not as empty and flat, but as a flexible fabric that can bend and stretch. Massive objects such as stars and black holes create deep curves in this fabric of space-time. If this curvature becomes extreme enough, it could theoretically form a tunnel connecting two separate regions of the universe. A simple analogy is to think of a sheet of paper: instead of traveling across its surface from one point to another, you could fold the paper and punch a hole through it, creating a shortcut. A wormhole would function in a similar way, potentially allowing travel across vast cosmic distances in a much shorter time.

HOW DO THEY FORM?

However, there is a significant challenge. The original concept of wormholes, often called Einstein–Rosen bridges, is not practically usable.

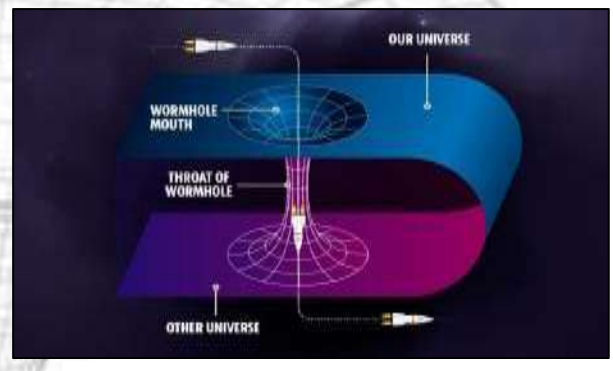


Fig. 1 — The concept of Wormhole

These structures would be highly unstable and would collapse almost instantly, making it impossible for anything to pass through them. To keep a wormhole open, scientists have proposed the existence of a hypothetical substance known as exotic matter. This form of matter would possess unusual properties, such as negative energy density, which could counteract the forces causing the wormhole to collapse. Unfortunately, exotic matter has not yet been observed, and its existence remains purely theoretical.

Despite these challenges, wormholes continue to capture the imagination of scientists, researchers, and students. They serve as a reminder of how much remains unknown about the universe. While no direct evidence of wormholes has been found so far, ongoing research in theoretical physics keeps the possibility open.

FEATURE ARTICLE:-15

Is Time Travel Possible According to Physics?

BY:- VIOLINA DAS, UG SEM III

Time travel is one of those ideas that almost everyone has thought about at some point-what if we could go back and fix our mistakes, or jump ahead to see the future? As a college student studying physics, I used to think this was purely science fiction. But after learning about theories like Relativity and Quantum Mechanics, I realized that time travel is actually a serious scientific topic.

TIME AND SPACE

Before understanding time travel, we need to understand what time actually is. According to Einstein's theory of relativity, time is not separate from space-it is part of a four-dimensional structure called spacetime. Time is not the same for everyone. It can speed up or slow down depending on motion and gravity.

TIME TRAVEL

According to Special Relativity, when an object moves close to the speed of light, time slows down. This effect is known as time dilation. Imagine a spaceship traveling at near- light speed. People inside the spaceship experience time normally. But for people on Earth, time moves faster.So when the travellers return, they will have aged less than people on Earth. In a sense, they have travelled into the future. Atomic clock experiments have confirmed this prediction, making future time travel a real, measurable phenomenon.

TIME AND GRAVITY

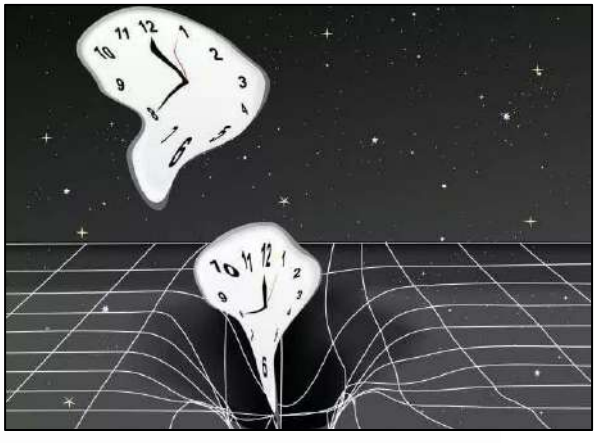
Gravity can slow time. Near massive objects like black holes, time passes more slowly—an effect predicted by General Relativity.

SCIENTIFIC OPINION

Many physicists believe that while the laws of physics do not completely forbid backward time travel, they may prevent it in practical situations. Stephen Hawking proposed the idea of a "chronology protection conjecture,"suggesting that nature itself prevents time travel to the past to avoid paradoxes.

AGE IS JUST A NUMBER

The faster you move, the slower you age. Astronauts age slightly less than people on Earth—this has been experimentally confirmed using atomic clocks.



FEATURE ARTICLE NO:- 16

The Big Bang Theory: The origin of our universe

BY:- GARIMA DEKA AND REEMA DAS, UG SEM V

The Big Bang Theory is the most widely accepted scientific explanation for the origin of the universe. According to this theory, the universe began approximately 13.8 billion years ago from a hot and dense point known as singularity. This singularity contained all the matter and energy of the universe compressed into an incredibly small space. It then began to expand, marking the event we call the Big Bang.

WHAT IS BIG BANG ?

It is important to note that the Big Bang was not an explosion in space, but rather an expansion of space itself. In the earliest moments after this event, the universe was extremely hot and filled with energy. As it expanded, it gradually cooled, allowing the formation of fundamental particles such as protons, neutrons, and electrons. These particles later combined to form simple atoms, primarily hydrogen and helium. After a few hundred million years, gravity began to pull these atoms together, leading to the formation of stars and galaxies. Over billions of years, these structures evolved into the vast and complex universe we observe today. Our own galaxy, the Milky Way, and the solar system are part of this ongoing cosmic evolution.

One of the strongest pieces of evidence supporting the Big Bang Theory is the discovery of cosmic microwave background radiation. This radiation is a remnant heat signal from the early universe, first detected in 1965, and provides a snapshot of the universe when it was about 380,000 years old.

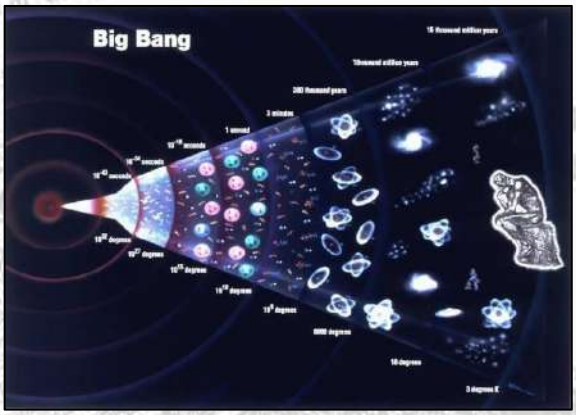
WHERE DID IT HAPPEN ?

The Big Bang wasn't an explosion in space. It was an expansion of space itself. Every point in the universe was once compressed—there is no "center" where it happened. This expansion was first observed by Edwin Hubble, who found that distant galaxies are receding from us, and that the farther away they are, the faster they move.

In conclusion, the Big Bang Theory offers a powerful framework for understanding the origin and evolution of the universe. Through continuous observation and research, it remains a cornerstone of modern physics and astronomy, helping us better understand space, time, and the cosmos.

FASTER THAN LIGHT ?

The universe inflated faster than light (and that's okay). During Cosmic Inflation, space expanded faster than light—not violating relativity, because it was space itself expanding.



FEATURE ARTICLE:-17

Artemis: Humanity's Return To The Moon

BY:- SATAKSHI CHAKRABORTY, UG SEM V

On 19 December 1972, the world witnessed a historic milestone as astronauts returned from the Moon during the Apollo 17 mission—the last time humans set foot on its surface. Now, over fifty years later, humanity is once again preparing for a long-term return to the Moon.

The United States-led Artemis Program aims to send the first woman and the first person of color to the lunar surface, marking a new chapter in space exploration.

THE TECHNOLOGY BEHING ARTEMIS

At the center of this mission is the Space Launch System (SLS), NASA's most powerful rocket to date. It is a heavy-lift launch vehicle designed to carry the Orion spacecraft from Earth into a trans-lunar orbit.

The Orion spacecraft serves as the crew vehicle, transporting astronauts from Earth to lunar orbit and safely back again. It will be used across all Artemis missions, forming the backbone of human deep-space travel.

BUILDING THE MISSION STEP BY STEP

The Artemis program is structured as a series of missions, each building upon the success of the previous one.

Artemis I, launched on 16 November 2022, was an uncrewed mission and the first integrated test of NASA's deep space exploration systems.

It included the Orion spacecraft, the SLS rocket, and upgraded ground systems at the Kennedy Space Centre. The mission lasted 25 days, 10 hours, and 53 minutes, successfully demonstrating the system's capabilities

RETURNING HUMANS TO DEEP SPACE

Following this, Artemis II marked the return of humans to deep space. A crew of four astronauts—Reid Wiseman, Victor Glover, Christina Koch, and Canadian astronaut Jeremy Hansen—undertook a lunar flyby mission.



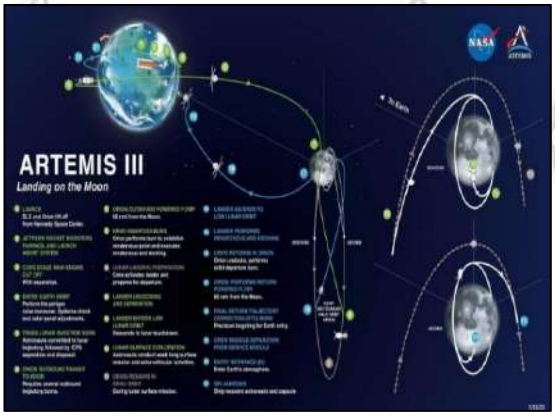
This mission was designed to test life-support systems and ensure that astronauts could safely live and work during the journey. It also marked the first time since the Apollo era that humans traveled beyond low Earth orbit. During the mission, the crew set a new record for the farthest distance traveled by humans from Earth, surpassing the record set by Apollo 13.

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TOWARDS A LUNAR LANDING

Artemis III is planned to be the first crewed mission to land on the Moon in the 21st century. It aims to send astronauts to the Moon's south pole, a region of great scientific interest due to the presence of water ice in permanently shadowed craters.

Astronauts will conduct scientific experiments, collect samples, and perform a series of moonwalks. These activities will help scientists better understand the Moon's geology and resources, paving the way for future exploration. The mission is expected to launch by 2027.



A STEP TOWARDS THE FUTURE

Artemis III represents more than just a return to the Moon—it marks the beginning of sustained human presence beyond Earth. Each mission expands our knowledge, improves technology, and strengthens our ability to explore deeper into space.

This program is a crucial step toward an even greater goal: sending humans to Mars and beyond.

FEATURE ARTICLE:-18

The Mystery of Dark Matter and Dark Energy

BY:- IPSHITA DAS, PG SEM I

Look up at the night sky and it is easy to believe that the universe is made of everything we can see: stars, planets, galaxies, glowing nebulae and enormous clouds of gas. But what if everything we can see is only a tiny fraction of what is actually there? According to our best current picture of the universe, ordinary matter the material that makes stars, planets, people and everything around us accounts for only about 5% of the universe. Another 27% is dark matter, while nearly 68% is dark energy. In other words, most of the universe is made of things we cannot directly see and whose true nature remains unknown. This is one of the greatest mysteries in modern astrophysics. Dark matter is not simply matter that happens to be black or difficult to photograph. Scientists call it "dark" because it does not appear to absorb, reflect or emit light in a way that our telescopes can detect. Yet its gravity is very real. We know it is there because we can observe what its gravity does to things we can see. One of the strongest clues came from studying galaxies. Stars near the outer edges of a galaxy move around its center at surprisingly high speeds. If a galaxy contained only the matter we can see, these stars should not move the way they do. There simply would not be enough gravity to hold them in their orbits. The observations of astronomer Vera Rubin and her colleagues in the 1970s provided important evidence for this invisible mass.

Something seemed to be surrounding galaxies, adding gravity without producing light. There is another remarkable way scientists can detect dark matter: gravitational lensing. According to Einstein's theory of general relativity, mass bends spacetime, and light passing through that distorted region can also be bent. When astronomers observe distant galaxies through massive galaxy clusters, their images can appear stretched or distorted. By measuring these distortions, scientists can work out where invisible mass must be located—even though they cannot see the dark matter itself. But knowing that dark matter exists does not tell us what it actually is. Scientists have proposed several possibilities, including new particles that interact extremely weakly with ordinary matter. Some possibilities include hypothetical particles called WIMPs and axions. Primordial black holes have also been considered as a possible contribution. So far, however, no candidate has been confirmed as the substance that makes up dark matter. And then the universe gives us an even bigger mystery: dark energy. Dark matter pulls through gravity. Dark energy appears to do almost the opposite on the largest scales. We know that the universe is expanding, but in the late 1990s astronomers studying distant exploding stars called supernovae discovered something unexpected:

the expansion of the universe is accelerating. The universe was not simply getting bigger; its expansion was speeding up. Scientists gave the unknown cause of this acceleration the name "dark energy." The name sounds like we have discovered a mysterious substance floating through space, but that is not necessarily what it is. Dark energy is really a name for whatever is responsible for the observed accelerated expansion. It may be a property of space itself, something related to Einstein's cosmological constant, a new form of energy, or perhaps even a sign that our understanding of gravity needs to be changed. Scientists simply do not know yet. This creates an extraordinary situation. We have incredibly powerful telescopes, spacecraft, particle detectors and mathematical theories. We can observe galaxies billions of light-years away and reconstruct events from the early universe. Yet the two things that appear to dominate the cosmos remain largely invisible to us.



There is also something beautiful about this mystery. Dark matter seems to help provide the gravitational framework in which galaxies and large cosmic structures form, while dark energy is associated with the universe's accelerating expansion. One helps shape the cosmic structure we see; the other appears to influence how that structure changes with time. The biggest question may therefore not be simply "What are dark matter and dark energy?" It may be whether our current picture of the universe is missing something fundamental. Perhaps dark matter is made of a particle that has not yet been discovered. Perhaps dark energy is a property of empty space itself. Perhaps gravity behaves differently on the largest scales than we currently understand. Or perhaps the answer lies in physics that has not yet been developed. For now, the universe remains strangely divided between what we can see and what we can only infer. The stars shine, galaxies glow and planets orbit within a cosmos whose greatest ingredients remain hidden. And that may be the most fascinating lesson of modern astrophysics; the more deeply we look into the universe, the more we realize how much of it we still do not understand. The night sky is not simply a view of everything that exists. It may be a glimpse of only the small part of the universe that has chosen to reveal itself.

FEATURE ARTICLE:-19

Black Holes: Exploring the Mysteries of the Universe – A Journey into the Darkest Corners of Space

BY:- SIRIN TABASSUM, PG SEM I

Introduction: The universe contains billions of galaxies, stars, planets and other extraordinary celestial objects. Among them, black holes are particularly mysterious because they cannot be observed directly through ordinary visible light. A black hole is formed when a sufficiently large amount of matter is compressed into an extremely small region, producing an intense gravitational field. Its gravitational attraction is so powerful that the escape velocity at its event horizon exceeds the speed of light. The theoretical foundation of black holes comes from Albert Einstein's general theory of relativity, published in 1915. In 1916, physicist Karl Schwarzschild obtained an exact solution to Einstein's field equations describing the gravitational field outside a spherically symmetric mass. Today, black holes are considered essential components of modern astrophysics. Their study helps scientists investigate extreme gravitational conditions and the relationship between quantum mechanics and general relativity.

Scientific Explanation of Black Holes:

2.1 Formation of Black Holes: Black holes can form through different astrophysical processes. One common formation mechanism involves the gravitational collapse of massive stars. During most of a star's life, nuclear fusion produces outward pressure that balances the inward gravitational force. When a sufficiently massive star exhausts its nuclear fuel, this balance can no longer be maintained. The stellar core may collapse under gravity, potentially forming a black hole. Other black holes, particularly supermassive ones, are found at the center of galaxies. Their formation and growth involve complex processes that may include the accumulation of matter and mergers of smaller black holes…2.2 Schwarzschild Radius: The Schwarzschild radius is the characteristic radius of a non-rotating, uncharged black hole. It is given by: $Rs = 2GM/C^2$ Where, •Rs= Schwarzschild radius

•G= Universal gravitational constant •M= Mass of the object

• C= Speed of light

If an object of mass M is compressed within its Schwarzschild radius, an event horizon forms under the assumptions of the Schwarzschild solution. This equation demonstrates that the Schwarzschild radius is directly proportional to the mass of the object…2.3 Event Horizon: The event horizon is the boundary surrounding a black hole beyond which no signal can escape to distant observers.

It is not a physical solid surface but a boundary in spacetime. According to general relativity, once matter or radiation crosses this boundary in a classical black hole spacetime, it cannot return to the outside universe.2.4 Singularity: In the classical Schwarzschild solution, the center of a black hole contains a gravitational singularity, where spacetime curvature becomes unbounded. However, this prediction also indicates a limitation of classical general relativity. A complete understanding of the black hole interior

may require a theory of quantum gravity.

2.5 Hawking Radiation: In 1974, physicist Stephen Hawking predicted that black holes can emit thermal radiation due to quantum effects in curved spacetime. This phenomenon is known as Hawking radiation. For a non-rotating black hole, its temperature is given by: $T_H = hc^3/8\pi GMk_B$ Where h is the reduced Planck constant and k_B is Boltzmann's constant. The equation shows that the temperature of a black hole is inversely proportional to its mass. Therefore, smaller black holes are hotter than larger ones. Hawking radiation suggests that black holes can gradually lose mass over extremely long periods.3. Types of Black Holes: Black holes are commonly classified according to their mass and physical properties. 1. Stellar-mass black holes: Form through the gravitational collapse of massive stars. 2. Intermediate-mass black holes: Have masses between stellar-mass and supermassive black holes. Their formation and population remain active research topics.

3. Supermassive black holes: Contain millions or billions of solar masses and are commonly found at the centers of large galaxies. 4. Primordial black holes: Hypothetical black holes that may have formed from density fluctuations in the early universe. Their existence has not yet been confirmed. 4. Observational Evidence of Black Holes: Although black holes do not emit ordinary visible light from within their event horizons, scientists can study their effects on surrounding matter and spacetime. In 2015, the LIGO observatory detected gravitational waves produced by the merger of two black holes. This provided direct evidence of black hole mergers. In 2022, the collaboration presented an image of Sagittarius A*, the supermassive black hole at the center of our Milky Way galaxy. These discoveries represent major achievements in observational astrophysics.

Applications and Scientific Importance:

Black holes are not conventional technological tools, but their study has several important scientific applications.

1. Testing General Relativity: Black holes provide natural laboratories for testing Einstein's theory of gravity under extreme conditions.
2. Gravitational Wave Astronomy: Observations of black hole mergers help scientists investigate gravitational waves and understand the population of compact objects in the universe.

3. Quantum Gravity Research: Black holes provide a theoretical framework for investigating the relationship between quantum mechanics and general relativity.
4. Understanding Spacetime: Their extreme gravitational fields help researchers study time dilation, gravitational lensing and the geometry of spacetime.
5. Future Scope of Black Hole Research: The future of black hole research is closely connected with advances in observational astronomy and theoretical physics. Next-generation gravitational-wave observatories, including the planned Laser Interferometer Space Antenna (LISA), are expected to investigate black hole mergers and other phenomenon. Scientists are also working to improve black hole imaging through advanced radio astronomy. Another important research direction is the black hole information paradox, which concerns the apparent conflict between quantum information conservation and the prediction of Hawking radiation. Understanding this problem may provide important clues towards developing a unified theory of quantum gravity. Future research may also reveal whether primordial black holes exist and whether they could contribute to the universe's dark matter.

Conclusion: Black holes represent one of the greatest mysteries of modern astrophysics. They demonstrate the extraordinary power of gravity and challenge our understanding of space, time and the fundamental laws of nature. From Einstein's general theory of relativity to Hawking radiation and the first direct images of black hole shadows, scientific discoveries have transformed black holes from theoretical predictions into observable astronomical objects. Their study has opened new research opportunities in gravitational-wave astronomy, cosmology, quantum mechanics and fundamental physics. Although many questions remain unanswered, black holes continue to inspire scientists to explore the deepest mysteries of the universe. They remind us that the universe still contains extraordinary phenomena waiting to be understood.

FEATURE ARTICLE:-20

THE PHYSICS BEHIND THE NORTHERN LIGHTS

BY:- BANDANA CHETRI, UG SEM I

Imagine looking up at the night sky and seeing waves of green, pink and violet light moving silently across the darkness. This beautiful natural display is known as the aurora. In the Northern Hemisphere, it is called the aurora borealis, or the Northern Lights.

WHERE DO THE NORTHERN LIGHT COME FROM?

The story begins with the Sun. The Sun constantly releases a stream of electrically charged particles, mainly electrons and protons, into space. This stream is known as the solar wind. When the solar wind reaches Earth, our planet's magnetic field guides many of these charged particles towards regions near the north and south magnetic poles. During periods of increased solar activity, such as solar flares and coronal mass ejections, stronger disturbances can make auroras brighter and sometimes visible farther from the polar regions.

WHAT MAKES THE SKY GLOW?

- As energetic charged particles travel into the upper atmosphere, they collide with atoms and molecules of gases such as oxygen and nitrogen. These collisions transfer energy to the atmospheric particles, placing them in excited states. When they return to lower-energy states, they release some of that energy as light. This process is called emission of light. The colours of an aurora depend mainly on which atmospheric gas is involved and the altitude at which the collisions occur.

Oxygen commonly produces green light, one of the most familiar auroral colours. At higher altitudes, oxygen can also produce red light. Nitrogen can contribute blue, violet and pink shades. The mixture of these emissions creates the colourful patterns that make each aurora unique.

THE ROLE OF EARTH'S MAGNETIC FIELD

Earth's magnetic field acts like a protective shield by deflecting much of the solar wind around our planet. However, some charged particles can enter the near-Earth environment and travel along magnetic field lines towards the polar regions. This is why auroras are most often seen in a broad ring-shaped region around the magnetic poles, known as the auroral oval. The magnetic field does not create the light itself; it helps guide the charged particles that trigger the light-producing collisions.

CAN THE SOURTHERN HEMISPHERE SEE AURORAS TOO?

Yes. A similar display occurs around the southern magnetic pole and is called the aurora australis, or the Southern Lights. Both auroras are produced by related interactions between charged particles, Earth's magnetic field and the upper atmosphere. They are most commonly observed from high-latitude regions, although strong geomagnetic storms can make them visible at lower latitudes.

Auroras are more than beautiful sights. By studying them, scientists can learn about the solar wind, Earth's magnetic environment and the behaviour of the upper atmosphere. Strong solar activity can also disturb geomagnetic conditions and affect technologies such as satellites, radio communication and power systems. Understanding auroras therefore helps researchers study space weather and prepare for its possible effects.



CONCLUSION

The Northern Lights are a striking reminder that our planet is connected to the activity of the Sun and the space around us. What appears to be a dance of coloured lights is actually the result of charged particles, magnetic fields, atomic collisions and the release of energy as light. The aurora beautifully demonstrates how physics can explain even the most breadthtaking sights in nature.

THE AURORA IS NOT MAGIC IN THE SKY; IT IS PHSICS PAINTING THE ATMOSPHERE WITH LIGHT.

FEATURE ARTICLE:-21

Solar Wind Classification at Mars:

BY:- UDISNA DEKA, UG SEM V

The variable behaviour of the solar wind throughout the heliosphere is essential for fundamental space physics and space travel to Mars. Organizations like NASA emphasize that space weather conditions driven largely by the solar wind pose risks to astronauts, spacecraft, and communication systems. The solar wind is a continuous stream of charged particles emitted by the Sun that varies significantly over time and space. It is influenced by the 11-year solar cycle and events such as solar flares.

MAGNETIC FIELD OF MARS

Unlike Earth, Mars does not possess a strong global magnetic field. Instead, it has a hybrid magnetosphere, combining an induced magnetic field (created by solar wind interaction with the ionosphere) and localized crustal magnetic fields, especially in the southern hemisphere. This makes Mars highly sensitive to solar wind changes with effects observable in its ionosphere within minutes, and such sensitive highlights the need to understand solar wind dynamics to ensure astronaut safety during future missions. To solve this issue, scientists have turned to machine learning techniques to analyse vast datasets. In this study, data from the MAVEN spacecraft, spanning over a decade and covering Solar Cycles 24 and 25 was examined using an unsupervised learning approach combining Principal Component.Analysis (PCA – method that reduces dimensionality of high dimensional data by transforming it into smaller set) and K- Means clustering.

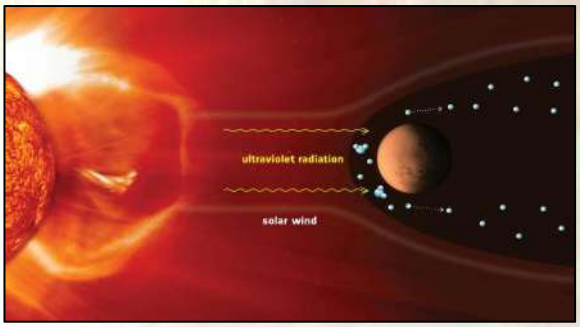


Fig:1- Magnetosphere of mars

V O L C A N O

Mars has the largest volcano in the solar system. Olympus Mons is about 22 km tall—nearly three times the height of Mount Everest.

It has been revealed that solar wind behaviour on Mars is strongly influenced by interplanetary magnetic fields. During solar minimum, conditions are relatively stable, dominated by slow solar wind with low variability and few disturbances. Whereas solar maximum periods show highly dynamic conditions, with frequent transitions between fast, slow, and compressed plasma states. Fast solar wind streams, often originating from coronal holes, exhibit high speeds and temperatures, while compressed regions are associated with disturbances like interaction regions or solar events.

Additionally, Mars' position at about 1.5 astronomical units from the Sun provides a unique perspective for studying how solar wind evolves as it travels through space.

Its magnetosphere is further complicated by factors such as crustal magnetic fields, seasonal dust storms, and extreme space weather events, all of which influence how solar wind interacts with the planet. Machine learning plays a crucial role in this research by identifying patterns in large, complex datasets that would be difficult to detect manually. The use of PCA reduces data complexity while preserving necessary physical relationships, and clustering helps group similar plasma conditions into categories. The six identified clusters represent different solar wind regimes, ranging from slow to fast streams and compressed conditions.

WATER IN MARS?

Mars once had flowing water

Evidence from rover and orbital shows ancient river valleys, lake beds, and minerals that form in water.

WHAT CAN WE CONCLUDE?

This study demonstrates that solar winds at Mars can be effectively classified and these findings improve our understanding of space weather at Mars and provide a foundation for future missions, including upcoming projects like the ESCAPADE mission, Mangalyaan-2. As human exploration of Mars approaches reality, such insights will be essential for predicting hazardous conditions and ensuring safety for the mission.

FEATURE ARTICLE:-22

COSMIC DANCE OF CHARGED PARTICLES:-
THE BEAUTY OF POLAR LIGHTS

BY:- KISHORE DUTTA
JYOTSHNA SAIKIA
FACULTY MEMBERS

Aurora, commonly known as the polar lights, is one of the most spectacular luminous display of light near the north and south poles of the Earth. In the northern hemisphere, it is termed as Aurora Borealis (Latin word for "northern"), while in the southern hemisphere as Aurora Australia (Latin word for "southern"). It is indeed indirect evidence suggesting that earth has a magnetic field, because this spectacular phenomenon is the result of the deflection of cosmic ray particles by the earth's non-uniform magnetic field.

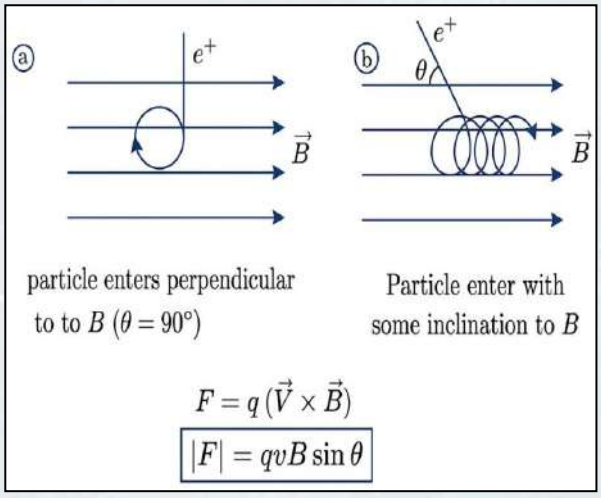


Fig.1. Trajectories of charged particles entering in uniform magnetic field.

Fundamental physics suggests that when charged particles like cosmic ray particles (protons) enter perpendicularly in a uniform magnetic field, they get deflected and trace out a circular path following Fleming's left-hand rule.

If such charged particles enter with some inclination (making some angle with the magnetic field other than 90̊), the trajectories will be helical with constant radii (Fig.1).

However, earth's magnetic field is similar to that of a bar magnet, which is non-uniform in nature. In such a magnetic field, the field intensity increases towards the poles. When cosmic ray particles enter in such a non-uniform magnetic field, the mathematical analysis suggests that the trajectory of such a particle remains helical but with gradually decreasing radius as shown in Fig.2. When cosmic ray particles are deflecting towards one of the poles of earth's magnetic field, they experienced intense magnetic field of the pole. Since the particles are in helical motion, they possess two velocity components, one of which (parallel to B) diminishes gradually towards the pole and becomes zero at some point called the magnetic mirror point.

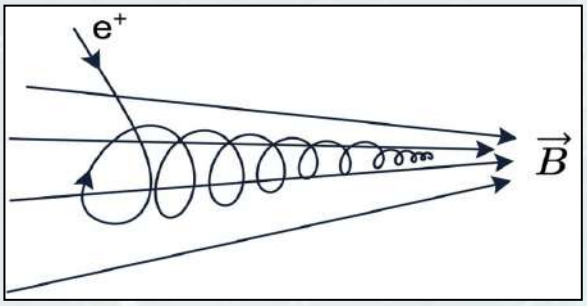


Fig.2. Trajectory of a charged particle entering in a non-uniform magnetic field.

However, earth's magnetic field is similar to that of a bar magnet, which is non-uniform in nature. In such a magnetic field, the field intensity increases towards the poles. From this point, particles reflect back due to a non-zero component of velocity (perpendicular to B). During this reverse motion, particles experienced decreasing field intensity. As a result, one of the velocity components (parallel to B) gradually increases, which allows them to traverse towards the other pole of the earth's magnetic field.

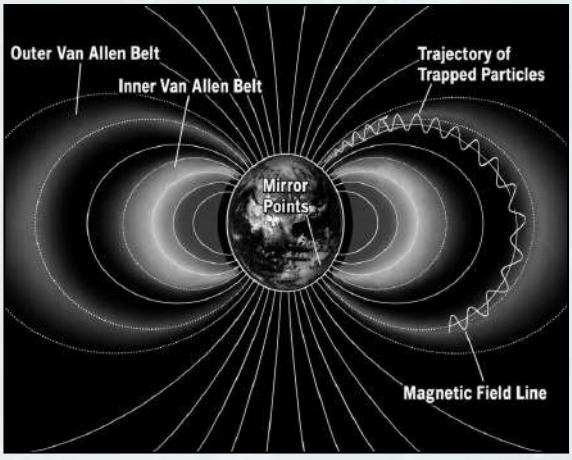


Fig.3. A schematic visualization of the Van Allen radiation belts in earth's magnetosphere

This way, the cosmic ray particles traverse back and forth between magnetic north and south poles of the earth. The particles those are trapped in between the poles solely because of the non-uniform nature of the earth's magnetic field, just like water inside a bottle. This effect, commonly called the magnetic bottle effect, is the core principle of aurora formation.

The entire phenomenon of trapping of charged particles, their accelerated motions, and accumulation mostly take place in a belt of the Earth's magnetosphere, known as Van Allen radiation belt. This belt acts as a storage zone for energetic charged particles confined by the Earth's magnetic field through the magnetic mirror effect.

These highly energetic charged particles when collide with atmospheric gas molecules, quantum transitions among their different energy states take place, and, accordingly they emit lights of different colours. This continuous emission of lights of different colours, visible in the polar regions are known as Aurora. Since, mostly cosmic particles are involved in this natural process, it is one of the intriguing examples of the cosmic dance of charged particles leading to the spectacular polar lights.

FEATURE ARTICLE:-23

The Invisible Force:
How Electromagnetism Shapes Our Daily Life?

BY:- ARCHITA KAUNDALYA, UG SEM III

We live in a world filled with invisible forces, but few are as important and fascinating as electromagnetism. This fundamental force governs everything from the light we see to the devices we use every day. Although we cannot directly observe it, its effects are everywhere around us.

WHAT IS ELECTROMAGNETISM?

At its core, electromagnetism is the interaction between electric charges and magnetic fields. When electric charges move, they create magnetic fields, and changing magnetic fields can, in turn, produce electric currents. This relationship is described by the famous Maxwell's equations, which form the foundation of classical electromagnetism.

POWERING THE WORLD

One of the most common applications of electromagnetism is electricity generation. Power plants use turbines to rotate coils of wire within magnetic fields. This motion generates electric current through a process known as electromagnetic induction. The electricity produced is then transmitted to power homes, schools, and industries.

COMMUNICATION WITHOUT WIRES

Electromagnetism also plays a crucial role in communication technologies.

Mobile phones, radios, and Wi-Fi devices rely on electromagnetic waves to transmit information These waves travel at the speed of light and carry signals across long distances without physical connections.

Without electromagnetism, modern communication would not exist.

IN EVERYDAY DEVICES

Simple devices like electric fans, speakers, and doorbells depend on electromagnetic principles. Electric motors convert electrical energy into motion using magnetic forces, while speakers use changing magnetic fields to produce sound.

DID YOU KNOW?

Lightning is a giant natural electrical discharge caused by charge separation in clouds. It is one of the most dramatic examples of electromagnetism in nature.

CONCLUSION

Electromagnetism is not just a theory studied in classrooms—it is a force that powers much of the modern world. From lighting our homes to enabling global communication, it silently shapes our everyday experiences. Understanding this invisible force helps us appreciate the science behind the technology we often take for granted.

FEATURE ARTICLE:- 24

Supercomputers in Physics
Digital laboratories exploring the extremes

BY:- KUMKUM BARUAH, UG SEM III

In physics, supercomputers act as "digital laboratories," allowing scientists to test theories that are too small (atoms), too large (galaxies), or too dangerous (nuclear reactions) to observe directly.

They have become central to modern physics, transforming how scientists explore the universe.

EXPLORING THE UNIVERSE

Since experiments on the universe are impossible, supercomputers run cosmological simulations. Scientists recreate the first moments after the Big Bang to study how dark matter and gravity formed galaxies. They also model black hole mergers by solving equations of general relativity, predicting gravitational waves, and simulate stellar interiors to understand how stars evolve and explode as supernovae.

INTERACTING WITH PARTICLES

At microscopic scales, supercomputers are essential. Facilities like the Large Hadron Collider generate enormous data, requiring advanced computation. Techniques such as lattice quantum chromodynamics help describe the strong force binding quarks, while AI-driven methods identify rare particles like the Higgs boson among vast collision data.

UNDERSTANDING FLUID MOTION

In computational fluid dynamics, supercomputers simulate airflow over aircraft and cars to improve efficiency. They also model Earth's atmosphere, solving the Navier–Stokes equations to predict weather and climate patterns.

DID YOU KNOW?

The world's fastest supercomputers can simulate complex systems like **entire galaxies or nuclear reactions** in real time.

THE ROLE OF MATHEMATICS

Supercomputers function as powerful "calculus machines," solving fundamental equations—such as the Schrödinger and Einstein field equations—using numerical methods like the finite element method.

CONCLUSION

Supercomputers have transformed physics into a computational science, enabling exploration of otherwise inaccessible realms. In doing so, they deepen our understanding of nature and drive future technological advancements.



FEATURE ARTICLE:-25

The Role of Physics In Modern Technology

BY:- DIYA MAZUMDAR , UG SEM V

Physics is the foundation of modern technology and plays a crucial role in shaping the world we live in today. From smartphones to space exploration, almost every technological advancement is based on the principles of physics. It helps us understand natural phenomena and apply that knowledge to develop innovative solutions.

CONNECTING THE WORLD

Modern communication systems such as mobile phones, television, and the internet rely on electromagnetic waves. Physics makes it possible to transmit and receive signals over long distances, enabling seamless global communication. What once seemed impossible is now an everyday reality because of these underlying principles.

TRANSFORMING MEDICINE

Physics has significantly contributed to the medical field, revolutionizing the way diseases are diagnosed and treated. Technologies such as X-rays, MRI scans, and ultrasound are all based on physical principles.



These tools allow doctors to look inside the human body with precision, making healthcare more accurate and effective.

POWERING THE FUTURE

Energy production is another area where physics plays a vital role. From solar power and wind energy to nuclear energy, physical principles guide how energy is generated, transferred, and utilized. Concepts such as electromagnetism, thermodynamics, and fluid dynamics help engineers design efficient solar panels, optimize wind turbine performance, and safely harness nuclear reactions. This understanding is essential for developing sustainable and efficient energy solutions, reducing environmental impact, and meeting the growing global demand for power.

FUN FACT

At high speeds, air resistance (drag) increases roughly with the square of velocity ($F_d \propto v^2$), which is why doubling a car's speed requires much more than double the power.

CONCLUSION

Physics lies at the heart of modern technology. It not only improves our quality of life but also drives innovation and progress. By understanding the laws of physics, we gain the ability to create technologies that continue to shape a better and more advanced future.

FEATURE ARTICLE:-26

Physics in Everyday Life: The Invisible Framework Around Us

BY:- MURCHANA BARMAN , RABINA BASUMATARY OF UG SEM V
RIMPI KALITA, JIMI DAIMARY OF UG SEM III

Physics is often perceived as a subject confined to textbooks and laboratories. In reality, it is deeply woven into our everyday lives, shaping the way we live, move, and interact with the world. From simple household activities to advanced technologies, physics operates silently in the background, making life more convenient and efficient.

POWERING DAILY LIFE

One of the most visible applications of physics is electricity. Everyday devices such as mobile phones, televisions, fans, and lights function using electrical energy. Even water pumps rely on electric motors that convert electrical energy into mechanical energy to lift water into storage tanks.

HEAT AND ENERGY IN ACTION

Heat and temperature play an important role in daily life. A pressure cooker cooks food faster because increased pressure raises the boiling point of water. Refrigerators, on the other hand, remove heat from their interiors and release it outside, keeping food fresh. Heat transfer in liquids occurs through convection, where hot fluid rises and cold fluid sinks, creating a continuous cycle.

SOUND AND SILENCE

A fascinating everyday example of physics is seen in noise-cancelling headphones. Sound travels in waves, and these devices use the principle of destructive interference to reduce unwanted noise. They generate a sound wave with the same amplitude but opposite phase to external noise, effectively cancelling it out.

WAVE NATURE

In moving sources, sound undergoes the Doppler Effect—compressing wavefronts (higher frequency) as a vehicle approaches and stretching them (lower frequency) as it recedes, which is why a passing siren changes pitch so sharply.

CONCLUSION

Physics surrounds us in ways we often overlook. By understanding its principles, we begin to recognize the extraordinary in the ordinary and appreciate how the fundamental laws of nature shape our everyday life.

This relation shows that smaller droplets have higher internal pressure than larger ones

This is why tiny droplets tend to merge in space when they combine, the total surface area decreases, reducing the overall surface energy.

EARTH VS SPACE

On Earth, the same physics still applies, but gravity usually overshadows it. In mist or fog, tiny droplets remain nearly spherical, and water beads on a leaf or a waxed surface due to surface tension.

Larger volumes of water, however, are shaped by gravity and their containers, so we rarely observe this natural spherical tendency. In space, by removing gravity's dominance, microgravity reveals this fundamental behaviour in its purest form.

WHY IT MATTERS

Beyond its visual appeal, the behaviour of water in microgravity has important scientific and practical applications. Understanding fluid behaviour in space is essential for designing life-support systems, fuel storage, and cooling mechanisms in spacecraft.

Since liquids do not settle at the bottom in microgravity, engineers rely on surface tension and capillary action to control their movement. This becomes crucial for long-duration missions, where efficient management of water, air, and fuel is vital.

"Living in space teaches you how much of life on Earth is governed by gravity."

-Scott Kelly

FEATURE ARTICLE:-27

Women In Physics

BY:- SNEHA SAIKIA, UG SEM V

Science knows no gender, yet history often forgets." Physics has long been considered a male-dominated field, but women have played a vital role in shaping its development. From groundbreaking discoveries to modern technological advancements, their contributions have transformed our understanding of the universe. The "Breaking Barriers" narrative emphasizes how women have overcome stereotypes, bias, and structural obstacles-such as limited mentorship, unequal access to funding, and workplace harassment to build careers and lead major research programs.

One of the most inspiring figures in physics is Marie Curie, whose pioneering research on radioactivity earned her two Nobel Prizes. Her work not only revolutionized physics but also had a lasting impact on medicine. Similarly, Chien-Shiung Wu made remarkable contributions to nuclear physics, challenging long-standing scientific principles and proving that talent knows no boundaries.

MARIE CURIE



One of the most iconic figures in science, Marie Curie broke barriers at a time when women were rarely allowed in laboratories. Her pioneering research on radioactivity not only introduced a completely new field of study but also changed the course of modern physics and medicine. She became the first person to win two Nobel Prizes—in Physics and Chemistry, an achievement still unmatched by many. Despite facing discrimination and limited opportunities, Curie's dedication and curiosity led her to discover elements like polonium and radium. Her journey reflects not just brilliance, but courage to persist in a world that often doubted women's capabilities.

CHIENG SHIUNGWU



Known as the "First Lady of Physics," Chien-Shiung Wu made groundbreaking contributions to nuclear physics. Her most famous work, the Wu Experiment, proved that a fundamental law of physics, the parity conservation was not always true.

This revolutionary discovery changed the understanding of particle physics forever. However, despite her critical role, the Nobel Prize for this discovery was awarded only to her male colleagues. Wu's story highlights both extraordinary scientific achievement and the persistent gender bias in recognition.

NOBLE PRIZE WINNER

Donna Strickland won the Nobel Prize in 2018 for her work in laser physics, remind us that excellence knows no gender.

While pioneers like Marie Curie, Chien-Shiung Wu changed physics worldwide, their impact reached beyond the West. Their courage and determination inspired many women around the globe, including in India. Despite facing similar social challenges, Indian women entered the field of physics and started forging their own paths, making important contributions to scientific progress both nationally and internationally.

TESSY THOMAS



Dr. Tessy Thomas is one of India's most inspiring women in applied physics, known as the "Missile Woman of India," played a key role in the development of the Agni missile series, showcasing excellence in applied physics and defense technology .As a leading scientist at DRDO, she contributed significantly to missile technology, especially the Agni series.

Her leadership in such a high- stakes, male-dominated field proves that women can excel in even the most challenging scientific domains.

BIBHA CHOWDHURI



Bibha Chowdhuri, one of India's first women particle physicists, contributed to the study of cosmic rays. She was among the earliest Indian women physicists who made significant contributions to cosmic ray research. Working during a time when very few women were in science, she helped lay the foundation for future generations of women in physics in India.

CONCLUSION

Women bring unique perspectives, creativity, and problem-solving approaches that enrich scientific discovery. Diversity fuels innovation, and when women rise, science itself evolves.

In conclusion, the story of women in physics and beyond is not just about struggle but it is also about triumph. It's about challenging norms, rewriting rules, and proving that brilliance cannot be confined by gender. As more women step forward, the barriers continue to fall, one breakthrough at a time.

FEATURE ARTICLE:-28

Symmetry- Asymmetry in this Amazing World!

BY:- ANURADHA DAS PURKAYASTHA, RETD FACULTY

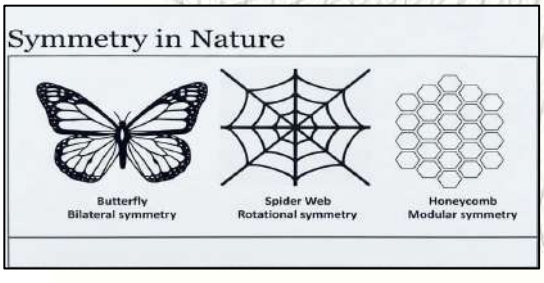
"Through symmetry man always tried to "perceive, create order, beauty and perfection".

- German mathematician Herman Weyl

INTRODUCTION

Symmetry is a concept that fascinates our minds right from childhood, consciously or unconsciously, evoking a sense of stability. A butterfly, when it emerges from its chrysalis, shows symmetry. The human body appears externally symmetrical, though the internal organs are arranged asymmetrically. Even the regular occurrence of day and night reflects a kind of symmetry in nature.

Artists like M. C. Escher, Glenn Gear, and Jamini Roy used symmetry as a powerful idea in their works, making them more rhythmic and visually balanced. Architecture, from ancient civilizations to the modern era, has relied on symmetry as a fundamental design principle. Structures like the Great Pyramid of Giza, the Taj Mahal, the Pentagon, and the Sydney Opera House all reflect this sense of order. Symmetry is also present in poems, patterns, and even the alphabets we use.



SYMMETRY IN PHYSICS

In modern physics, symmetry means that certain properties of a system remain unchanged under specific transformations. These ideas are closely linked to conservation laws. For instance, symmetry over time leads to the conservation of energy.

The stability of fundamental particles depends on such laws. The electron remains stable due to conservation of electric charge, while the proton's stability arises from conservation of baryon number. Our existence itself depends on the stability of these particles.

The idea of symmetry also contributed to major developments such as relativity and particle physics. Mathematicians developed group theory to describe symmetry operations like rotations using algebra. Even the prediction of particles such as the neutrino was based on conservation principles, later confirmed through experiments.

DID YOU KNOW?

Emmy Noether showed that every symmetry in nature corresponds to a conservation law, for example time symmetry leads to conservation of energy.

THE ROLE OF ASYMMETRY

Interestingly, symmetry does not exist alone—it coexists with asymmetry. The asymmetry of physical laws at different scales places the microscopic world under quantum mechanics rather than classical mechanics. Life itself depends on asymmetry. The structure of DNA shows a specific handedness, which is essential for biological processes. Many natural phenomena also display.

CONCLUSION

The world around us is shaped by both symmetry and asymmetry. Symmetry brings order, balance, and conservation, while asymmetry introduces complexity and variation. Together, they reveal the deeper structure of nature and continue to inspire our understanding of science, mathematics, and art.

"The laws of physics are symmetrical", but the world we see is not.
- Steven Weinberg

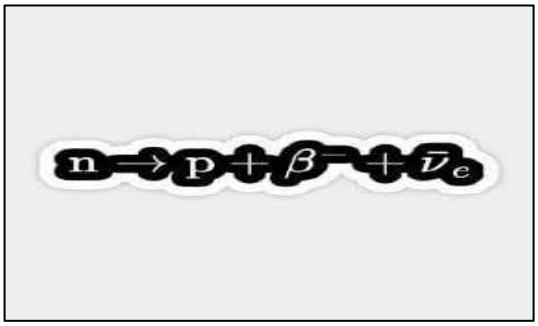
FEATURE ARTICLE:-29

The Mystery of Proton Decay: Will Matter Itself Vanish One Day?

BY:-DIKSHITA BHATTACHARJEE, ALUMNI OF THE DEPARTMENT

Everything around us is made of atoms, and atoms contain protons. For a long time, scientists believed protons were perfectly stable particles that could exist forever. However, some modern theories suggest that protons may slowly decay over extremely long periods of time. This idea, known as proton decay, could completely change our understanding of the universe.Although this article mainly focuses on proton decay, it is important to first take a brief look at the fascinating world of elementary particles. Elementary particles are broadly divided into two classes: Leptons and Hadrons. Leptons, derived from a Greek word meaning "light," are fundamental particles with no known internal structure. They are affected by electromagnetic and weak interactions. Leptons consist of electrons(e), muons(μ), taons(τ) and their respective neutrinos(ν); including their counterpart antiparticles (more like an evil twin, you could say). Hadrons, meaning "heavy," are particles that experience the strong nuclear interaction and are composed of smaller particles called quarks(q). Hadrons are further classified into Baryons and Mesons. Baryons, further divided into Nucleons and Hyperons, consist of three quarks(qqq), lifetime must exceed at least 1032years — enormously greater than the age of the universe itself, which is about 13.8×1010years. This makes proton decay extraordinarily rare and difficult to observe

Why does proton decay matter? If protons decay, then stars, planets, and even black holes will eventually disintegrate, leaving behind only radiation and elementary particles.Observing proton decay would confirm theories beyond the Standard Model.It challenges the notion that nothing is truly permanent.Fortunately, proton decay poses no practical danger to humanity because the predicted timescales are unimaginably vast. Yet philosophically, the concept carries a powerful message that even the most fundamental building blocks of reality may be temporary. Whether proton decay is ever observed or not, the search itself reminds us that science is driven not only by answers, but also by the courage to question even the most "certain" aspects of reality.



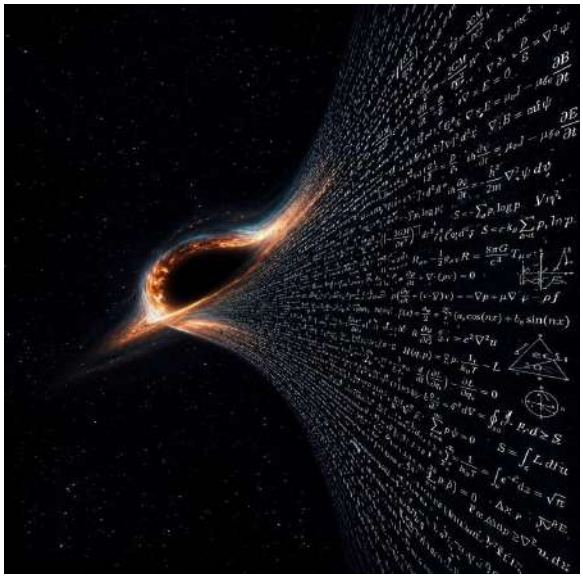
PHYSICS DEPARTMENT E-MAGAZINE

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Physics is not merely the study of established laws and theories; it is a continuous journey of questioning, exploring, and discovering the unknown. Research lies at the heart of this journey, enabling us to challenge existing ideas, uncover new phenomena, and deepen our understanding of the universe.

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It develops critical thinking, analytical skills, creativity, and the ability to approach complex problems with curiosity. Exploring the research contributions of our teachers also inspires students to look beyond textbooks and recognise the possibilities that scientific inquiry holds.

Every discovery begins with a question, and every question opens the door to a new possibility.

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Research article

Green synthesis, characterization and bioactivity of zinc oxide nanoparticles: Experimental and computational approaches

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ARTICLE INFO

Keywords:
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Structure elucidation
Band gap
Phytochemical analysis
Antibiofilm activity

ABSTRACT

Phyto-mediated nanoparticles (NPs) are known for their high biocompatibility, eco-friendliness, and cost-effectiveness, and they have been gaining significant attention recently. Here, we present a unique method for synthesizing zinc oxide nanoparticles (ZnO NPs) using *Datura metel* L. leaf extract as capping and reducing agents followed by characterization with X-ray diffraction (XRD), field emission electron microscopy (FESEM), transmission electron microscope (TEM), Fourier transform infrared spectroscopy (FTIR) and UV–vis spectroscopy. XRD and TEM confirmed the formation of ZnO NPs. XRD reported a decrease in crystallite size from 32.9 to 26.5 nm, with strain proportionately increasing from 3.6×10^{-3} to 4.7×10^{-3}. FESEM elucidated the morphology of the NPs and agglomeration was clear in the micrographs. FTIR identified the functional groups in the *Datura metel* L. leaf extract and supported the extract's qualitative phytochemical analysis. UV–vis spectroscopy confirmed the optical band gap of ZnO NPs (E_g ~3.98–4.03 eV), further validated by the density function theory (DFT), computed HOMO-LUMO energy gap values. The bacterial isolates extracted from spoiled fruits and vegetables examined using tube techniques and congo red agar (CRA) for analysing phenotypic biofilm formation capability. ZnO NPs exhibited strong anti-biofilm activity against the primary biofilm-forming isolate - *Klebsiella pneumoniae*. Hence, this investigation demonstrated that the green synthesized ZnO NPs using *Datura metel* L. leaf extract promise to serve as an antibacterial reagent to avert the microbial spoilage of fruits and vegetables.

1. Introduction

Fruits and vegetables are vital to human health, providing a rich source of vitamins, minerals, and fibre. They are also high in antioxidants, essential for preventing illness and maintaining overall health[1]. However, consuming fruits and vegetables contaminated with harmful microorganisms can lead to serious health issues[2]. Furthermore, bacterial contamination during storage can lead to spoilage, with reports indicating that approximately 20 % of fruits and vegetables are lost to spoilage bacteria, particularly during post-harvest stages [3–5]. The formation of bacterial biofilms complicates this problem, as these biofilms make bacteria more resilient, often exhibiting over 1000 times the

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Original Research

Experimental Insights and DFT Study of Green Synthesized CdS Nanoparticles, a Sustainable Approach for Preservation of *Capsicum chinense* Jacq.

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Abstract: This study presents a novel approach for synthesizing CdS nanoparticles by employing tea (*Camellia sinensis* L.) leaf catechins as a potent chelating agent. The production of spherical, cubic, and crystallite CdS nanoparticles was confirmed by XRD and HRTEM investigations. The existence of biomolecules that encapsulated and stabilized the CdS nanoparticles was verified by UPLC and FTIR analysis. These nanoparticles demonstrated antimicrobial activity against microorganisms isolated from spoiled *Capsicum chinense* Jacq. Additionally, the cytotoxic effect of CdS nanoparticles on HEK-293 normal kidney cells showed safe level of cytotoxicity. The theoretical investigation reveals a substantial interaction between CdS nanoparticles and the bio- constituents of tea. Therefore, due to their favorable biocompatibility, antimicrobial activity, and low cytotoxicity, the green synthesized CdS nanoparticles hold promise as a preservative to control microbial contamination of *Capsicum chinense* Jacq., thereby enhancing its shelf life.

Keywords: green synthesis; CdS nanoparticles; antimicrobial activity; cytotoxicity; DFT.

1. Introduction

In light of the shifting global environment, ensuring food and nutritional security of the world's growing population is a difficult and demanding task. Hence, cutting-edge technologies like biotechnology and nanotechnology are thought to be the ideal ways to handle this difficult task by boosting production and lowering post-harvest losses. In developing countries , up to 30% of horticulture crop products are lost due to microbiological spoilage and physiological processes [1]. The majority of bacteria that were initially discovered on entire fruit or vegetable surfaces are found in soil. Studies have demonstrated that using contaminated irrigation water can raise the frequency of harmful microorganisms from harvest [2].

Bhut Jolokia (*Capsicum chinense* Jacq.) popularly known as King Chilli is a significant chilli that is widely grown, particularly in the northeastern Indian states of Assam, Nagaland, Manipur, and Arunachal Pradesh. In addition to its enormous domestic market demand, Bhut Jolokia has excellent export potential [3]. According to earlier research, a variety of bacteria that have been discovered from *Capsicum chinense* Jacq. may be the result of soil contamination as well as surface damage such bruising, cracks, and punctures that provide opportunities for the establishment and proliferation of spoilage microbes [4]. These issues may result in losses after harvest.

However, this post-harvest loss can be significantly reduced to an extent of 5-10% by the application of antimicrobial nanomaterials, thereby saving huge amounts of nutritious foods. Cadmium sulfide (CdS) nanoparticles have found several uses in the biomedical area because of its consistent, exceptional luminescence, continuous excitation spectrum, and narrow emission bands.

Quantitative Acoustic Profiling of Zubeen Garg's Humming: Temporal Patterning and Spectral Balance☆

Kishore Dutta, and Jyotshna Saikia, *Guwahati, India*

SUMMARY: Vocal humming occupies a distinctive position in Indian popular music as an emotive bridge linking melody, memory, and mood. Zubeen Garg's characteristic humming style, noted for its fluidity and expressive warmth, invites systematic investigation of what acoustically defines its appeal. This study presents a quantitative acoustic profiling of Garg's humming, focusing on how measurable voice parameters contribute to its distinct sonic character. A detailed set of temporal, spectral, and timbral features was extracted, including jitter, shimmer, harmonic-to-noise ratio, spectral centroid, rolloff, tilt, roughness, and Mel-frequency cepstral coefficients (MFCCs). The analyses reveal characteristic temporal patterns (mean jitter ≈ 0.34, shimmer ≈ 0.18). Statistical comparisons show highly significant differences in fundamental frequency between Garg's humming and singing ($P < 0.01$) and in jitter between his humming and other singers' humming ($P < 0.01$). Multiple MFCCs also showed significant distinctions ($P < 0.05$), indicating limited timbral differentiation in harmonic structure. Spectral features showed non-significant trends toward lower centroid ($P \approx 0.11$) and elevated roughness ($P \approx 0.06$). These results indicate that a subset of temporal and timbral features contributes to an acoustic profile associated with Garg's humming. While no perceptual testing was undertaken, interpretations are grounded in established psychoacoustic literature linking acoustic measures to perceived attributes such as tonal warmth and vocal steadiness. Within this interpretive framework, the findings suggest that Garg's humming exhibits an acoustically measurable combination of selected temporal and spectral characteristics that may be associated with its perceived resonant quality.

Keywords: Vocal humming–Vocal timbre–Tonal warmth–Acoustic correlates–Expressive voice–Indian popular music.

INTRODUCTION

Humming represents one of the oldest and enduring forms of human vocalization.[1,2] Across cultures, it serves both instinctive and artistic functions: an intimate act of self-resonance on one hand, and a deliberate musical gesture capable of conveying emotion without words on the other.[3–5] In Indian popular music, humming often operates as an expressive interlude, bridging lyrical sections with moments of melodic reflection and emotional release.[6] Its ability to evoke intimacy and aesthetic depth has made it a common feature of modern playback singing, where a brief hum can convey affective nuance comparable to sung lyrics.

Within this expressive tradition, Zubeen Garg's vocal style is known for its distinctive use of humming. His humming often functions as a musical signature that transcends linguistic boundaries and has been described in journalistic[7,8] and listener accounts as "soothing," "soulful," or "magnetic." Such responses suggest that its appeal arises not from linguistic meaning but from its underlying acoustic organization and timbral expressivity. Despite its artistic and cultural significance, the acoustic structure of such humming has rarely been examined through a quantitative lens. Prior studies in vocal timbre, resonance shaping, and emotional prosody have established important perceptual correlates of voice quality, yet specific acoustic attributes that define expressive humming, particularly within Indian popular music, remain largely unexplored.

Recent computational approaches to humming have focused primarily on transcriptional and algorithmic perspectives. Huang et al[9] introduced cepstrum-based pitch and mode recognition methods to manage contour instability, while Liu et al[10] developed the Hum-Trans dataset to facilitate large-scale analyses for melody transcription and generative modeling. Although these approaches enable systematic benchmarking, they focus primarily on pitch tracking and melodic contour, offering limited insight into psychoacoustic qualities such as tonal warmth, steadiness, and spectral smoothness that govern expressive perception. In contrast, the present study investigates the *acoustic expressivity* of humming, examining how measurable voice parameters jointly shape its perceptual distinctiveness.

This work builds on a methodological lineage that connects acoustic measurement with perceptual interpretation. Instead of direct psychoacoustic testing, the analysis draws upon established theoretical mappings between acoustic features and perceived timbral qualities, as outlined in prior psychoacoustic literature.[11–14,15,16] Such grounding enables a perceptually meaningful interpretation of quantitative

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Dynamic optimization of multi-layered defenses inspired by Chakravyuh

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Chakravyuh strategy
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Reinforcement learning
Network optimization

ABSTRACT

As adversaries grow more sophisticated, critical infrastructure demands defense systems that not only react but also learn and adapt dynamically. This work introduces a novel reinforcement learning framework inspired by the ancient Indian *Chakravyuh* formation, integrating Q-learning, Markov decision processes, and network optimization to model multi-layered security under uncertainty. The system enables attackers to attempt sequential node breaches while defenders deploy adaptive traps and allocate resources through quantifiable metrics including ROI-driven investment and critical node vulnerability analysis. Results demonstrate both vulnerabilities and strengths: universal Layer 0 breaches occur (Mean Time to Breach = 52 episodes) due to uneven resource allocation quantified by a high Gini coefficient of 0.712. Despite this vulnerability, deeper layers remain highly resilient — with over 90% of attacks halted by Layer 1 and fewer than 5% of episodes resulting in breaches beyond Layer 2. Trap deployment achieves high efficiency, with approximately 82% of traps being triggered, especially during early episodes. However, efficiency declines over time as attackers adapt and avoid traps. Resource allocation patterns scale linearly, ensuring sustainable defense operations. These findings validate how the fusion of *Chakravyuh* strategy with modern reinforcement learning creates an adaptive defense system, simultaneously exposing perimeter vulnerabilities for targeted reinforcement and demonstrating effective deeper-layer security through optimized stochastic policies.

1. Introduction

In high-stakes systems such as cybersecurity, military operations, and disaster management, safeguarding critical assets often relies on multi-layered defense strategies. These hierarchical formations are designed to delay and mitigate adversarial breaches by incorporating dynamic, adaptive responses. However, optimizing such defenses is challenged by resource constraints, asymmetric information, and stochastic uncertainties, including probabilistic attack success, hidden traps, and random reinforcement opportunities [1–4]. The dynamic interplay between attackers, who strategically navigate these layers, and defenders, who must allocate resources and reinforce weak points without full knowledge of the adversary's plans, creates a complex and evolving problem space.

These challenges echo broader concerns highlighted in complexity science, where rigid, deterrence-based strategies often fail to cope with evolving threats. Helbing et al. [5] argue that in crises ranging from cyberattacks to disease outbreaks, traditional approaches that ignore feedback loops, instabilities, and cascading effects are insufficient. Instead, they advocate for adaptive system design grounded in real-time learning and dynamic interactions — principles central to our proposed model. By recognizing multi-layered defense as a complex, evolving system, our work responds to this call for resilience through intelligent adaptation. In parallel, recent advances in social physics further affirm the relevance of physics-inspired methods for modeling complex societal threats. Jusup et al. [6] highlight how tools from statistical physics, network theory, and dynamical systems have increasingly been used to study urban resilience, crime, financial instability, and migration. Their work underscores that modeling societal defense is not solely a matter of policy or control, but also of understanding emergent behavior across adaptive agents. These insights reinforce the applicability of reinforcement learning and game-theoretic frameworks in adversarial environments, where defender strategies must evolve alongside attacker behaviors in a co-adaptive system.

This study draws inspiration from the *Chakravyuh*, an ancient Indian military formation renowned for its multi-layered and adaptive defense structure [7–10]. The *Chakravyuh* metaphor aptly reflects the challenges faced in modern defense systems, where attackers overcome successive barriers while defenders dynamically adapt to maintain resilience [11]. The layered, resource-allocation strategies inherent in *Chakravyuh* parallel modern reinforcement learning approaches, where adaptive decision-making is central to evolving defense responses to attackers' actions. By incorporating this framework, we aim to address sequential breach and defense optimization under uncertainty.

Existing research spans a range of approaches to securing dynamic systems, including adversarial optimization, game-theoretic modeling,

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Molecular interaction of amino acid-RNA based complex as a probe for prostate cancer treatment: Experimental and computational approaches

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ARTICLE INFO

Keywords:
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CDK2
NCI
ELF
LOL

ABSTRACT

The identification of novel CDK2 inhibitors has become a key area of focus nowadays due to their pivotal role in cell cycle regulation and the potential to arrest cell proliferation, thereby advancing effective cancer treatment. The current manuscript aims to unveil the mechanism of interactions between the amino acid L-Phenylalanine (L-Phe) and the purine base Guanine and highlight its potent inhibitory activity against CDK2 protein. DFT/B3LYP/6–311++ G(d,p) is utilized to examine their molecular interaction and the structure-property relationship. The conformational analysis has been performed by studying the variation of bond length, which further influences their vibrational properties. Raman, SERS, FTIR, UV–Vis, and XRD spectra are recorded for L-Phe–Guanine. The vibrational frequency shift of O–H group to lower wavenumber region corroborates the respective bond elongation in L-Phe–Guanine, which is attributed to the transition of electron density and the presence of H34••••O2=C9 and N32••••H23-O1 interactions between the two units. Atoms in Molecule (AIM), Non covalent interaction (NCI), Electron localization function (ELF), and Local orbital locator (LOL) analyses are performed for the topological study. Molecular docking against 4EK3 receptor depicts that Glu81 (2.66 Å), Asp145 (2.67 Å), and Asn132 (1.70 Å, 2.23 Å) residues strongly take part in the binding interaction, revealing its novel inhibition against prostate cancer. In addition, drug-likeness and toxicity assessments validated its application in drug formulation.

1. Introduction

Prostate cancer is the world's second most frequent type of malignant tumor and a leading cause of death among elderly males [1]. According to Global Cancer Statistics 2022, more than 1460,000 new cases of prostate cancer and 396,000 deaths were recorded worldwide [2]. Numerous studies have shown that environmental factors, lifestyle, genetic factors, age, and diet are some common risk factors associated with prostate cancer and its progression [3]. Current treatment for prostate cancer focuses on drug therapy, chemotherapy, radiotherapy, and endocrine therapy; however, due to poor efficacy and drug resistance, the existing treatments are not sufficient to cure the disease. Recently, combined therapies have gained momentum as an efficient treatment modality to prevent or treat cancer disease and extend patient's lifespan [4,5]. In combination therapy, multiple drugs can target different pathways, unlike monotherapy, which greatly enhances the therapeutic effect, overcomes drug resistance, and reduces the toxicity of drugs [6].

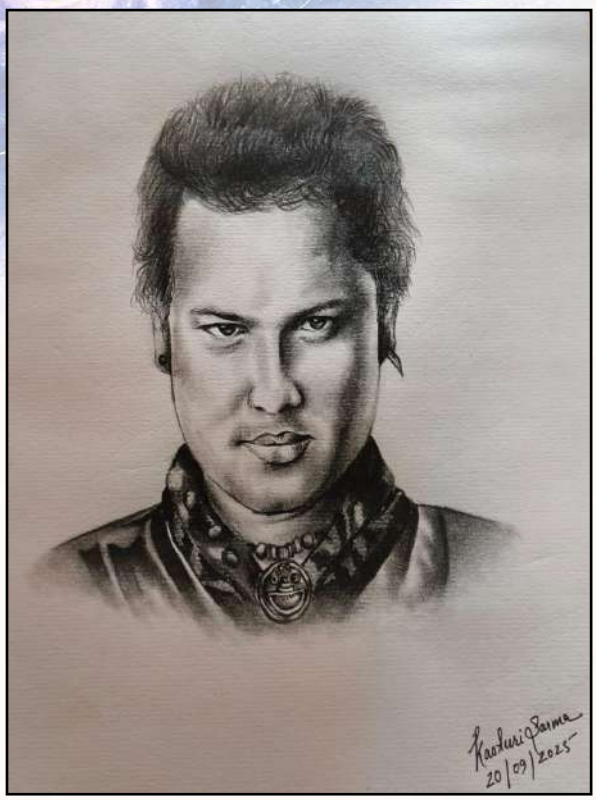
Amino acids are one of the most essential organic molecules, play a crucial role in a variety of cellular processes in human body. Amino acids regulate gene expression, act as cellular signal molecules, and precursors in hormone synthesis that govern physiological activities in human body [7]. Combination of amino acids with other pharmaceutically active compound can modulate morphology as well as bioavailability of the candidate due to the presence of hydrophilic sites. L-Phenylalanine (L-Phe) is an essential amino acid that can serve as a carrier for anticancer drug delivery into the specific tumor site. L. Li et al. [8] studied a novel L-Phe Dipeptide compound as a candidate for cancer treatment and demonstrated its significant anti-prostate cancer activity. The compound inhibited prostate cancer cell growth and metastasis of human prostate cancer cells (PC3) cells by regulating two prominent target genes dual specificity phosphatase 1 (DUSP1) and Tumor necrosis factor ligand superfamily member 9 (TNFSF9) [8]. Ribonucleic acid (RNA) is a crucial biomolecule that acts as chemical catalyst, involved in many cellular processes, including control of gene expression and protein synthesis [9,10]. The field of RNA therapy is

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ARTISTIC CORNER

BY:- KASTURI SARMA , FACULTY MEMBER



Sketching a legend whose voice lives beyond time.



An eternal melody of divinity, wisdom and love.

ALUMNI PRIDE



Farman Y Rahman

From Department of Physics, Handique Girls' College to National Taipei University of Technology, Japan.







Dikshita Bhattacharjee

Secured the highest CGPA in B.Sc. Examination in the Subject of Physics.

Dibya Subedi

Qualified JAM 2026

BEYOND THE CLASSROOM



Astami Devi

Completed a Cyber Defender Course- 2026



Mirtalin Beypi

A student of Semester VI, her team won Champion's Trophy at Gauhati University Inter-College Badminton Tournament 2026.



STUDENT SEMINER







"Learning is not just about finding answers; it is about discovering how much more there is left to know."

DEPARTMENTAL EVENTS

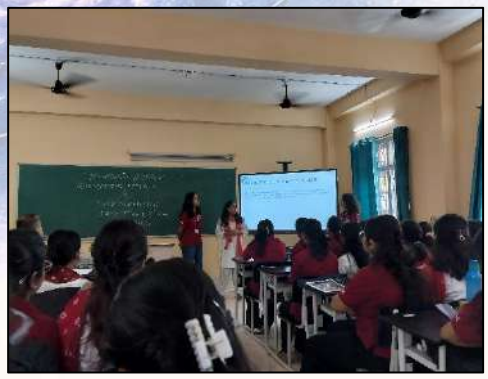


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PICTURES TAKEN BY STUDENTS



UTSHA SENGUPTA
PG SEM I



DIMPI KALITA
PG SEM I



SATAKSHI CHAKROBORTY
UG SEM V



SATAKSHI CHAKROBORTY
UG SEM V



SIRIN TABASSUM
PG SEM I



UDITA BAISHYA
UG SEM V



ADITI DAS
UG SEM I



PARISMITA PATHAK
PG SEM I



RICHA ROY
UG SEM III

We may turn the final page, but the universe never runs out of mysteries to explore. For Physics teaches us not to merely understand the world around us, but to let curiosity lead us beyond the boundaries of the known and into the wonders of the unknown.