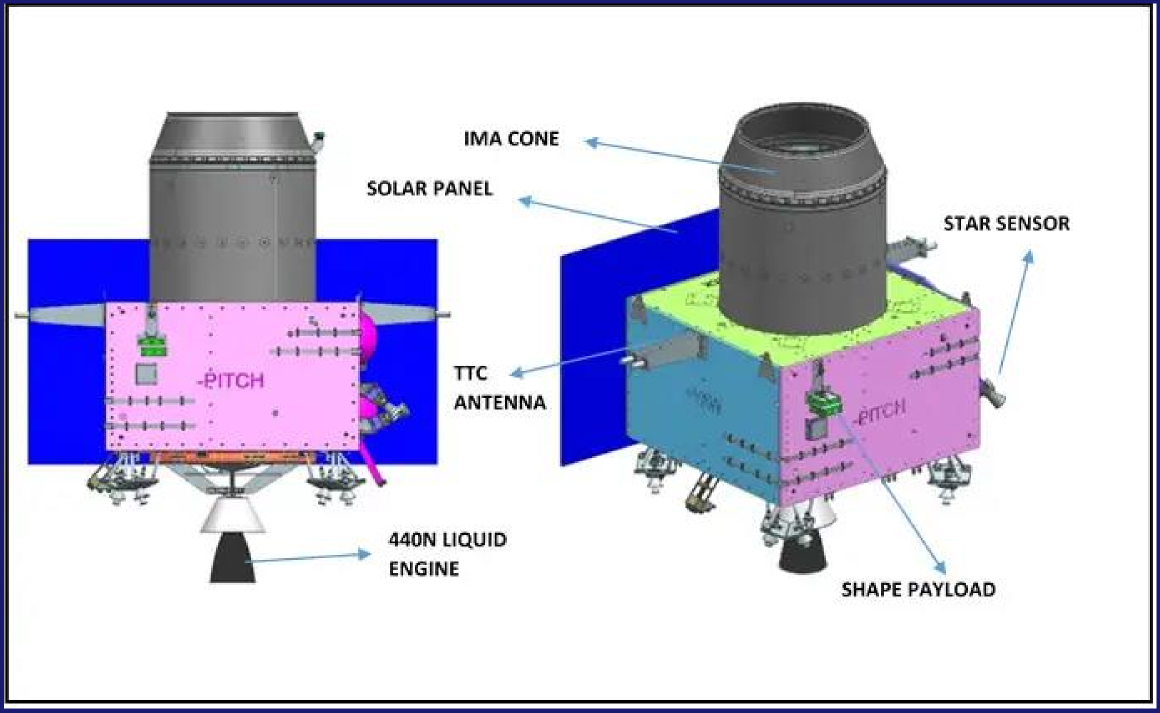
SIR P. T. SARVAJANIK COLLEGE OF SCIENCE
DEPARTMENT OF PHYSICS

SPECTRUM

2023



Editorial

"Science is not only a disciple of reason but, also, one of romance and passion."

- Stephan Hawking

The idea behind the SPECTRUM was to provide our readers a bunch of articles from different genre. We always try to include articles by which we can share knowledge, provide information about new findings or history of science, etc. This issue of the SPECTRUM contains articles about Physics and Mathematics as a two sides of a coin, contributed by Dr. Jenish Patel and Dr. Jani Vashi. The article portraits the highlights of necessity, inevitability and complimentary aspects of both physics and mathematics. The issue also contains the article on the Quantum World and Nobel Prize in Chemistry written by Dr. Sutapa Mondol Roy. The article throws light on the historical facts about the discovery of nanoparticles in 1925 even before Richard Feynman's work in 1959. The article highlights of Nobel Prize winning work on molecular machines that led to wonderful applications in the nanomedicines. The article concludes with the description on the Nobel Prize in Chemistry in 2023 that was inspired by the Qdot technology. This issue also comprises three articles written by our students: Evolution of Quantum Computing by Mr. Dhwaneel Kapadia, Put Up Pursuit by Mr. Devansh Bhutwala (which gives in-depth review on the Chandrayan-3 mission by ISRO), AI Among Us by Ms. Fatema Salejee.

We hope you will enjoy this collection of articles. We look forward to hearing from you! We welcome your feedback and creative contribution for the magazine on spectrum@ptscience.ac.in

SPECTRUM

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1. Physics and Mathematics – Two sides of a coin

Dr. Jenishkumar Patel (Department of Physics)
Dr. Janki Vashi (Department of Mathematics)

The fields of physics and mathematics are often seen as distinct disciplines, with different goals and methodologies. However, they share a deep connection that cannot be ignored. The physics of mathematics refers to the application of mathematical concepts and techniques in solving physical problems. One key similarity between physics and mathematics is their reliance on logical reasoning. Both fields require precise thinking, rigorous proofs and the ability to construct valid arguments. In this sense, they both strive for clarity and precision. However, there are also notable differences between the two disciplines. Physics deals with the study of natural phenomena through observation and experimentation, while mathematics focuses on abstract concepts and logical structures.

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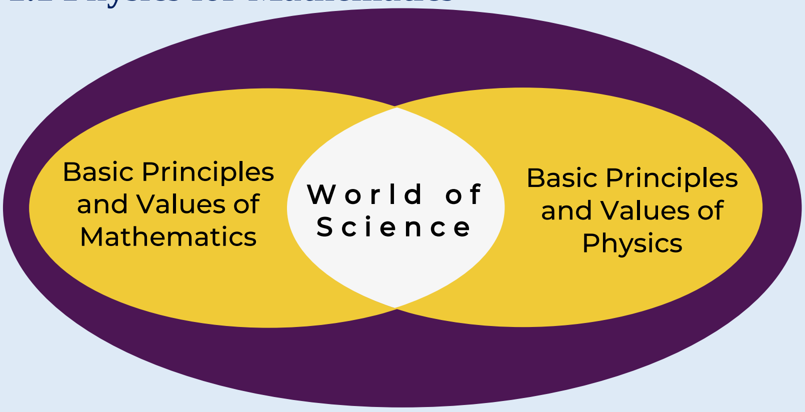
1.1 Physics for Mathematics



Mathematics and physics are two subjects that are closely intertwined and have a significant relationship. Mathematics plays a critical role in scientific calculations within the field of physics. Physics and mathematics share several concepts, which can be a source of inspiration for mathematicians. Central to this relationship is the fact that physics deals primarily with mathematical concepts. It is generally considered a relationship of great intimacy, with mathematics being described as an essential tool for physics. Without mathematics, physics would become little more than unconstrained speculative metaphysics. Therefore, it is important to have a good understanding of physics for mathematics students. To understand the relationship between physics and mathematics, it is essential to have a basic understanding of the fundamental concepts of physics. Some of the basic concepts of physics that are relevant to mathematics include logarithms, trigonometry, and slope. Additionally, mathematical physics involves topics and concepts such as vector spaces, matrix algebra, differential equations, integral equations, integral transforms, etc. By understanding these concepts, mathematics students can appreciate the relevance of physics to their studies and gain a deeper understanding of the mathematical concepts that underpin physics.

The relationship between physics and mathematics is not one-sided. Mathematics also plays a crucial role in physics, providing physicists with the tools they need to find answers to their questions. One of the language of physics is mathematics and physics is all about doing measurements, building theories and performing more measurements to justify these theories. Therefore, for mathematics students, it is essential to have a good understanding of physics to appreciate the role that mathematics plays in the study of physics. By understanding the relationship between physics and mathematics, students can gain a deeper appreciation for both subjects and develop a more comprehensive understanding of the world around them.

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1.1.1 Classical Mechanics and its association with Mathematics

Classical mechanics is a branch of physics that deals with the motion of objects under the influence of forces. The principles of classical mechanics have numerous applications in mathematics, particularly in the study of differential equations and calculus. Newton's laws of motion, which form the backbone of classical mechanics, explain why forces are necessary to change an object's state of motion. These laws were first published in Newton's famous work Philosophy Naturalis Principia Mathematica in 1687. Newton's three laws of motion, namely the law of inertia, the law of acceleration, and the law of reciprocal actions, have been instrumental in the development of mathematical models for physical phenomena.

Conservation laws, which are fundamental laws of nature, also have vast applications in the study of differential equations. These laws are based on the principle that certain physical quantities, such as energy and momentum, are conserved over time. Conservation laws are used to study a wide range of physical phenomena, including fluid mechanics, quantum mechanics, and classical mechanics. In mathematics, conservation laws provide one of the basic principles in formulating and investigating models. They have been used to study a variety of differential equations, including the (2+1) dimensional KdV-mKdV equation.

The principles of classical mechanics have also found applications in the study of calculus and differential equations. The study of classical mechanics involves the use of differential equations and phase flows, as well as smooth mappings and manifolds. Many different mathematical methods and concepts are used in classical mechanics, making it an important area of study for mathematicians. Courses in mathematics often cover topics in classical mechanics, as it provides a rich source of problems for the study of differential equations and calculus. Overall, classical mechanics has proven to be a valuable tool for mathematicians in the study of various physical phenomena.

1.1.2 Quantum Mechanics and its association with Mathematics

Quantum mechanics is a fundamental theory in physics that describes the physical properties of nature at the scale of atoms and subatomic particles. However, the principles of quantum mechanics can also be applied in mathematics, particularly in linear algebra and calculus. Introduction to the Maths and Physics of Quantum Mechanics, a textbook by Ralph Baierlein, introduces and solves problems in quantum mechanics using linear algebra methods. The course on quantum mechanics by Professor Susskind also emphasizes the non-intuitive nature of quantum mechanics. Therefore, understanding the basic principles of quantum mechanics is essential for its applications in mathematics.

The applications of quantum mechanics in linear algebra and calculus are vast and varied. Principles of Quantum Mechanics, a textbook by R. Shankar, is a requisite text for advanced undergraduate and graduate-level students. The book provides a mathematical formalism that permits a rigorous description of quantum mechanics. Furthermore, quantum mechanics can be regarded as a non-classical probability calculus resting upon a non-classical propositional logic. This relationship between quantum mechanics and probability theory is significant in understanding the applications of quantum mechanics in mathematics.

The applications of quantum mechanics in mathematics are not limited to linear algebra and calculus. Quantum mechanics has also contributed to the development of quantum probability theory, which is well-suited to quantum mechanics. The theory of quantum mechanics became necessary because classical mechanics was not able to predict or explain certain experiments. Some researchers have also used mathematical tools from quantum probability theory to contribute novel points of view to the foundations of quantum mechanics. Thus, the applications of quantum mechanics in mathematics are extensive and continue to be an area of active research and development.

1.2 Mathematics for Physics

In a world where scientific advancements continually push boundaries, mathematics stands as the cornerstone in unravelling the secrets of the cosmos. For physicists, the marriage between mathematics and physics has proven to be indispensible, enabling us to understand fundamental principles and predict the behavior of the world around us. In this article, we delve into the vital role mathematics plays in the realm of physics, exploring how the two intertwine seamlessly, powered by the ingenious API of mathematics.

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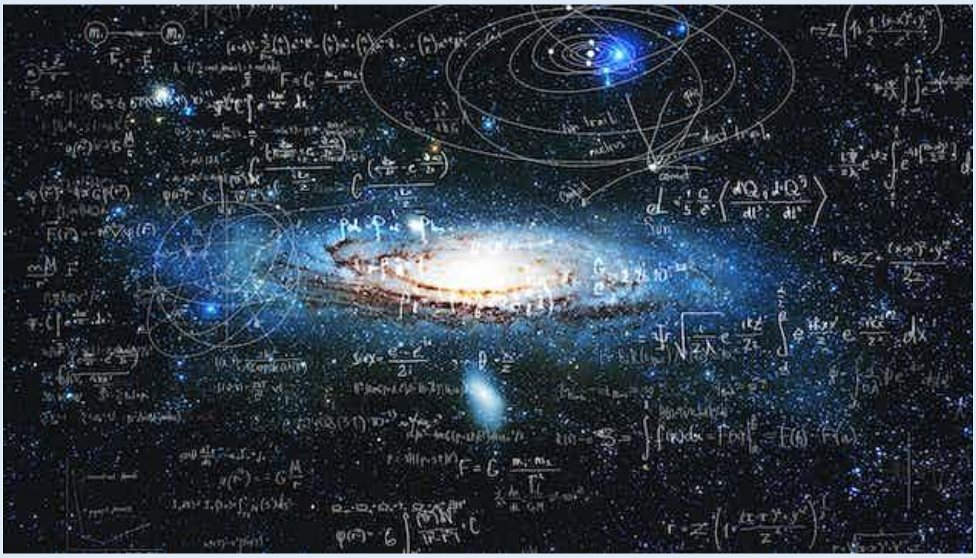
1.2.1 Bridging the Gap: Mathematics and Physics

Mathematics is the language of the universe, acting as the backbone of physics. It provides physicists with a precise toolset to describe and understand the intricate workings of nature. From principles such as calculus, linear algebra, and differential equations to complex mathematical concepts like Fourier transform and probability theory, mathematics offers invaluable representations of physical phenomena that would otherwise remain enigmatic.

1.2.2 Precision at Its Finest: Predictability through Mathematical Models

One of the most remarkable aspects of mathematics in physics lies in its predi-



ctive power. Mathematical models allow physicists to anticipate outcomes, test hypotheses, and make precise calculations that directly influence experimental designs. The profound accuracy achieved through mathematics serves as a testament to its irrefutable value within the realm of physics

The significance of mathematics extends far beyond its role in physics. It serves as a powerful tool across diverse scientific disciplines, including engineering, computer science, and economics

1.2.3 Mysteries Unfolded: Advancing the Boundaries

The ever-increasing complexities of theoretical physics require mathematics to push the boundaries of our understanding further. Concepts like quantum mechanics, relativity, and string theory rely heavily on intricate mathematical frameworks. The use of APIs (Application Programming Interfaces) in mathematics allows physicists to rapidly implement and utilize complex algorithms for simulations, modelling, and understanding cosmic phenomena.

1.2.4 Mathematica: Unleashing the Power of APIs

The advent of modern computational tools, such as the Mathematica programming language, has revolutionized the way physicists use mathematics in their research. Mathematica's rich API ecosystem provides physicists access to an extensive library of mathematical functions, cutting-edge algorithms and visualizations, empowering them to explore complex problems and uncover novel insights.

1.2.5 From Classroom to Cosmos: Applications Beyond Physics

The significance of mathematics extends far beyond its role in physics. It serves as a powerful tool across diverse scientific disciplines, including engineering, computer science, and economics. By using mathematics to build bridges between different fields, we can tackle interdisciplinary challenges, promoting innovation and creating new possibilities for scientific breakthroughs.

1.3 Conclusion

As we gaze upon the vastness of the cosmos, it becomes evident that mathematics and physics are inherently entwined. With its precision, predictability, and capacity to unravel complex mysteries, mathematics fuels our understanding of the universe, pushing the boundaries of scientific knowledge. By harnessing the power of mathematics through intelligent APIs like Mathematica, we elevate our explorations and pave the way for ground-breaking discoveries. So, let us embrace mathematics as the key to unlocking the secrets of the universe, propelling us towards a future where the mysteries of physics unravel.

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2. Evolution of Quantum Computing

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F Y BSc (Physics) Sem-1

2.1 What is Quantum Computing?

Quantum computing is a relatively recent state of the art technology that uses the principles of quantum mechanics to process information. Instead of using 0s and 1s as in classical bits, quantum computers use “qubits” (shorthand of quantum bits) which can exist in both states simultaneously due to a property known as superposition. This allows quantum computers to process a vast number of possibilities all at once, which makes them exponentially faster than classical computers for certain types of problems.

2.1.1 How are quantum computers different from classical computers?

Quantum computers differ from classical computers in the manner that they use quantum bits, or qubits, instead of classical bits. This allows them to process information at a speed of 2^n, as opposed to n^2, where n is the number of bits. This exponential increase in processing power enables quantum computers to solve complex problems in cryptography, optimization, and quantum system simulation. Furthermore, the use of qubits allows quantum computers to manipulate information in ways that are not possible with classical computers. It is also worth mentioning that quantum computers are not intended to replace classical computers, but to solve a different set of problems that are too time intensive in classical computers.

2.1.2 What is the scope in Quantum Computing?

The scope of quantum computing is immense and is also continuously expanding. Its applications include potentially revolutionary discoveries in fields like drug discovery, climate modeling, and financial modeling as well as solving variety of complex problems like factoring large numbers, simulating physical and biological systems, optimizing large systems (like global supply chains), and machine learning.

2.2 Recent advances and IBM Quantum Roadmap

The recent advancements in quantum computing have been driven by new algorithms inspired by quantum computing for simulating polymeric materials (i.e., a particle of any composition with a continuous polymer surface), and the development of hybrid quantum-classical algorithms. These advancements are opening various perspectives for solving problems in cryptography, pharmacology, chemical properties of molecules and materials, etc.

The recent advancements in quantum computing have been driven by new algorithms inspired by quantum computing for simulating polymeric materials (i.e., a particle of any composition with a continuous polymer surface), and the development of hybrid quantum-classical algorithms.

2.2.1 IBM Quantum Roadmap

IBM, a leading developer in quantum computing technology, has been making significant strides in the development of the field. They have a detailed roadmap (see figure 1)

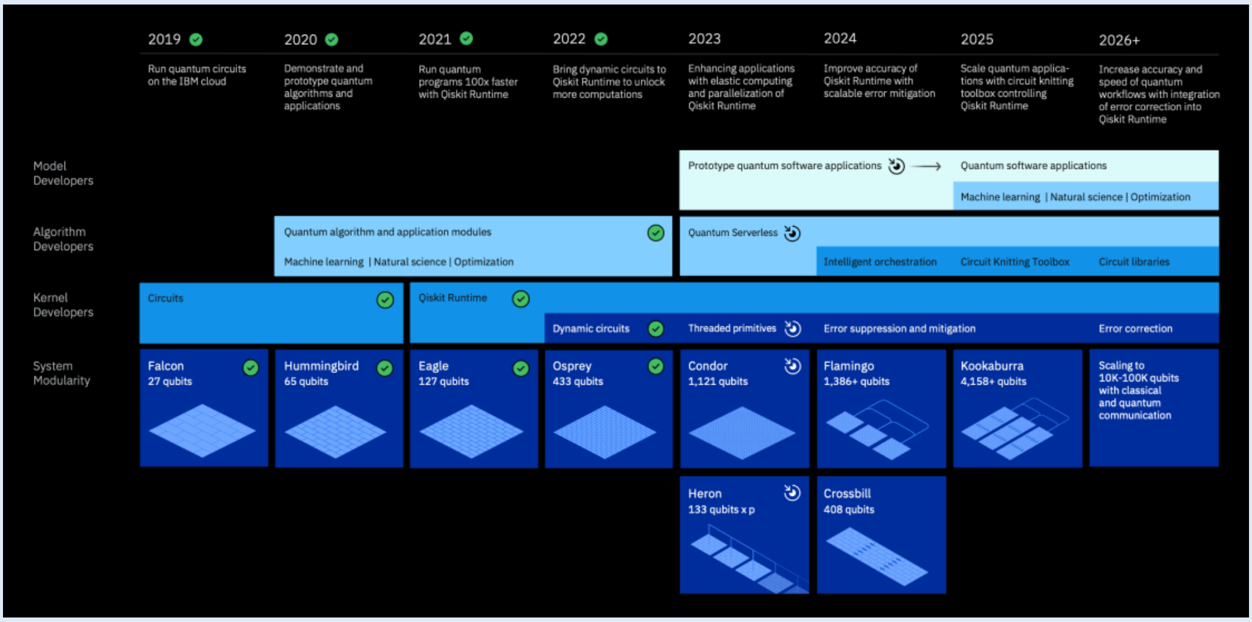

Figure 1: Quantum Computing Roadmap by IBM

for advancing quantum technology through 2026.

In November of 2021, they broke the 100-qubit barrier with their 127-qubit Eagle chip, and in 2022 they broke the 400-qubit barrier with the Osprey processor. This year they're on the way to deliver the 1121-qubit Condor processor, and they also plan to introduce classical parallelized quantum computing with multiple Heron processors connected by a single control system. So, IBM is not only being the lead in the development but also shaping the future of quantum computing.

2.3 How to get started?

There are many resources that can help you get started with quantum computing. Some of them are given below.

- The Complete Quantum Computing Course (Udemy)
- IBM Quantum Learning
- Qiskit
- Azure Quantum

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Website - https://qiskit.org/

3. Put Up Pursuit

Devansh Bhutwala
S Y BSc (PM) Sem-3

September 6th 2019, Hopes and Eyes of Indians were on Indian Space Research Organization (ISRO). A continuous watch on the trajectory graph and numbers of Chandrayan 2 were supervised by thousands of physicists. Prayers were chanted repeatedly by millions of people at early in the morning. The mighty Vikram lander descends itself towards the surface of the moon aiming not only to make INDIA the fourth country in the list of countries that successfully soft landed on moon but also the first country to land at such location which had never been reached by others, THE SOUTH POLE.

The ISRO's mission control center is humming with activity. The scientists and engineers crowd around computer displays, following the progress of India's ambitious moon mission, Chandrayaan 2. Tension is palpable in the air as they anticipate a critical moment. One of the monitors suddenly displays an error notice. Anxiety sweeps over the room, as scientists exchange apprehensive glances. As the seconds pass, it is clear that something has gone horribly wrong. During its descent to the lunar surface, Chandrayaan 2 suffered a severe breakdown. The screen shows a fast-approaching picture of the lunar surface. Everyone in the room goes silent as they watch helplessly. The objective they've been working on for years is slipping away. Suddenly, a voice comes over the intercom, announcing the final moments of Chandrayaan 2's descent.

As the seconds pass, it is clear that something has gone horribly wrong. During its descent to the lunar surface, Chandrayaan 2 suffered a severe breakdown. The screen shows a fast-approaching picture of the lunar surface.

INTERCOM trembles
Lunar impact in T-minus...ten...nine...
But all eyes fill with tears, heads bowed down, unable to bear the sight on the screen.
Three...two...one...

Figure 1: Image captured by MIS

As the displays go black, there is a collective gasp. The lunar lander Chandrayaan 2 has crashed. The room is filled with a deafening quiet. Many scientists' eyes fill up with tears and their shoulders sag. In building probes and satellites, designing for failure is important. To define a successful module, we consider that making a working probe for an instance is very easy when compared with making a probe that never fails. Even it fails, the system should handle it well. No doubt, the Chandrayaan 2's experiment suit was one of the best suits and an advanced one, many of which equipment were carried to moon for the first time in human history. But the ultimate scenarios were not in the system favor and the output was drastic.

However, was CH 2 (CH= Chandrayaan) INDIA'S first step towards the south pole of moon? The answer is no. While the average vision of the earth was on the orbiter of CH 1 also of which profoundness was gained by the orbiting aim, ISRO envisioned lunar surface. They specially designed MIP i.e., Moon impact probe which was a 32Kg payload which was responsible to make an impact with lunar surface back in 2008. It had MIS i.e., Moon Imaging System that captured roughly 3000 images. Secondly it had Radar Altimeter Antennae (RAA) which was responsible for altitude detection and profile the landing for future lunar landings and moon missions. And thirdly CACE i.e., Chandra's Altitudinal Compositional Explorer which is a mass spectrometer.

To pursue the mission of scientific curious minds, ISRO announces. Chandrayaan Mission 3. Major flaws had been overcome this time and it is worth noting that even though both CH 2 and 3 look same but their difference is like that of analogous to the difference between birth and berth

To pursue the mission of scientific curious minds, ISRO announces Chandrayaan Mission 3. Major flaws had been overcome this time and it is worth noting that even though both CH 2 and 3 look same but their difference is like that of analogous to the difference between birth and berth.

CH 2 had a stack of lander and an orbiter. CH 3 also has the same stack but the main difference lies in the functionality. CH3 has a lander but its orbiter majorly is just a propulsion module and has just one experiment on it. Where as in CH 2 not only the lander, but also the orbiter had variety of scientific equipment. Even though the lander crashed, CH 2 orbiter is still in the working condition which also played a major role for CH 3. The science on CH 3 orbiter is termed SHAPE meaning Spectro Polarimetry of Habitable Planet Earth that will gather the spectrum and polarimetry of earth's light polarization data which can help us to determine the blue print in, other words the signature for a planet to be habitable.[1]

The second difference is TTC Antennae or Telemetry Tracking and Command Antenna which gives us telemetry data or tracking data which is discussed further. The third difference is made by the presence of 2 Hazard Avoidance Camera. The name itself is self-explanatory to the functionality. These are expected to help the lander land safely, avoiding the hazardous landing itself. The fourth difference is an extended fuel tank. And this led to not so major but important difference that is absence of Central engine in the module. The CH 2 module had a central engine i.e. 5 engine system. But in case of CH 3, this 5-engine system is converted to a 4-engine system for which the extended fuel tank plays a major role.[2] Our Major fifth difference is LDV i.e. Laser Doppler Velocimeter. It is designed to determine the velocity of the lander in all X, Y, Z directions. It will create an interference pattern with the help of multiple

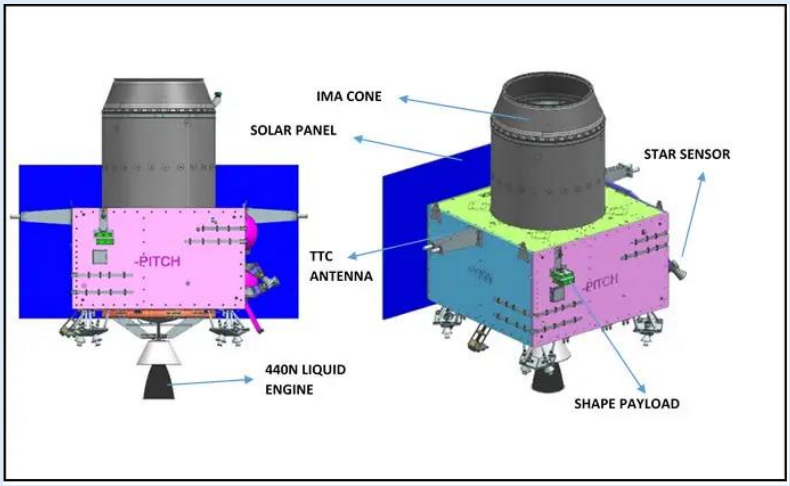

Figure 2: Schematic Diagram of CH3

lasers and by studying the rate of change of this interference pattern, we can determine that how far we are going back and forth.[3] The size of the attached solar panel is increased and additionally, the panels are attached on the both the sides, even in CH 2. But the factor of size has been increased and which results in our sixth difference. The seventh difference is in the numbers. Previously the Co-Ordinates were 70,20 degrees but now its replaced with 69,32 degrees. This landing site has already been imaged with the help of CH 2 orbiter. CH 2 had a camera OHRC i.e. Orbiter High Resolution Camera which is also called world's highest resolution moon camera. It helped in detecting rocks and boulders with fine detail. The last difference makes the biggest difference that is its software.

Looking towards Cool systems of Chandrayaan 3, the first highlight of the innings points towards its antenna.CH 3 has an insane 14 antenna communication system, that solves majority of communication problems. The one is TTC antenna as mentioned above. It refers to the telemetry data which has different meanings depending on where its used. In this case it refers to data related with fuel level, thrust levels, etc... The C stands for commands which suggests its use i.e., it receives the command sent to the probe here from earth. This TTC data is routed to TTC antenna. There are pair of antennae at the eighter sides of the lander and 3 antennae on the top. But then it makes one ask the question on what is there inside this antenna. Inside the cylinder is QFH antenna i.e. Quadrifilar Helix Antenna which basically means 4 wires going around in helix whose length and size aways depends on the desired range. As above mentioned, we get an idea about the "Pair" of the antenna. The reason for them to be in pair is because one antenna is responsible for receiving the signals whereas the other ensures transmittance [4]. The most Fascinating note about this system is that it gives a coverage of almost 180° or a hemisphere. We also know that this same setup is on the opposite side of the lander. Which can make one to reach the fact that we now have 180° coverage on both the side. Resulting into our lander's 360° or omnidirectional TTC signal is received. If you have the spacecraft with such system, no matter what is the "Altitude" (A term used to refer the orientation of the system) of the lander, it will always receive the signal. The 3-antenna system on the top, is for the same (receiving and transmittance) but it would be for the rover. There will be the same antenna system on the rover which will communicate with lander because we cannot use

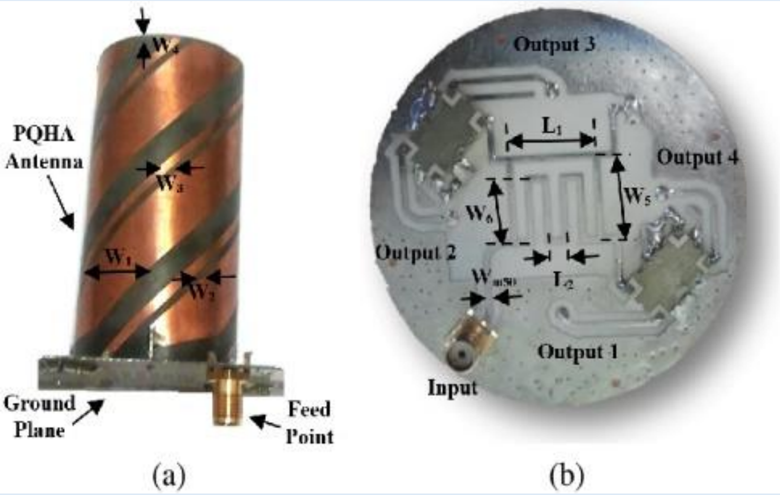

Figure 3: QFH Antenna

a high-end antenna for the cause, it may drain the batteries attached on the rover. Once the data is received from rover, the lander will send it back on earth. But this process will not be followed with help of TTC antenna. The reason is its speed on board TTC antenna that has speed of 4KBPS only which is quite low data rate for a huge data. The use of X band antenna is made with the speed of 1MBPS. The coolest part with this antenna is that it is attached with a gimbal. Gimbal for this system becomes necessity because unlike TTC antenna, it is not wide open. It is a focused beam type of the direction really matters. Even while the landing process, the X antenna will be active which will frequently send data even while the lander lands. [5, 6]

The second system is the Moon Drill and the moon quack sensor. The moon drill is termed CHASTE i.e. Chandra's Surface Thermophysical Experiment. It is attached on the backside of the lander which quite looks like a stick and will swing out of the system after the lander lands. It will enter the soil and has the ability to go in for around 10 cm [7]. The probe has the temperature sensor to measure the heat of soil. The amazing functionality is that we now can also determine if this temperature varies with time or not. By the variation of time, we mean the angle subtended by the lunar surface and the Sun. Additionally, the probe also has its own heating system with which the sensors can determine the characteristics of the Regolith (Lunar soil) and estimate how quickly can it lose its heat. The reason why this equipment is necessary is because it is theorized that the upper lunar surface is loose and its beneath layers are so very dense. Also, because the upper regolith is loose, it is a poor conductor. But the theoretical ideas are to verified experimentally to enhance the understanding of the soil [8]. The second sensor is ILSA i.e. Instrument for Lunar Seismic Activity. This sensor will be dropped from the lander softly using ropes [9]. This seismometer is based on MEMS technology which is Micro Electro Mechanical System (see figure 4 and 5) which are very small mechanical systems that move consequently to the smallest disturbance. In presence of the disturbance i.e., the moon quack, the Seismic Mass moves back and forth. This leads to the change in the distance of two consecutive plates resulting in change of the capacitance [10]

The moon drill is termed CHASTE i.e. Chandra's Surface Thermophysical Experiment. It is attached on the backside of the lander which quite looks like a stick and will swing out of the system after the lander lands.

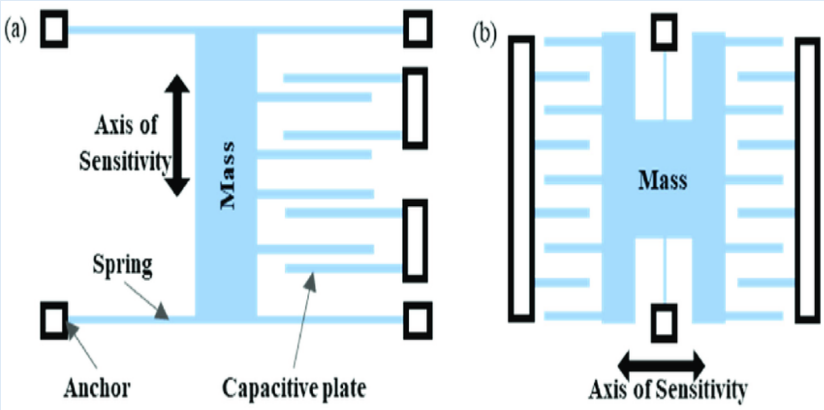

Figure 4: MEMS Capacitor Structure

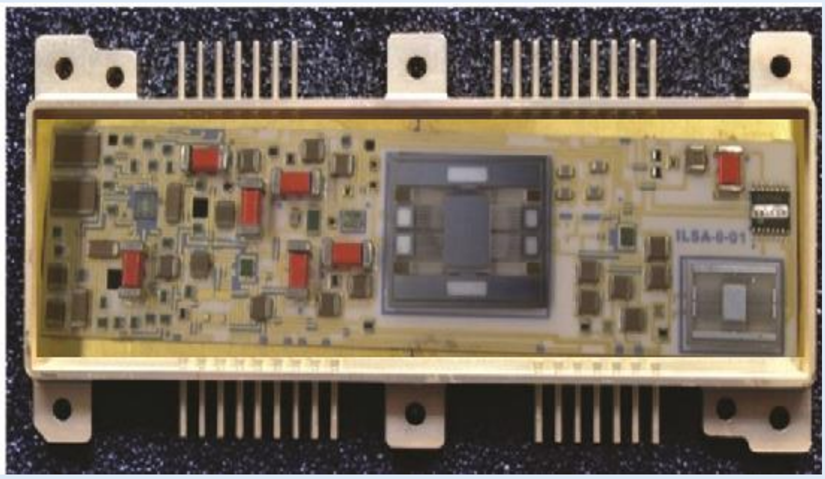
Figure 5: MEMS Circuit

In addition to study the lunar soil, the next fascinating equipment is a radioactive equipment. It is world's first in-situ measurement equipment for lunar soil. Glimpses of X-Ray spectroscopy is also seen in CH 2 with the on-board equipment called CLASS which just doing remote sensing. The setup which will conduct this in-situ experiment is termed APXS i.e., Alpha Particle and X-ray Spectrometer. It is mounted on the front side of the Pragyan rover which folds out itself and takes the related measurement. These estimations are useful in determining the presence of the elements in the Regolith. It is theoretically capable of determining elements like Na, Mg, Al, Si, Ca, Ti and Fe. It is quite fascinating that in spite of rover's relatively small dimensions, it has an on-board X-ray shooting system and with this, the curiosity reaches on the peak willing to know how that works. Well, the on-board equipment has free X-ray source. The answer lies in the structure. (see Figure 2). If we glance over the head of the sensor, we notice a circle in the middle which is an X-Ray detector and that is surrounded by 6 other circles each contained with a radioactive source Curium 244 with half life of about 18 years. While its radioactive decay, it emits X-rays and alpha particles which is involuntary in nature. Alpha particles are nothing but helium nucleus i.e., 2 protons and 2 neutrons which makes it quite heavy. So, if we bombard alpha particles, it is highly probable that it knocks out an electron. In the case of this system, both the X-Rays and the alpha particles play a significant role. There is a well-

Glimpses of X-Ray spectroscopy is also seen in CH 2 with the on-board equipment called CLASS which just doing remote sensing. The setup which will conduct this in-situ experiment is termed APXS i.e., Alpha Particle and X-ray Spectrometer.

known concept called X-Ray Fluorescence (XRF). According to XRF, when a primary X-ray is incident on an atom, it might blow up the low energy electron in its inner orbits. Consequently, the atom becomes unstable. With concern to atom’s stability, an electron from outer orbit which is relatively highly energetic, gives out some of the energy and will make a transition form the upper orbit to lower orbit. This energy is usually of the range of X-Ray and so is called Secondary X-Ray. Every element has its unique wavelength as its secondary X-Rays for such transitions and analyzing these secondary X-Rays, we can conclude the presence of certain elements in the lunar soil. But we also have alpha particle as a second player of the game. This case of measurement is popularly known as PIXE i.e. particle-induced X-Ray Emission. They collectively give a very efficient way for studying different atomic ranges.[11]

23rd August 2023 in a cosmic ballet between technology and the uncharted, Chandrayaan-3 descended towards the lunar surface, a heart-stopping crescendo in the vastness of space. The lunar horizon stretched like an endless canvas beneath as the spacecraft, a marvel of human ingenuity, pierced through the celestial darkness. The control room echoed with bated breaths, pulses racing in synchrony with the mission's heartbeat. Every second was an eternity as the lander navigated the final descent. Silence hung heavy, interrupted only by the rhythmic exchanges between mission control and the spacecraft.

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The moon's craggy surface rushed to meet the vessel; the tension palpable as the craft meticulously executed its choreographed touchdown. A collective gasp filled the room, swiftly followed by a euphoric eruption of cheers and applause as telemetry confirmed the successful landing. In that instant, humanity's aspirations and the culmination of relentless scientific pursuit echoed across the cosmic tapestry, marking another monumental step in our quest to unlock the mysteries of the universe. Now it is wholesome to see Moon knowing... that a part of my country is up there.

The moon's craggy surface rushed to meet the vessel; the tension palpable as the craft meticulously executed its choreographed touchdown. A collective gasp filled the room, swiftly followed by a euphoric eruption of cheers and applause as telemetry confirmed the successful landing

After landing, almost after 5-6 hours, the rover begins imprinting India on the lunar land. But the most fascinating part of this mission is its scientific fun. The rover and lander have worked for a lunar daylight i.e., 14 Earth days giving a lot amount of scientific output. Primarily, the moon drill worked behind the variation of temperature on lunar surface with increase in depth. It proved how hot is the lunar surface just by digging in accompanying the coldness just 8 cemi beneath. Its uncommon among all but its true that our lander did perform a not too high hop. The amazing fact reflected through this hop is that all the payloads like ChaSTE, ILSA and the Ramp were re-deployable. Unlike APXS, there had been a second in-situ spectrometer on the rover called LIBS (Laser Induced Breakdown Spectrometer). As the name suggests, it’s a laser on the rover of just 0.4 watt with peak power of 10 watt. When a sample is stroked by laser, it heats up and eventually cools down. As it cools down, variety of elements like sodium, magnesium, etc… can be detected by the emitted radiations. LIBS is also somewhat sensitive to oxygen and hydrogen. To note a clarification, the oxygen been mentioned here is a bounded oxygen and not a literal.

LIBS has two modes in it i.e., single shot and multi shot capture. In single shot capture, we do come to know the composition of lunar soil. But unlike it, in multi shot capture, lasers are shoot at certain succession which helps studying both plasma and the dust which created by previous shots. It confirmed Sulphur on its surface. LIBS is analogous to APXS which also confirmed presence of sulphur. The problem with APXS is that it needs quite a long time for observation versus LIBA that gives out the result in just few milli seconds. It was quite important to see the combo which also verified the performance of LIBS. [11, 12, 13]

As the lunar night veiled the frigid surface in an icy shroud, ISRO embarked on a daring endeavour to awaken Chandrayaan-3's slumbering lander and rover. With the sun dipping below the horizon, plunging the landing site into a prolonged darkness lasting over two weeks, the challenge was daunting. ISRO's ground control became a symphony of innovation and determination. Engineers meticulously planned and executed a meticulous sequence of commands, attempting to rouse the dormant machinery from its deep lunar sleep. They sent pulses of electrical current, initiated power-up sequences, and anxiously awaited any sign of response. Days passed, the silence of the lunar landscape echoing the tense anticipation on Earth. Hope intertwined with uncertainty as each attempt to establish contact was met with an eerie silence. The Lander and Rover thereby are just INDIAN AMBASSADORS on the moon. However, the reason for “NO RESPONSE” is quite fundamental. The panels on lander and rover were designed so as to bear certain amount of temperature. In full sunshine, temperatures on the Moon reach 127°C. There are 13 and a half days of high temperatures followed by 13 and a half days of darkness, and once the Sun goes down the temperature plummet to -173°C. which is way too cold for the battery/ panel to work. Considering the battery type to be electrochemical, this staggering temperature is enough to freeze the panel and the electrolyte which consequently results in no reaction.

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However, it was possible to get the surety of reactivation after the lunar night if the CH3 had an on board RTG or radioactive thermoelectric generator. Other moon missions like CHANG’E and Apollo Missons are evident for the use of RTG in their rovers and landers which basically provides heat to the entire system. The use of RTG in CH3 could easily reactivate the rover and lander. The principles on which RTG works is quite simple. Its traces go way back to 1821. It just works on the principle of Seeback effect which suggests that if the junctions of two appropriately chosen metals are arranged in such a way that its one end’s temperature is hot and the other is cold, it results in generation of electron movement or simply put generates current. If the modified thermocouple (MODIFIED THERMOCOUPLE IMPLIES USE OF P-N JUCTION) used in large amount are put together, it is RTG. Providing this system cold temperature is very logical and simple, the lunar night temperature. But in order to provide heat, we ought to use a radioactive material over which we have no control. The also so-called problem in this is its weight. Our entire on-board rover weighs 26 kgs where as the weight of RTG itself is around 36 to 37 kgs and is one of the reasons for NO RESPONSE

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Chandrayaan-3 is a symbol of human ingenuity, perseverance, and the persistent quest of knowledge beyond terrestrial limitations, not only a journey to the moon. It has fed us with much of scientific data which is too useful to plan, structure and design ISRO'S future moon missions. It exemplifies humanity's persistent spirit of exploration and discovery. Despite the difficulties experienced during the lunar night, ISRO's commitment and inventiveness continue to inspire. While the lander and rover's stillness reverberate over the lunar surface, their journey exemplifies the tenacity inherent in scientific endeavour. Each initiative, whether successful or unsuccessful, moves us ahead in our quest to fathom the secrets of the universe

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4. AI Among Us

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T Y BSc (Physics) Sem-6

Artificial Intelligence, or "AI," is the buzzword of the moment. AI art generators to AI chatbots.[1] The companion designed by humans for humans to improve precision and speed up decision- making. A lot of us have been using chatbots to complete essays, assignments, and other tasks. Despite being present for decades, this technology looks new because of the attention it has received in the last ten years. So, how was AI developed and what it simply is?

The topic of "Can machines think?" emerged in the 1950s as a result of science fiction from the first half of the 20th century, which portrayed artificially intelligent robots, or humanoid robots, in films like "Metropolis" and "The Wizard of Oz." Can machines think like humans and solve challenges and make decisions? Alan Turing, a British polymath, was among of the great scientists, mathematicians, and philosophers of the generation that proposed the concept of artificial intelligence. He argued that since humans use available information and logic to solve problems and make decisions, why couldn't machines do the same? In his paper "Computing Machinery and Intelligence," he set forward the conceptual framework and covered the topics of building intelligent machines and testing their intelligence.

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The concept was groundbreaking, but it was not easy to implement. To start, computers in the 1950s could execute orders, but they could not store them in memory, meaning they could not recall what they had done. Second, the cost of computers was high. A few years later, AI grew rapidly as technology progressed. John McCarthy first used the phrase "Artificial Intelligence" in 1956 at The Dartmouth Workshop, which is regarded as the birthplace of AI. Machine learning algorithms[2] were made possible by faster and more widely available computers. In the 70s, defense organizations were interested in computers that could process large volumes of data and interpret spoken languages. Despite having high hopes and aspirations, there were many challenges. Increased funding in the 1980s gave rise to the "deep learning"[3] theories put forth by David Rumelhart and John Hopfield. As part of its "Fifth Generation Computer Project" (FGCP), the Japanese government invested $400 million between 1982 and 1990 in order to advance artificial intelligence and logical programming. Though not totally met, the objectives motivated a new generation of engineers and scientists.

Many of the objectives of artificial intelligence were accomplished in the 1990s and 2000s. A computer program called IBM's Deep Blue that played chess beat world champion Gary Kasparov in 1997. Chinese go champion Ke Jie was defeated by Google's AlphaGo in the same year. From speech recognition software “Dragon system” to “Kismet”, a robot that could recognize and display emotions were developed. Big Data became popular in the 2000s, and as computing power grew and deep learning techniques were developed, artificial intelligence started to advance significantly.The 2010s saw the mainstreaming of AI. Tech giants like Google, Amazon, and Facebook began incorporating AI into their goods. Within the AI community, language models like (GPT-3)[4] began to gain traction in the late 2010s and early 2020s. These language models could produce writing that was remarkably close to human writing, and they could even write in a variety of genres, including formal, informal, and humorous. This gave artificial intelligence access to entirely new possibilities. AI could now produce creative content on par with human writers; it was no longer just about crunching numbers or seeing patterns.

Artificial Intelligence (AI) is a branch of computer science that aims to create systems capable of performing tasks that would usually require human intelligence.

In a nutshell AI has come a long way. After providing a brief overview of its history, artificial intelligence can be technically defined as:
Artificial Intelligence (AI) is a branch of computer science that aims to create systems capable of performing tasks that would usually require human intelligence. These tasks include learning and adaptation, perception (e.g., understanding speech or recognizing objects), reasoning, problem- solving, decision-making, and Natural Language Processing.[5]

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<u>Terminology</u>

1. Chatbots: A computer program designed to simulate conversation with human users, especially over the internet.
2. Machine learning Algorithms: A set of mathematical processes or techniques by which an artificial intelligence (AI) system conducts its tasks.
3. Deep learning: Deep Learning is a subfield of Machine Learning that involves the use of neural networks to model and solve complex problems. Neural networks are modeled after the structure and function of the human brain and consist of layers of interconnected nodes that process and transform data.
4. GPT-3: Generative Pre-Trained Transformer 3 (GPT-3) is a Large Language model released by OpenAI in 2020. Large language model is a deep learning algorithm that can perform NLP tasks.
5. Natural Language Processing (NLP): A type of artificial intelligence (AI) that enables machines to understand and process human language.

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5. The Quantum World and Nobel Prize in Chemistry

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Department of Chemistry

It all started with the famous quote from the very famous professor Richard Feynman back in 1959 when he said "there's plenty of room at the bottom". But even before this in 1925 Professor Richard Adolf Zsigmondy, won the Nobel Prize in Chemistry for detailed study of gold nanoparticles (as sol) and other nano particles with size as low as 10 nm. Moreover, he was the first to coin the term "Nano metre".Yet "the room at the bottom"made the scientists extensively inquisitive so much, so that around 1 million research papers have been published in the last 60 to 70 years.In 1974 atomic layer deposition was patented by Dr. Tuomo Suntola, a Finnish physicist. Fullerene was discovered by Dr. Henry Kroto, Dr. Richard Smalley and Dr. Robert Curl in 1985. Thereafter in 1991, carbon nanotube was discovered by Japanese physicist Sumio Ijima. These discoveries opened up a new vista of applying nanotechnology in our life.

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Now coming back to the Nobel Prize winning work on molecular machines, it had opened up a vista of applications from material science to nanomedicine. The journey of the molecular machines started in 1983 with the synthesis of catenanes and Rotaxanes. Prof. Jean Pierre Sauvage's work on catenanes (the entwined double or triple ring structures) and Prof. Sir. J. Fraser Stoddart's work on rotaxanes (the dumbbell shaped molecule interlocked with a ring shaped macromolecule) paved the way to the design and development of molecular switches and molecular motors.[1,2] This work was taken further by Prof. Bernard Feringa to synthesize the dynamic molecular systems that could be activated through light to perform a motor function. Prof. Bernard Feringa and his team designed the nano-car, a synthetically assembled molecule that has a body and four wheels (figure 1).

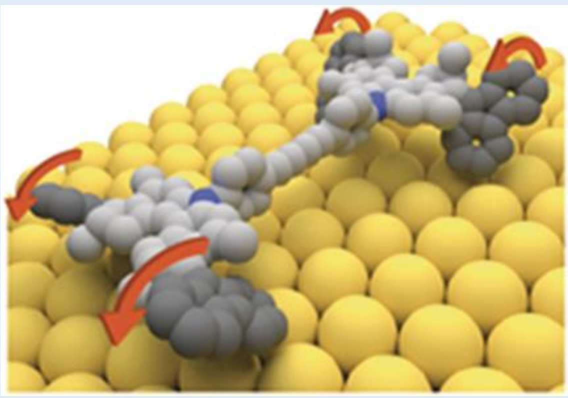

Figure 1Nano-car: Four wheel drive molecular car [3]

Upon electrical excitation from the scanning tunnelling microscope tip the nano-car moved a few nanometers in a straight line. The molecular modelling indicated "walking-type" motion that resembled the movement of kinesin protein motors on actin filaments. In future this could be exploited for cargo transport by nano-car at the molecular level.

Thus, Nanotechnology is one of the most promising technologies of the 21st

Nanoscience & nanotechnology is basically a convergence of physics, materials science and biology, which deal with the ability to observe, measure, assemble, manufacture, control, and manipulate matter at the nanometre scale with unique properties.

century. It has the ability to convert the nanoscience theory to useful applications by observing, measuring, manipulating, assembling, controlling and manufacturing matter at the nanometer scale. The definition of nano-particle suggests the presence of two conditions. The first one considers the size scale i.e. the structures controlled by their shape and size at nanometre scale. The second one has to do with the novelty, which is solely comprised by the properties that is some kind of unique because of the nanoscale. [4]

Nanoscience & nanotechnology is basically a convergence of physics, materials science and biology, which deal with the ability to observe, measure, assemble, manufacture, control, and manipulate matter at the nanometre scale with unique properties. In recent decades we've come across some typical terminologies like Nanoparticles (NPs), Quantum Dots (QDs), Nano Clusters (NCs) etc. The top 20 of the most cited papers published between 2015 and 2019 from the WOS ESI database were selected on the basis of their terminology and has been shown below in the following Table 1. [5]

	Quantum Dots	Nanodots	Nanoclusters	Clusters
Size range	Typically 2−15 nm	2−20 nm range (11 out of 20 papers satisfied) metal/metal compound (11 papers)	≤2 nm range (18 out of 20 papers satisfied)	≤2 nm range (16 out of 20 papers satisfied)
Nature	Semiconductor (13 papers)	Nonmetal/metalloid (9 papers)	Noble metal (17 papers) metal/metal compound (3 papers)	Noble metal (15 papers) metal/metal compound (14 papers)
	Graphitic (7 papers)	Noble metal (2 papers)	Nonmetal/metalloid (1 paper)	Nonmetal/metalloid (2 papers)
Mainly focused properties	Quantum confinement size-dependent PL	PL size-dependent SPR	PL structure synthesis method	PL self-assembly magnetism

This unique property is mainly attributed to the exceptionally high surface to volume ratio (~10^7 fold higher) and the tunable band gap with respect to the dimension of the nanomaterials. NPs with a radius smaller than the excitonic Bohr radius have size-tunable band-gap energy. [6] According to the effective mass approximation (EMA), the band-gap energy of a spherical crystalline NPs deviates from its bulk value in inverse proportion to the square of the NP's radius (the localization term) plus the term that scales inverse with the radius (polarization term), [7] and a similar trend is also predicted by the first-principles methods. [8] This tunable bandgap is an excellent point of consideration in order to synthesize semiconductor nanomaterialls of specific bandgap or nanomaterials with distinctly definite colour.

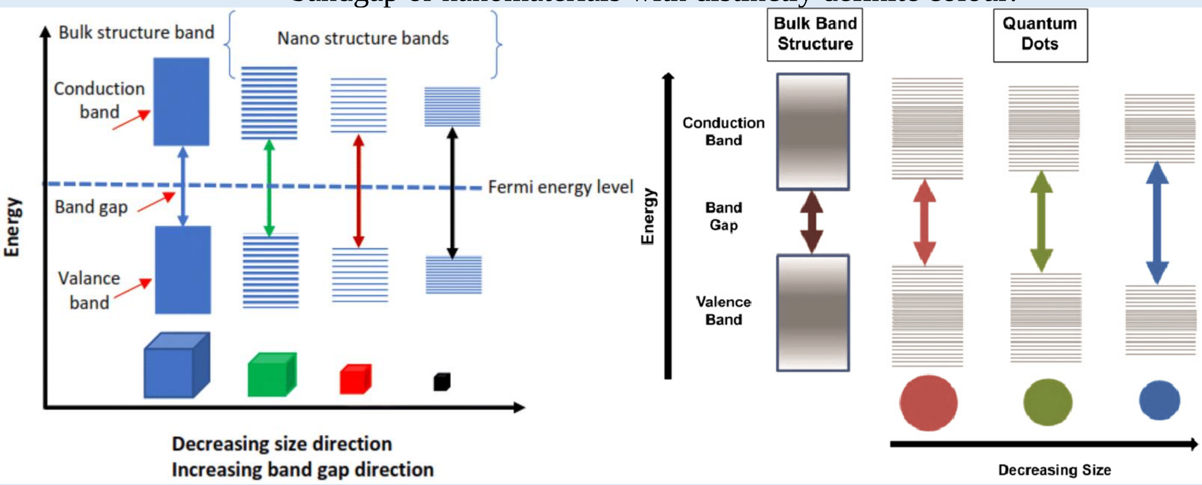

Figure 2: Bulk, nano structure bands and their band gap relationship diagram. The quantum confinement effect on the energy levels in semiconductor quantum dots (QDs). The band gap energy increases with decreasing QD size, thus affecting the colour. [9]

Quantum dots (Qdots) are particularly significant for optical applications owing to their bright, pure colors with longer lifetimes and high extinction coefficient. Being zero dimensional, Qdots have a sharper density of states than higher-dimensional structures. Their small size also means that electrons do not have to travel as far as with larger particles, thus electronic devices can operate faster. The ultra-small size of Qdots also allow them to go anywhere in the body, making them suitable for different bio-medical applications like medical imaging, biosensors, etc. Qdots can emit the whole spectrum, are brighter and have little degradation over time thus proving them superior to traditional organic dyes used in biomedical applications. [10-12]

For playing a pivotal role in the discovery and synthesis of Qdot technology, 2023 Nobel Prize in Chemistry was awarded to three stalwarts in the field viz. Moungi G. Bawendi (Massachusetts Institute of Technology), Louis E. Brus (Columbia University), and Alexei I. Ekimov (Nanocrystals Technology, New York). The particles, once considered impossibly small to make, is not only possible to prepare in the laboratory but can also be applied in LED lights, TV screens and even to visualize the vasculature of a tumor.

The ultra-small size of Qdots also allow them to go anywhere in the body, making them suitable for different bio-medical applications like medical imaging, biosensors, etc.

The concept of bandgap has been used to create more efficient semiconductors, LEDs, and voltage references. As the size of the material shrinks, the bandgap itself starts to change. Larger nanoparticles will see a shrinking bandgap, causing redder light to be reemitted after absorbing high-energy photons. Conversely, as the NPs becomes smaller, electrons move between bands, causing a hypsochromic shift, and releasing more energy, causing the reemitted light to move toward the bluer end of the spectrum. This allows designers to control the color of light produced by a material without changing the chemical composition, opening the door for improved displays and optics technology.

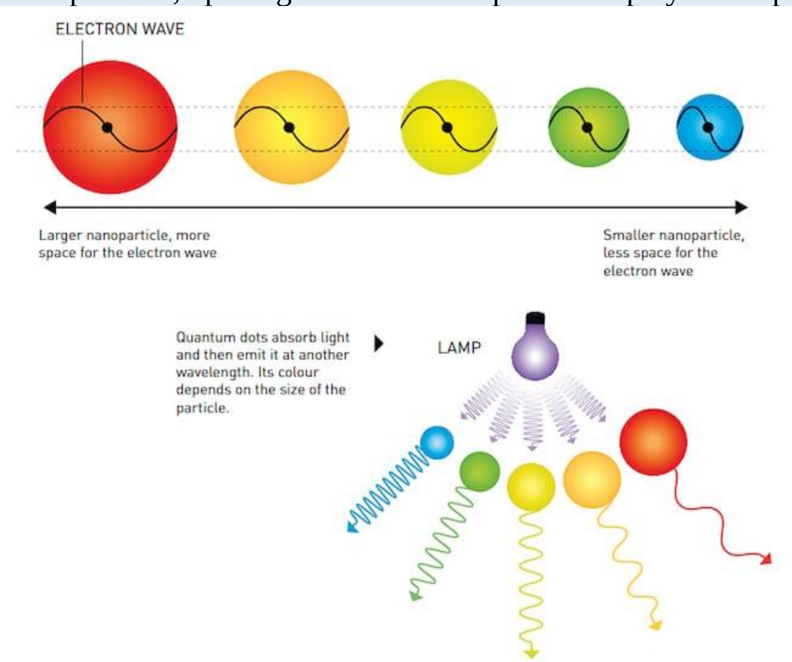

Figure 3 The research of the three scientists showed the impacts of reducing nanoparticle size, allowing designers to create different colors of light from the same materials. Image taken from the Royal Swedish Academy of Sciences.

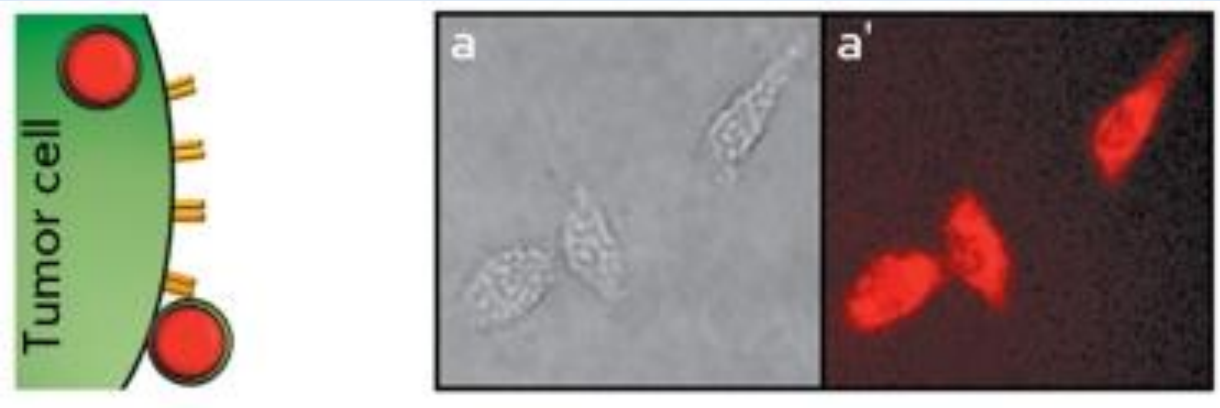

Figure 4 Schematics (on the left) and results (on the right) of fluorescent microscopy of SKOV-3 cells after incubation with QD (Qdot 565 ITK™). Cell images in visible light (a) and fluorescent cell images (a') [13]

Researchers believe that in the future they could contribute to flexible electronics, tiny sensors, thinner solar cells and encrypted quantum communication – so we have just started exploring the potential of these tiny particles .

"Quantum dots have many fascinating and unusual properties. Importantly, they have different colours depending on their size," says Johan Åqvist, Chair of the Nobel Committee for Chemistry.

Quantum dots are thus bringing the greatest benefit to humankind. Researchers believe that in the future they could contribute to flexible electronics, tiny sensors, thinner solar cells and encrypted quantum communication – so we have just started exploring the potential of these tiny particles.

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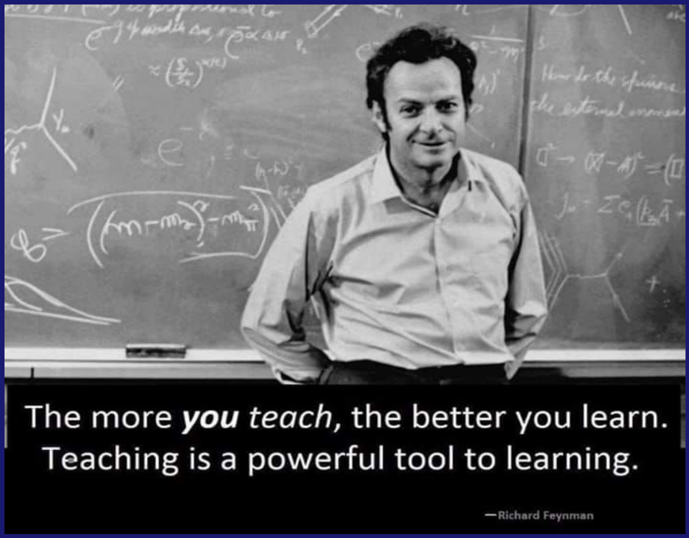

"It doesn't matter how beautiful your theory is, it doesn't matter how smart you are. If it doesn't agree with experiment, it's wrong."

"We do not know what the rules of the game are; all we are allowed to do is to watch the playing. Of course, if we watch long enough, we may eventually catch on to a few of the rules. The rules of the game are what we mean by fundamental physics."

"I would rather have questions that can't be answered than answers that can't be questioned."

— Richard P. Feynman