KARNATAKA PHYSICS ASSOCIATION (R)

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Website: **www.karphysics.org**

KPA NEWSLETTER – 8 AUGUST 2025

Contents

FROM THE EDITORS

This issue of the newsletter has several interesting articles penned by our members and others. It also has several open-source articles on modern topics that will be of interest to physics teachers and students.

One of the most distinguished astrophysicists, institution builders of India and a very popular science communicator - Prof. Jayant V. Narlikar passed away on 20th May 2025. We have here a brief account of the unique personality of Prof. Narlikar, written by one of his close associates and former Director of IUCAA : Prof. Ajit Kembhavi.

An account of a selected few of ancient Indian scientists written by Dr. Paniveni U. Shankar tells us about their contributions in astronomy, mathematics and medicine.

A review article about the ever-pervasive AI tells us about the theory, types, applications and hazards of the present-day AI.

While everyone wishes to do it but is unable to do so - teaching engineering in Indian languages - we have an article about one attempt in Maharashtra that has succeeded in that direction. It should inspire a few others to take the route!

We have an article by a well-known practicing physicist about astrology that should clear many doubts.

One of the most common questions of all time is related to the origin and ending of our universe. We have here an article that details the current thinking on the matter.it needs to be communicated to a wider audience.

Gravitational influence is believed to travel with a finite speed. It is now believed that such a speed is nothing but the speed of light. The article written by Steve Carlip et.al explains it.

While radars play such an important role in our lives, most physics students are unaware of the details. An article by Sr. Srinivasa Murthy serves as an eye-opener.

Everyone would like to know what great scientists thought about various issues; we have here a collection of their sayings related to science and education to ponder. While cosmology is fast developing as a precision science with a lot of theories and observations, we have here a short article about the key ideas of cosmology that every student should know. One of the scientists of the Middle Ages about whom we know very little is Alhazen.A short write-up about him should make us learn more about such forgotten scientists.

What we see does not correspond to the present reality! An article about reality tells us how. An article about sensors in satellites written by an ISRO scientist gives an account of different kinds of sensors. Another article in Kannada about the special properties of the planet Saturn can be found for learning about the gaseous planet.

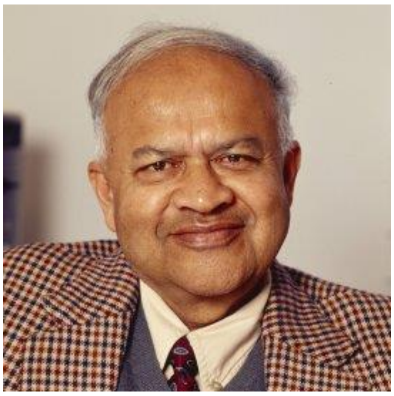
Two regular features of the Newsletter – academic activities of the KPA members and webinars held from May to July 2025 can also be found near the end.

KPA thanks Dr.Muktha B.Kagali for designing and editing this journal at short notice, that too free of charge

We welcome comments and suggestions from the readers about the contents and style of the Newsletter. We also appeal to the members of KPA, as well as others interested in science communication to contribute articles of interest to physics teachers and students for publication in the next issue of the newsletter.

Chief Editor

Prof. Jayant Vishnu Narlikar (19 July 1938 – 20 May 2025)



Professor Jayant Narlikar passed away in his sleep in the early hours of May 20, following a brief illness precipitated by a simple fall at home, the ensuing surgery and the effects of a heart condition. He had not been in the best of health for some time, and yet was able to carry out his routine in a highly productive way. Since January 2024, he was writing a blog, covering different stages of his life, which I am sure will be sorely missed by the tens of thousands of people who read it.

By any measure, for long Jayant has been the face of astronomy, and even wider science, in India. He rose to fame as a research student of the great Fred Hoyle at the University of Cambridge. He did an astonishing amount of work, got coveted awards including the Adams Prize, and held his own in fiery meetings of the Royal Astronomical Society. On a visit to India in the mid-sixties, he thoroughly impressed the scientific community, and captivated the public imagination through his ever smiling face, a gentle way of talking about the most profound matters, and a singular ability to convey to non-expert people his thoughts about the universe including his own researches. He was awarded the Padma Bhushan at the tender age of 26 years. He continued to interact with the public in many ways right to the end.

Jayant's first work was on the distribution of cosmic radio sources as a function of their flux, the log N-Log S distribution. The shape of the distribution depends on the metric of the Universe, the distribution of the sources in space, and whether or not the source population evolves as a function of cosmic time. The radio data was from the Cambridge radio telescopes built by astronomers from Cavendish Laboratory led by Martin Ryle. Ryle favoured the Big Bang theory of the Universe in which the radio source population could be evolving, while Fred Hoyle, one of the creators of the steady state theory, believed that the distribution should be constant in time. The young Narlikar was sandwiched between these quite different points of view. A clear resolution of the problem would have then been impossible, because of the very limited data available and absence of measured redshifts of the sources. Nevertheless, the debates had far reaching consequences, not only for cosmology, but also for the career paths of the protagonists. Martin Ryle and Anthony Hewish jointly won the Nobel Prize in Physics for 1974, being the first astronomers to be so honoured.

Along with the data analysis, Narlikar also worked on difficult theoretical problems, including Newtonian cosmological models with rotation and shear, to study the nature of the singularity present in them. Such models in general relativity had already been studied by A. K. Raychaudhuri, but models in the Newtonian framework could not be obtained as simple special cases of the Raychaudhuri equation, and needed a sophisticated approach. In the same years, Jayant worked with Hoyle on the age of galaxies and the avoidance of singularities in steady state cosmology, Mach's Principle and the Creation of Matter, Time Symmetric Electrodynamics and Arrow of Time in Cosmology. This output was remarkable by any standards; it had great variety, depth and novelty, and went against many cherished conventional ideas. In 1966, Hoyle and Narlikar published work on a new theory of gravitation, which is invariant under conformal transformations. The theory incorporated Mach's Principle, action-at-a-distance concepts and so forth, and is sweeping in its scope. It reduced to Einstein's theory in the weak field regime of the classical test, but was different in its global implications. The attractive nature of the gravitational force arose as a consequence of the theory.

Jayant spent much effort, first with Fred Hoyle, and then with other distinguished astronomers including Geoffrey Burbidge, on the steady state theory, working out its astrophysical implications. The model lost much of its allure after the first discovery of the cosmic microwave background, but in the early years of the discovery, attempts were made by Jayant, Hoyle and Chandra Wickramasinghe to attribute the origin of the radiation to Galactic sources. Over the years, accurate measurements of the Planckian form of the radiation and its isotropy made an early hot phase of the Universe inescapable. That required a modification of the model to a quasi-steady state theory in which hot phases would be possible with mini-bangs, but there would be no singularity, making the Universe eternal as in the pure steady state theory. A possibility here is that galaxies from an earlier phase of the Universe could survive to appear as seemingly prematurely evolved galaxies in early epochs of our phase. Jayant carried out observations with collaborators to find such galaxies, and, intriguingly, the JWST is finding just such objects in the very early epochs. With Burbidge and Halton Arp, Jayant also worked on the possible anomalous redshift of quasars.

In later years Jayant pursued the idea, originally due to Fred Hoyle, that microorganisms could have entered the Earth's atmosphere from outer space. The idea seemed very fanciful when Hoyle first proposed it. He was denied publication of his theory in scientific journals, and he had to publish it as a science fiction novel. Jayant proposed experiments that could be carried out to detect organisms in the upper atmosphere, which could not have gotten there from the surface of the Earth, and which could possibly have a nature distinct from their terrestrial counterparts. While much planning was done in collaboration with people from ISRO and other organisations, the experiment was never carried out. That was possibly a great lost opportunity, especially given the growing realisation that living organisms could exist in several locations in the Solar system, and the ubiquity of habitable extrasolar planets in our Galaxy, even though those planets are too distant to Contribute organisms to our atmosphere.

After he joined TIFR in 1972, Jayant continued his work on various fronts in gravitation and cosmology. He mainly worked with a number of talented graduate students, with some working on problems of his interest, while others devoted their effort to areas of their own choice. He was very democratic in the matter, as he was in all his interactions at every level, and that attitude seems to have worked very well. Many of his students and other young researchers have done excellently in their professions, and others who have worked for him in various capacities have always contributed their best.

Jayant's phase as an institution builder started when Professor Yash Pal, who was then the Chairman of the University Grants Commission, invited him to set up a new institution, which would be unique in addressing the difficulties of the universities in carrying out research in astronomy and astrophysics. When Jayant moved to Pune for the purpose on June 1, 1989, the piece of land where IUCAA now stands was a verdant plot with tens of banyan trees, and where buffalo grazed peacefully on the abundant grass. Soon the buffalos moved on, the trees were relocated to other places on the plot where they have thrived, and in their place rose the unique buildings of IUCAA, designed by Charles Correa. But even before the facilities became available, scientific work and all related activities had started, and soon IUCAA became known as a place where good astronomy was done.

The unique feature of IUCAA, of course, was the tens of visitors from the universities and colleges who came from distant parts of the country, even though there were hardly any facilities. They worked in collaboration, and brought their students, and soon there was a thriving astronomical community in the universities. Jayant helped by interacting personally with the visitors, who soon increased greatly in number. He often visited departments all over the country lecturing and introducing teachers and students to IUCAA, and providing basic email and other then emerging facilities at IUCAA's cost. The development of the university community is Jayant's greatest contribution to astronomy in India.

The process was far from simple. First, there was widespread scepticism in the existing astronomical community about setting up a new centre outside the traditional umbrellas, and that too by a small group of untested young persons. There was great support from the highest levels of the government, but there was the regulatory space to be traversed, which was made so much more difficult because of the uniqueness of the new venture. Jayant mostly got over the difficulties in his usual gently persuasive way, but on occasion he had to tell people at the highest level that either the project goes in his way, or he goes.

Jayant made public outreach an integral part of IUCAA. The activities began with hundreds of school children coming to the campus, still under construction for Saturday lectures. In many countries that would have been an insurance nightmare. But the children were not worried, and now in their middle age, still fondly recount the inspiration that they received from Jayant to do well, and better, in whatever they were doing. That was a simple message, but it has produced many stars over the decades. Jayant took the message beyond students and teachers to the general public, who always came in great numbers whenever and wherever he lectured, and were mystified that the great person they had heard so much about was, after all one of their own. Jayant's books, articles and science fiction stories have been received very well. The public affection and adulation he got have been truly unique. Jayant's father was a general relativist, with his first student P. C. Vaidya, being the discoverer of the famous Vaidya metric, and his mother was a Sanskrit pandit. Jayant lost his wife, Mangala, almost two years ago, just two days before his 85th birthday. She was a mathematician, teacher and author, but spent much of her time facilitating, and in later years, enabling his many activities. She was a great strength and inspiration for him and to countless others who met her. Jayant is survived by his three daughters, Geeta, Girija and Leelavati, and their families. The three work at the top of their chosen professions in science and technology.

Dr. Ajit Kembhavi
Former research student and colleague of Prof. Jayant V Naralikar.
He also served as the Director of IUCAA, Pune

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It was around dusk when my companion and I noticed the position of the sun closer to the west horizon, and the sun was going up.

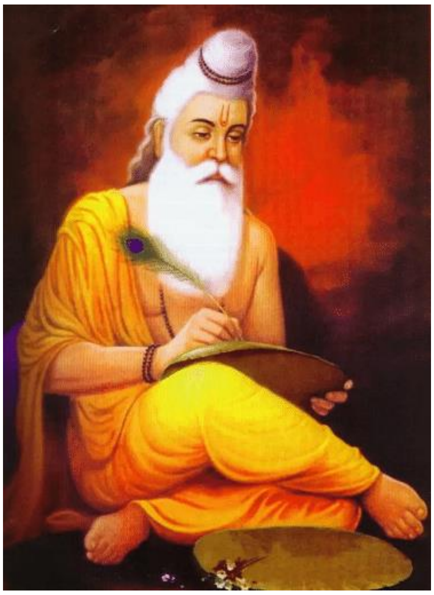
Found that in a universe that is expanding after a big bang event, neutrinos would turn up at a detector before they were emitted. Only future-going neutrinos were possible in the Steady State cosmology, while the ever-expanding Big Bang models gave neutrinos travelling into Steady State theory to the past.

Science popularization involves information about science explaining the things and their implications in detail, or any beliefs the reader might have and also tells them about the newer discoveries so as to enlarge the person's horizons.

Some people were leaders in their field in Cambridge, and they lectured. And what impressed me the most was that all these big names never said that they were busy with their research and did not want to be burdened with lectures. They took part in the lectures.

- JAYANT NARLIKAR

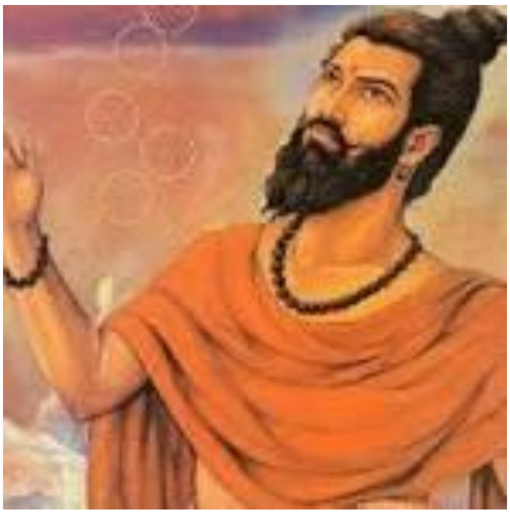
RENOWNED EARLY AGE SCIENTISTS OF INDIA IN ASTRONOMY, PHYSICS AND MATHEMATICS



BAUDHAYANA (800BCE -740BCE

Baudhayana lived during the 8th century BCE, specifically between 800 BCE and 740 BCE. He is considered an important figure in ancient Indian mathematics and originally discovered the Pythagorean theorem. He is known as the 'father of geometry'. He is known for his contributions to geometry and religious law, including the 'Baudhayana Sulba Sutras' and 'Shrauta Sutra'. These Sutras were composed in the 8th-7th century BCE. The Baudhāyana Sūtras are a group of Vedic Sanskrit texts which cover dharma, daily ritual and mathematics. It is one of the oldest Dharma-related texts of Hinduism that have survived into the modern age from the 1st-millennium BCE. 'Shrauta Sutras' are ritual manuals used by priests in ancient Vedic practices, particularly for large public sacrifices called 'Yajnas'. 'Sulba Sutras' contain theorems of early mathematics and geometry, including the Pi value, the square root of 2, and a statement of the Pythagorean theorem. He gave many important principles of mathematics. Bodhayana composed more than two hundred religious texts.

It is told by a verse that in a rectangle, the square of the hypotenuse is equal to the sum of the squares of the base and the perpendicular. This verse, described in his work 'Vriti Granth', is known as 'Bodhayana Theorem'. The theorem was elaborated by the Greek scholar Pythagoras. Later on, its basis Aryabhatta made discoveries in the field of space science. Bodhayana was a great scholar of philosophy, religion, mathematics and language. He wrote more than two hundred treatises. Among them, Vedavruti, Vedanta, Ratna Manjush, Dharmasutra and Grihasutra are prominent. He was likely motivated by his priestly duties to construct altars and other religious structures, leading him to develop the mathematical principles used in those constructions.

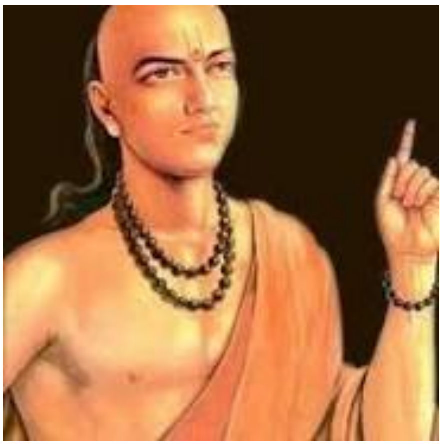


ACHARYA KANADA– (Between the 6th century BCE and the 2nd century BCE)

Acharya Kanad was an ancient Indian philosopher. While no specific birth or death year is definitively known, estimates place his birth around 600 BCE in Prabhas Kshetra (near Dwaraka) in Gujarat, India. His original name was Kashyapa. He got the name Kanad, because even as a child, he was interested in very minute particles called 'kana'. He discovered the atomic structure, atomic theory, and even sub-atomic particles some 2600 years before John Dalton's discovery. His atomic theory can be a match to any modern atomic theory. According to Kanad, material universe is made up of kanas, (anu/atom) which cannot be seen through any human organ. These cannot be further subdivided. Thus, they are indivisible and indestructible. While Kanada's atom was ~ 700 times bigger than what we know today, conceptualizing such small sizes 2600years back without the aid of modern scientific instruments is a remarkable feat. He was recognized as 'father of atomic theory'.

He described the universe with six categories, which are 1) Dravya, which is defined as a substance, 2) Guna, which is defined as the quality,3) Karman, which is defined as a motion,4) Samanya, which is defined as Generic Species, 5)Visesa, which is defined as a unique Trait, and 6) Samavaya is defined as inherence.

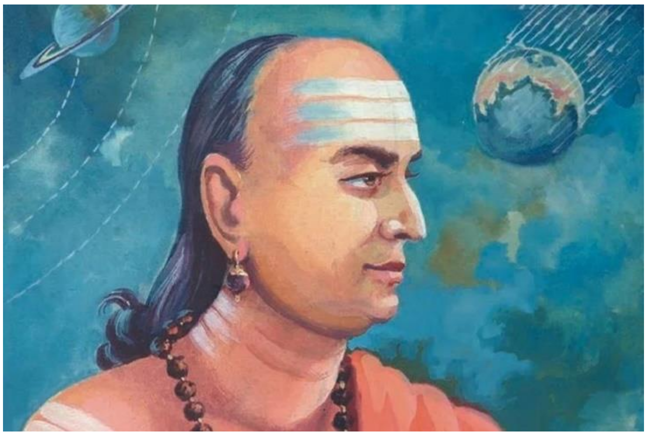
He founded the 'Vaisheshika' school of Indian philosophy that epitomised the earliest Indian physics. He used this to explain the creation and existence of the universe by proposing an atomistic theory, applying logic and realism, which made his school one of the earliest known systematic realist ontologies in human history.



ARYA BHATTA (476AD -550 AD)

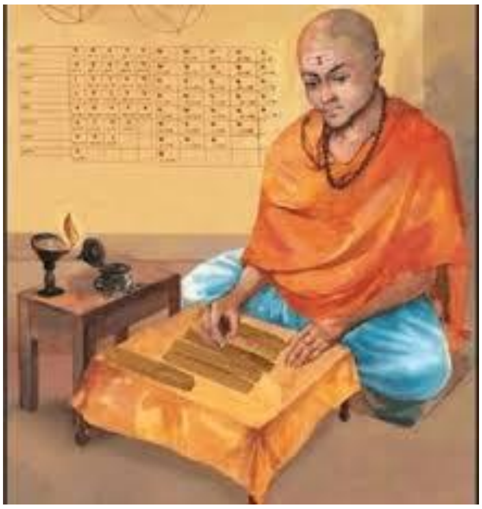
Born on 18^{th} Sept. in 476 AD in Patna, Bihar, Arya Bhatta is a Hindu mathematician and Astronomer. Arya Bhatta was the first of the major mathematician-astronomers from the classical age of Indian mathematics and Indian astronomy. For his explicit mention of the relativity of motion, he also qualifies as a major early physicist. He brought out 'Aryabhatiya' also known as 'Arya Siddhantha' which summarizes the mathematics as known in his time. His contributions were in spherical grigonometry, Arithmetic, Algebra, Plane trigonometry etc. He gave accurate approximation of 'pi' as 3.1416. He introduced sine function into trigonometry. Aryabhatta used the word 'kha' for positional purposes, hinting towards a placeholder concept similar to zero. He is credited to have invented zero.

He was the one who came up with the formula for computing the areas of triangles and circles. Arya Bhatta was awarded the title of 'Father of Algebra' because of his remarkable grasp and explanation of planetary systems employing it. He genuinely made the world recognize India. His astronomical findings were published in Arabic in the eighth century. His birthday is celebrated as 'Arya Bhatta Jayanthi'. The Aryabhata space mission, India's first satellite, was launched on April 19, 1975. He lived till 550AD



VARAHAMIHIRA (505 AD- 587 AD)

Varāhamihira, also called Varāha or Mihira was born in 505AD. He was an ancient Indian astrologer-astronomer who lived in or around Ujjain in present-day Madhya Pradesh, India. He was also a philosopher and mathematician. He was the author of 'Panca Siddhantha', the five treatises and a compendium of Greek, Egyptian, Roman and Indian Astronomy. His writings give a comprehensive picture of 6th-century India. He had a thorough knowledge of western astronomy. He discovered a version of Pascal's triangle and worked on magic squares. Pascal's triangle, in algebra, is a triangular arrangement of numbers that gives the coefficients of any binomial expression such as $(x+y)^n$. Varahamihira wrote the 'Brihat Samhitha', an important encyclopedic text in Sanskrit. The thirty second chapter of this Brihath Samhita is devoted to signs of earthquakes. He has tried to relate earthquakes to the influence of planets, undersea activities, underground water, unusual cloud formation and abnormal behaviour of animals. This text exists in many Indian scripts and is preserved in Hindu, Jain and Buddhist temples and monasteries. He lived till 587 AD.



BRAHMAGUPTA (598 AD- 668 AD)

Brahagupta in 598 AD in a town Bhinmal in the state of Rajasthan. He was the most accomplished Indian astronomer who set forth the Hindu astronomical system in verse form known as Brahma-Sputa-Siddantha (Opening of the Universe). Both the '*Aryabhatiya'* and an early text of the '*Brahma-sphuta-siddhanta'* school entered the muslim world and were translated into Arabic near the end of the 8th century, profoundly influencing the development of Islamic mathematical astronomy.

Brahmagupta made substantial contributions to arithmatic, including advancements in the understanding of zero and negative numbers. He provided rules for performing calculations with zero and negative numbers. In the 'Brahmasphutasiddhanta', Brahmagupta presented solutions to quadratic equations, including both positive and negative roots. He introduced methods for solving linear and quadratic indeterminate equations. Brahmagupta's work in geometry included the calculation of the area of cyclic quadrilaterals. He provided a formula for the area of a cyclic quadrilateral in terms of its side lengths and this was known as 'Brahmagupta's formula'. *BrahmaGupta is known as the 'Newton of India'.* Late in his life, Brahmagupta wrote '*Khandakhadyaka'* an astronomical handbook that employed Aryabhata's system of starting each day at midnight. *He lived till 668AD.*

MAHAVIRACHARYA (800 AD - 870 AD)

Mahavira or Mahaviracharya was a 9th century (about 800 AD -870 AD) Jain mathematician, who made significant contributions to the development of Algebra born in the present day city of Gulbarga, Karnataka, in southern India. He was the mathematical prodigy of ancient India. He perhaps took his name to honour the great Jainism reformer *Mahavira*. He was the author of the earliest Indian text '*Ganitsarasangraha'* in 850AD devoted entirely to mathematics and which is this first text book on arithmetic in present day form. . He was patronised by the king *Amoghavarsha* of the *Rashtrakuta Dynasty*. Mahavira stresses the importance of mathematics in both secular and religious life and in all kinds of disciplines. He is highly respected among Indian mathematicians because of his establishment of terminology for concepts such as equilateral triangle, isosceles triangle, rhombus, circle and semicircle and the rest of mathematical procedures such as basic operations, reduction of fractions, miscellaneous problems involving a linear or quadratic equation with one unknown, the rule of three (involving proportionality), mixture problems, geometric computations with plane figures, ditches (solids) and shadows. He also included rules for permutations and combinations and for the area of a conch like plane figure (two unequal semi circles stuck together along their diameters). The current method of solving Least common Multiple (LCM) of given numbers was also described by him. Thus, long before John Napier introduced it to the world, it was already known to Indians. There is an elaborate description of mathematics in Jain literature (500 B.C -100 B.C).

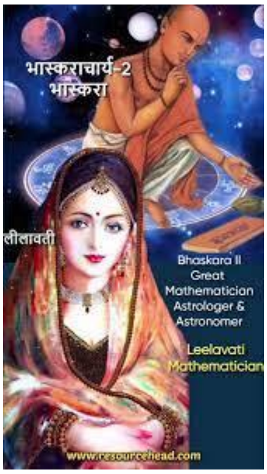
Jain gurus knew how to solve quadratic equations. They have also described fractions, algebraic equations, series, set theory, logarithms and exponents in a very interesting manner. According to some scholars, Jainism's origin can be traced to the 23rd Tirthankara Parshvanatha (8^{th} – 7^{th} century BCE). They consider the first twenty-two Tirthankaras as legendary mythical figures.

BHASKARACHARYA (1114AD-1185AD)

Bhāskara II also known as Bhāskarāchārya was born in 1114AD in Bijapur, Karnataka, India. He was *an Indian polymath, mathematician, astronomer and engineer*. Six works by Bhaskaracharya are well known. The six works are: 1) '*Lilavati'* (The Beautiful) which is on mathematics; 2)'*Bijaganita'* (Seed counting or root extraction) which is on algebra; 3) the '*Siddhantasiromani'* which is in two parts, the first on mathematical astronomy and the second part on the sphere; 4) the '*Vasanabhasya* of *Mitaksara'* which is Bhaskaracharya's own commentary on the '*Siddhantasiromani'*; 5) the '*Karanakutuhala'* or '*Brahmatulya'* Which is a simplified version of the 'Siddantasiromani' and the 6) 'Vivarana' which is a commentary on the 'Shishyadhi viddhidatantra' of 'Lalla'(Sanskrit Astronomy text by Lalla). It is the first three of these works which are the most interesting, certainly from the point of view of mathematics. Bhaskaracharya is credited with significant contributions to mathematics and astronomy, including discovering spherical trigonometry, a key concept in astronomy and navigation. He also developed an understanding of calculus, the number system, and solving equations, and was considered a pioneer of differential calculus. Additionally, Bhaskara II is believed to have understood the concept of infinity and described the heliocentric view of the solar system and elliptical orbits of planets.

Bhaskaracharya became head of the astronomical observatory at Ujjain, the leading mathematical centre in India at that time. He died in Ujjain in 1185.

LILAVATI (12th Century)



Lilavati born in 12th century was daughter of Bhaskaracharya, an illustrious mathematician from ancient India She left an incredible mark in the history of mathematics which was always a man dominated area. She is credited with developing new methods of solving complex mathematical problems. Bhaskaracharya dedicated his treatise 'Lilavati' to his daughter Lilavati which mainly covers a wide array of topics, including arithmetic, algebra, geometry, and equations. Lilavati was an extraordinary woman whose contributions continue to resonate in the realms of mathematics. Lilavati's mind was always busy in solving the mathematical problems posed by her father Bhaskaracharya.. It is believed that the problems posed to 'Lilavati' form the major portion of 'Bhaskara's Treatise', which is named after her. Lilavati could solve complex problems that are now resolved using the Pythagoras theorem. Lilavati's work includes a number of methods of computing numbers, such as multiplication, squares and progressions with examples using kings and elephants, objects which a common man could understand.

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Dr. Paniveni U.Shankar
Hon. Professor, Poornaprajna Institute of Scientific research, Bengaluru

WHAT IS ARTIFICIAL INTELLIGENCE?

Artificial intelligence (AI) is a branch of computer science that aims to build machines capable of performing tasks that typically require human intelligence. AI enables machines to simulate human abilities, such as learning, problem-solving, decision-making and comprehension. Common applications of AI include speech recognition, image recognition, content generation, recommendation systems, self-driving cars and AI agents.

What Is Artificial Intelligence?

Artificial intelligence refers to computer systems that are capable of performing tasks traditionally associated with human intelligence — such as making predictions, identifying objects, interpreting speech and generating natural language. AI systems learn how to do so by processing massive amounts of data and looking for patterns to model in their own decision-making. In many cases, humans will supervise an AI's learning process, reinforcing good decisions and discouraging bad ones, but some AI systems are designed to learn without supervision.

Over time, AI systems improve on their performance of specific tasks, allowing them to adapt to new inputs and make decisions without being explicitly programmed to do so. In essence, artificial intelligence is about teaching machines to think and learn like humans, with the goal of automating work and solving problems more efficiently.

Why Is Artificial Intelligence Important?

Artificial intelligence aims to provide machines with similar processing and analysis capabilities as humans, making AI a useful counterpart to people in everyday life. AI is able to interpret and sort data at scale, solve complicated problems and automate various tasks simultaneously, which can save time and fill in operational gaps missed by humans.

AI serves as the foundation for computer learning and is used in almost every industry — from healthcare and finance to manufacturing and education — helping to make data-driven decisions and carry out repetitive or computationally intensive tasks.

Many existing technologies use artificial intelligence to enhance capabilities. We see it in smartphones with AI assistants, e-commerce platforms with recommendation systems and vehicles with autonomous driving abilities. AI also helps protect people by piloting fraud detection systems online and robots for dangerous jobs, as well as leading research in healthcare and climate initiatives.

"AI is the new electricity," according to Andrew Ng, co-founder of Google Brain and a leader in the AI industry.

How Does AI Work?

Artificial intelligence systems work by using algorithms and data. First, a massive amount of data is collected and applied to mathematical models, or algorithms, which use the information to recognize patterns and make predictions in a process known as training. Once algorithms have been trained, they are deployed within various applications, where they continuously learn from and adapt to new data. This allows AI systems to perform complex tasks like image recognition, language processing and data analysis with greater accuracy and efficiency over time.

Subfields of AI

Artificial intelligence is composed of several specialized subfields, each focused on solving unique problems and advancing specific aspects of AI behavior. The main subfields of AI include:

1. Machine Learning

The primary approach to building AI systems is through machine learning (ML), where computers learn from large data sets by identifying patterns and relationships within the data. A machine learning algorithm uses statistical techniques to help it "learn" how to get progressively better at a task, without necessarily having been programmed for that certain task. It uses historical data as input to predict new output values.

Machine learning consists of different types of learning methods:

- **Supervised learning** trains models on labeled data, where the correct outputs are provided to help the models learn mappings from inputs to outputs.
- **Unsupervised learning** trains models to identify patterns or structures in unlabeled data, such as grouping similar items (clustering) or simplifying data by reducing its dimensions (dimensionality reduction).
- **Semi-supervised learning** trains models on a combination of labeled and unlabeled data to improve learning efficiency and accuracy.
- **Reinforcement learning** teaches AI agents to make decisions by rewarding desired behaviors and penalizing mistakes through interactions with an environment.

Neural Networks

Machine learning is typically done using neural networks, a series of algorithms that process data by mimicking the structure of the human brain. These networks consist of layers of interconnected nodes, or "neurons," that process information and pass it between each other. By adjusting the strength of connections between these neurons, the network can learn to recognize complex patterns within data, make predictions based on new inputs and even learn from mistakes. This makes neural networks useful for recognizing images, understanding human speech and translating words between languages.

2. Deep Learning

Deep learning is an important subset of machine learning. It uses a type of artificial neural network known as deep neural networks, which contain a number of hidden layers through which data is processed, allowing a machine to go "deep" in its learning and recognize increasingly complex patterns, making connections and weighting input for the best results. Deep learning is particularly effective at tasks like image and speech recognition and natural language processing, making it a crucial component in the development and advancement of AI systems.

Natural Language Processing

Natural language processing (NLP) involves teaching computers to understand and produce written and spoken language in a similar manner as humans. NLP combines computer science, linguistics, machine learning and deep learning concepts to help computers analyze unstructured text or voice data and extract relevant information from it. NLP mainly tackles speech recognition and natural language generation, and it's leveraged for use cases like spam detection and virtual assistants.

Computer Vision

Computer vision is another prevalent application of deep learning techniques, where machines process raw images, videos and visual media, and extract useful insights from them. Deep learning and convolutional neural networks are used to break down images into pixels and tag them accordingly, which helps computers discern the difference between visual shapes and patterns. Computer vision is used for image recognition, image classification and object detection, and completes tasks like facial recognition and detection in self-driving cars and robotics.

3. Generative AI

Generative AI is a subfield of artificial intelligence focused on creating new content — such as text, images, videos and more — that mimics human creativity based on user prompts. Using deep learning technologies like large language models (LLMs) and generative adversarial networks (GANs), generative AI learns patterns from large data sets to output content that is highly similar to its original training data.

Generative AI has applications across industries like art, entertainment, marketing and software development, and is redefining how humans and machines collaborate in the creative process.

4. AI Agents and Agentic AI

AI agents are AI systems designed to autonomously perceive their environment, make decisions and take actions to accomplish specific tasks.

Agentic AI refers to a system of multiple AI agents that combine reasoning and memory over time. This enables an agentic AI system to perform complex, multi-step tasks that a single agent couldn't accomplish on its own, such as conducting research or troubleshooting software without constant human intervention.

The capabilities of AI agents and agentic AI are powered by deep learning models, which allow these systems to understand language, interpret data and predict outcomes based on patterns learned from large data sets.

Generative AI and How It Works

Generative AI has gained massive popularity in the 2020s, especially as chatbots and image generators get increasingly more sophisticated. These tools are often used to create written copy, code, digital art and object designs, and they are leveraged in industries like marketing, entertainment, consumer goods and manufacturing.

Generative AI also comes with challenges, though. For instance, it can be used to create harmful content and deepfakes, which could spread disinformation and erode social trust. And some AI-generated material could potentially infringe on people's copyright and intellectual property rights.

To work, a generative AI model is fed massive data sets and trained to identify patterns within them, then subsequently generates outputs that resemble this training data. Here's a breakdown of each step:

1. Training

The basis of generative AI models are foundation models, which are large-scale AI systems trained on massive amounts of data to develop a broad understanding of language, images, code and related content. In the generative AI training phase, a foundation model is fed large data sets from the internet, books and literature in order to learn and understand patterns and relationships within this data.

Over time, the model learns to generate outputs that resemble the training data, though it does not memorize it directly.

2. Tuning

After general training, generative AI models are often fine-tuned for more specific applications, whether that be to generate images, text or other specific media. Fine-tuning involves retraining the model on a smaller, application-specific data set, such as technical documents or legal texts. This helps the model become more accurate and relevant within its particular context.

In some cases, reinforcement learning from human feedback (RLHF) is also used to guide the model toward preferred outputs and reduce hallucinations.

3. Generation, Evaluation and Further Tuning

Once trained and initially tuned, the generative AI model can generate content based on user prompts. The way it generates content relies on probabilistic predictions to create outputs that are contextually appropriate and align with the given inputs.

At this stage, the model tends to be evaluated using automated metrics and human judgement in order to assess factual accuracy, quality and alignment with user intent.

Depending on regular model assessments, a generative AI model can also be further tuned for greater relevance and accuracy.

Types of AI

Artificial intelligence can be classified in several different ways.

Strong AI vs. Weak AI

AI can be organized into two broad categories: weak AI and strong AI.

- **Weak AI** (or narrow AI) refers to AI that automates specific tasks. It typically outperforms humans, but it operates within a limited context and is applied to a narrowly defined problem. For now, all AI systems are examples of weak AI, ranging from email inbox spam filters to recommendation engines to chatbots.
- **Strong AI**, often referred to as artificial general intelligence (AGI), is a hypothetical benchmark at which AI could possess human-like intelligence and adaptability, solving problems it's never been trained to work on. AGI does not actually exist yet, and it is unclear whether it ever will.

4 Main Types of AI

AI can then be further categorized into four main types: reactive machines, limited memory, theory of mind and self-awareness.

1. **Reactive machines** perceive the world in front of them and react. They can carry out specific commands and requests, but they cannot store memory or rely on past experiences to inform their

decision making in real time. This makes reactive machines useful for completing a limited number of specialized duties. Examples include Netflix's recommendation engine and IBM's Deep Blue (used to play chess).

2. **Limited memory** AI has the ability to store previous data and predictions when gathering information and making decisions. Essentially, it looks into the past for clues to predict what may come next. Limited memory AI is created when a team continuously trains a model in how to analyze and utilize new data, or an AI environment is built so models can be automatically trained and renewed. Examples include ChatGPT and self-driving cars.
3. **Theory of mind** is a type of AI that does not actually exist yet, but it describes the idea of an AI system that can perceive and understand human emotions, and then use that information to predict future actions and make decisions on its own.
4. **Self-aware** AI refers to artificial intelligence that has self-awareness, or a sense of self. This type of AI does not currently exist. In theory, though, self-aware AI possesses human-like consciousness and understands its own existence in the world, as well as the emotional state of others.

Benefits of AI

AI is beneficial for automating repetitive tasks, solving complex problems, reducing human error and much more.

Automating Repetitive Tasks

Repetitive tasks such as data entry and factory work, as well as customer service conversations, can all be automated using AI technology. This lets humans focus on other priorities.

Solving Complex Problems

AI's ability to process large amounts of data at once allows it to quickly find patterns and solve complex problems that may be too difficult for humans, such as predicting financial outlooks or optimizing energy solutions.

Improving Customer Experience

AI can be applied through user personalization, chatbots and automated self-service technologies, making the customer experience more seamless and increasing customer retention for businesses.

Advancing Healthcare and Medicine

AI works to advance healthcare by accelerating medical diagnoses, drug discovery and development and medical robot implementation throughout hospitals and care centers.

Reducing Human Error

The ability to quickly identify relationships in data makes AI effective for catching mistakes or anomalies among mounds of digital information, overall reducing human error and ensuring accuracy.

Disadvantages of AI

While artificial intelligence has its benefits, the technology also comes with several risks and potential dangers to consider.

Job Displacement

AI's abilities to automate processes, generate rapid content and work for long periods of time can mean job displacement for human workers.

Bias and Discrimination

AI models may be trained on data that reflects biased human decisions, leading to outputs that are biased or discriminatory against certain demographics.

Hallucinations

AI systems may inadvertently "hallucinate" or produce inaccurate outputs when trained on insufficient or biased data, leading to the generation of false information.

Privacy Concerns

The data collected and stored by AI systems may be done so without user consent or knowledge, and may even be accessed by unauthorized individuals in the case of a data breach.

Lack of Explainability

AI systems may be developed in a manner that isn't transparent or inclusive, resulting in a lack of explanation for potentially harmful AI decisions as well as a negative impact on users and businesses.

Environmental Costs

Large-scale AI systems can require a substantial amount of energy to operate and process data, which increases carbon emissions and water consumption.

AI Use Cases

Specific use cases and examples of AI include:

Generative AI Tools

Generative AI tools — including ChatGPT, Gemini, Claude and Grok — use artificial intelligence to produce written content in a range of formats, from essays to code and answers to simple questions.

Smart Assistants

Personal AI assistants, like Alexa and Siri, use natural language processing to receive instructions from users to perform a variety of "smart tasks." They can carry out commands like setting reminders, searching for online information or turning off your kitchen lights.

Self-Driving Cars

Self-driving cars are a recognizable example of deep learning, since they use deep neural networks to detect objects around them, determine their distance from other cars, identify traffic signals and much more.

Wearables

Many wearable sensors and devices used in the healthcare industry apply deep learning to assess the health condition of patients, including their blood sugar levels, blood pressure and heart rate. They can also derive patterns from a patient's prior medical data and use that to anticipate any future health conditions.

Visual Filters

Filters used on social media platforms like TikTok and Snapchat rely on algorithms to distinguish between an image's subject and the background, track facial movements and adjust the image on the screen based on what the user is doing.

Industry Applications of AI

Artificial intelligence has applications across multiple industries, ultimately helping to streamline processes and boost business efficiency.

Healthcare

AI is used in healthcare to improve the accuracy of medical diagnoses, facilitate drug research and development, manage sensitive healthcare data and automate online patient experiences. It is also a driving factor behind medical robots, which work to provide assisted therapy or guide surgeons during surgical procedures.

Retail

AI in retail amplifies the customer experience by powering user personalization, product recommendations, shopping assistants and facial recognition for payments. For retailers and suppliers, AI helps automate retail marketing, identify counterfeit products on marketplaces, manage product inventories and pull online data to identify product trends.

Customer Service

In the customer service industry, AI enables faster and more personalized support. AI-powered chatbots and virtual assistants can handle routine customer inquiries, provide product recommendations and troubleshoot common issues in real-time. And through NLP, AI systems can understand and respond to customer inquiries in a more human-like way, improving overall satisfaction and reducing response times.

Manufacturing

AI in manufacturing can reduce assembly errors and production times while increasing worker safety. Factory floors may be monitored by AI systems to help identify incidents, track quality control and predict potential equipment failure. AI also drives factory and warehouse robots, which can automate manufacturing workflows and handle dangerous tasks.

Finance

The finance industry utilizes AI to detect fraud in banking activities, assess financial credit standings, predict financial risk for businesses plus manage stock and bond trading based on market patterns. AI is also implemented across fintech and banking apps, working to personalize banking and provide 24/7 customer service support.

Marketing

In the marketing industry, AI plays a crucial role in enhancing customer engagement and driving more targeted advertising campaigns. Advanced data analytics allows marketers to gain deeper insights into customer behavior, preferences and trends, while AI content generators help them create more personalized content and recommendations at scale. AI can also be used to automate repetitive tasks such as email marketing and social media management.

Gaming

Video game developers apply AI to make gaming experiences more immersive. Non-playable characters (NPCs) in video games use AI to respond accordingly to player interactions and the surrounding environment, creating game scenarios that can be more realistic, enjoyable and unique to each player.

Military

AI assists militaries on and off the battlefield, whether it's to help process military intelligence data faster, detect cyberwarfare attacks or automate military weaponry, defense systems and vehicles. Drones and robots in particular may be imbued with AI, making them applicable for autonomous combat or search and rescue operations.

AI Regulation and Governance

As AI grows more complex and powerful, lawmakers around the world are seeking to regulate its use and development.

The first major step to regulate AI occurred in 2024 in the European Union with the passing of its sweeping Artificial Intelligence Act, which aims to ensure that AI systems deployed there are "safe, transparent, traceable, non-discriminatory and environmentally friendly." Countries like China and Brazil have also taken steps to govern artificial intelligence.

Meanwhile, AI regulation in the United States is still a work in progress. The Biden-Harris administration introduced a non-enforceable AI Bill of Rights in 2022, and then The Executive Order on Safe, Secure and Trustworthy Development and Use of Artificial Intelligence in 2023, which aimed to regulate the AI industry while maintaining the country's status as a leader in the industry. However, The Executive Order on Safe, Secure and Trustworthy Development and Use of Artificial Intelligence was revoked by President Donald Trump in January 2025.

The U.S. Congress has also made several attempts to establish more robust legislation, but it has largely failed, leaving no laws in place that specifically limit the use of AI or regulate its risks. For now, all AI legislation in the United States exists only on the state level.

With that said, in May 2025, President Trump's "One, Big, Beautiful Bill" Act — which proposes a 10-year ban on all U.S. state regulations of artificial intelligence — passed the U.S. House of Representatives, leaving the future of U.S. AI regulation to be uncertain.

Though as stated by Microsoft CEO Satya Nadella, "[AI] regulation that allows us to ensure that the broad societal benefits are amplified, and the unintended consequences are dampened, is going to be the way forward."

The Future of AI

The future of artificial intelligence holds immense promise, with the potential to revolutionize industries, enhance human capabilities and solve complex challenges. It can be used to develop new drugs, optimize global supply chains and power advanced robots — transforming the way we live and work.

Looking ahead, one of the next big steps for artificial intelligence is to progress beyond weak or narrow AI and achieve artificial general intelligence (AGI) — and eventually superintelligence. With AGI, machines will be able to think, learn and act the same way as humans do, blurring the line between organic and machine intelligence. This could pave the way for increased automation and problem-solving capabilities in medicine, manufacturing, transportation and more — as well as sentient AI down the line.

In a 2024 essay about the promises of the technology, Anthropic CEO Dario Amodei speculates that powerful AI might accelerate innovation in the biological sciences as much as tenfold by enabling a larger number of experiments to be conducted at any given time, and by shortening the gap between new discoveries and subsequent research building on those discoveries.

On the other hand, the increasing sophistication of AI also raises concerns about heightened job loss, widespread disinformation and loss of privacy. And questions persist about the potential for AI to outpace human understanding and intelligence — a phenomenon known as technological singularity that could lead to unforeseeable risks and possible moral dilemmas.

For now, society is largely looking toward government and business-level AI regulations to help guide the technology's future.

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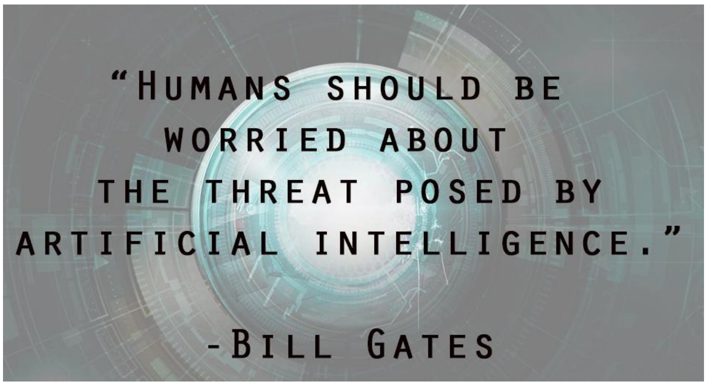

ENGINEERING CHANGE WITH MOTHER TONGUE

Sufiya Sayyad, 22, is the first from her village Belwadi, in Pune district's Indapur taluka, to become a computer engineer; she is in fact the first learner from her village. Her father Mahamad Sayyad is a farm labourer who brings home between ₹300- ₹400 on good days, while her mother is a homemaker. Her classmate Vaibhav Indure, 23, is the son of a farmer, Ganesh Indure, from Shahajanpur village, in Beed district. While Sufiya's parents took a loan of ₹4 lakh to put her through engineering college, Vaibhav joined his college's earn-and-learn scheme, which he says "not only helped him make productive use of free hours but also earn an hourly pay" to fund his tuition.

Armed with insights from this pilot, the institute launched the B.Tech in Marathi programme in July 2021, admitting 66 students through the state's Centralized Entrance Test (CET) Cell. (HT)

Sufiya, Vaibhav and 64 others are the first batch of students, who having emerged from Marathi medium or semi-English medium state and zilla parishad schools, received their B.Tech degrees from the Pimpri Chinchwad College of Engineering (PCCOE) yesterday – their social advancement an academic milestone from the college's Computer Engineering (Regional Language) Department that tutored students in Marathi, marking a major achievement in the implementation of the National Education Policy (NEP) 2020.

Forty of the 66 graduates have found tech jobs through campus placements, with salaries between ₹5 to 10 lakh per annum – "way beyond our dreams," said one -- dispelling all scepticism about the employability of regional language-trained engineers.

PCCOE was among 14 institutions across India to receive approval from the All India Council for Technical Education (AICTE) in 2021 to offer undergraduate engineering programmes in vernacular languages. It is the only institution in Maharashtra that was granted permission to initiate such a programme, to make technical education more inclusive.

How the programme started

"Before the programme formally began, we conducted a pilot project on diploma students, teaching them core engineering subjects in Marathi for two weeks. The initiative included assessments and feedback," said Rachana Patil, head of the Computer Engineering (Regional Language) Department. "Most students appreciated the effort and found it beneficial, although they requested that the core textbooks remain in English."

Armed with insights from this pilot, the institute launched the B.Tech in Marathi programme in July 2021, admitting 66 students through the state's Centralized Entrance Test (CET) Cell – the cut off for the course was above 96 per cent that year, which has now gone up to 98 per cent. The first batch included 51 boys and 15 girls from 20 districts across Maharashtra (who had a rudimentary knowledge of English), reflecting the wide reach and demand for such an initiative. At least 50 students are first generation learners emerging from the state's tribal belts, such as Chandrapur, and tribal parts of Nashik, Buldhana and Akola.

“A dedicated team of nine faculty members was appointed to teach this batch, and a detailed curriculum delivery strategy was drawn up. Initially, the team aimed to translate the entire syllabus into Marathi, but due to technical limitations and terminological challenges, they adopted a blended approach,” said Patil.

Early challenges

The admissions were not without challenges either: as this was the first-ever regional language engineering course in the state, families feared their children might face discrimination and lack of opportunities in the job market. Counselling and assurance of industry interaction and internships integrated into the curriculum, quelled their doubts.

“Their faith has now been rewarded, evidenced by over 60 per cent placements in the first batch from well-known start-ups and established companies,” added Patil.

Sujata Kolhe, associate dean (academics), said offering conceptual clarity was key for the faculty. “We realised that a full translation was not feasible due to the lack of equivalent terminology in Marathi for many technical terms. So, we decided to teach in Marathi while retaining the textbooks and core materials in English,” said Kolhe.

It fell upon the instructors to simplify complex subjects explaining them in the mother tongue, all the while encouraging students to refer to English textbooks for industry-standard knowledge. “The dual-medium approach helped students gain a deeper understanding without being overwhelmed by language barriers,” she added.

Examinations were also conducted in a blended format, where students were allowed to write in both languages together. “The endeavour was to offer them flexibility without compromising on academic rigour,” Kolhe added.

First stepping stone

Internships from the third year onwards allowed students hands-on experience about interactions in the real world, with mentors focussing on personality development, interview preparation and soft skills, helping students from the special batch gain confidence to compete with their English-speaking peers. “We ensured they felt no less than any other B.Tech graduate,” shared an alumni volunteer.

Prajakta Maratkar, from Chandrapur district, shared her journey saying, “My father is a state government employee; we are used to speaking and thinking in Marathi which filled me with anxiety when I went to college. But, over time, the faculty’s support and teaching methods helped me, and others like me, not just survive but also succeed.”

Her classmate Gauri Nimje from Yavatmal district, echoed similar sentiments, “I come from a family of small farmers; my primary goal was to get a good job to support my family financially. We were apprehensive initially about how we would be treated in the industry. But during internships and interviews, we realized that what mattered were was our skills, not the language we studied in.”

Prathamesh Theurkar, from Pimpri Chinchwad, who bagged the highest salary package of ₹10 lakh per annum, said, “Studying in Marathi actually helped me grasp difficult concepts more easily. Equally helpful was the blend of languages in the exams and during interviews, as it allowed us to express our understanding clearly.”

Dr Govind Kulkarni, director of PCCOE, termed this endeavour “a landmark event in the landscape of Indian technical education”.

“Today, as we witness our first batch of graduates with outstanding placement records and industry recognition, it reaffirms our belief that regional language can be a powerful medium for technical excellence,” he said.

Ashish Gawali, founder and CEO of ATX Labs, based in upscale Baner, Pune, said he was apprehensive when one of the students, Guruprasad Pathak, joined the company for an internship. “We were curious how his background would amalgamate with a fast-paced tech environment. However, within weeks it became clear that he had both the technical depth and the right attitude we look for in our team members. Guruprasad quickly stood out with clarity of concepts, eagerness to learn, and ability to apply knowledge in practical product development. We gave him a key responsibility on one of our flagship products, and he handled it with professionalism, insight, and maturity well beyond his years. Naturally, when it was time to expand our team, hiring him full-time was an easy decision,” said Gawali.

Moment of pride

On Saturday, some of the parents gathered at the campus to celebrate their children’s successes. A beaming Ganesh Sunderrav Indure, Vaibhav’s father, said: “He is the first in our family who has pursued degree-level education. He had the spark and we let him pursue his interest. All subsequent decisions were taken by him independently.”

Vaibhav, who was placed at Encora, an information technology (IT) company, said, “Every hour I worked as part of the Earn and Learn scheme was a lifeline – it made me disciplined and every subject I studied brought me closer to my dream. My journey proves that with hard work and the right opportunities, anything is possible.”

Mahammad Sayyad, Sufiya’s father, recalled how his daughter would study under a single dim light “not ever complaining”. “I work on someone else’s land and barely earn enough to make ends meet. She made every rupee of the loan we took count,” he said.

“There were days when even affording a bus pass felt like a luxury, but I never let my circumstances define my future. Every semester I topped was a silent answer to every doubt and struggle we faced. Completing my engineering degree is not just my achievement, it’s a victory for every girl in my village who dares to dream,” said Sufiya.

Author: Dheeraj Bengrut, Hindustan Times

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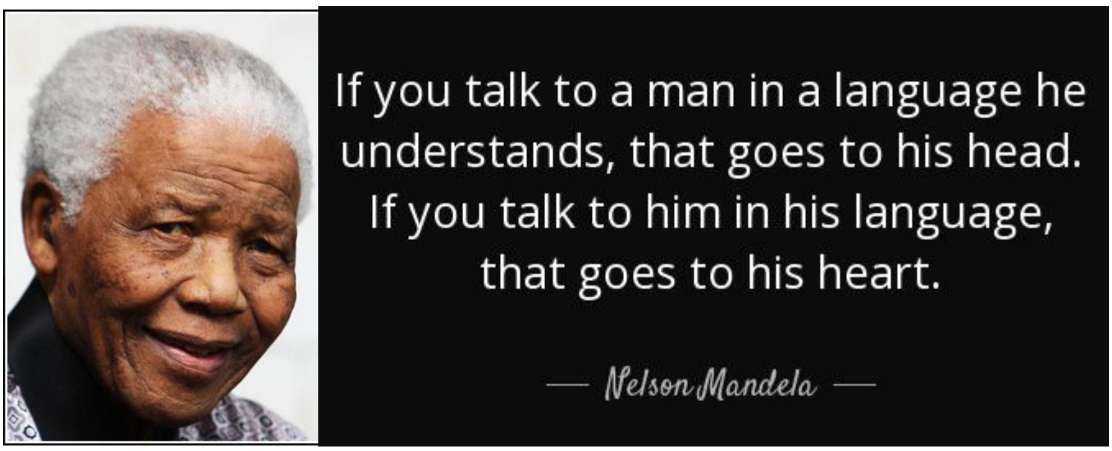

HOW DOES ASTROLOGY WORK?

Hardened scientists will tell you astrology doesn't work. Believers will tell you it does. Who is right? They are both right. It depends on what you mean by the word "work". Astrology is the belief that the alignment of stars and planets affects every individual's mood, personality, and environment, depending on when he was born. Astrologers print horoscopes in newspapers that are personalized by birth date. These horoscopes make predictions in people's personal lives, describe their personalities, and give them advice; all according to the position of astronomical bodies. A survey conducted by the National Science Foundation found that 41% of respondents believe that astrology is "very scientific" or "sort of scientific". Let us break the original question into two separate, more specific questions: 1) Does the position of astronomical bodies affect a person's life? 2) Can horoscopes make people feel better? These questions are both very different. Both can be determined scientifically.

Does the position of astronomical bodies affect a person's life (beyond basic weather)? No. The position and orientation of the sun relative to earth does cause seasons. Anyone who has shovelled snow off his walk in January when he would rather be at the beach can tell you that the astronomical bodies definitely affect our lives. Solar flares cause electromagnetic disturbances on earth that can disrupt satellites and even cause blackouts. The position of the moon causes ocean tides. If you are a fisher, the position of the moon can have a significant effect on your livelihood. The solar wind causes beautiful aurora, and sunlight itself is the main source of energy for our planet. But all of these effects fall under the umbrella of basic weather; not astrology. Astrology purports that astronomical bodies have influence on people's lives beyond basic weather patterns, depending on their birth date. This claim is scientifically false. Numerous scientific studies have disproven that astronomical bodies affect people's lives according to their birth date. For instance, Peter Hartmann and his collaborators studied over 4000 individuals and found no correlation between birth date and personality or intelligence. In one of the most famous experiments, Shawn Carlson had 28 astrologers make predictions and then tested the accuracy of their predictions. Before conducting the experiment, he fine-tuned the method so that various independent scientists agreed the method was scientifically sound, and also so that all of the astrologers agreed the test was fair. As published in Nature, he found that the astrologers could do no better at predicting the future than random chance. These results agree with fundamental science.

Fundamentally, there are four forces of nature: gravity, electromagnetism, the strong nuclear force, and the weak nuclear force. If an object affects a person, it must do so by interacting through one of these fundamental forces. For instance, strong acid burns your skin because the electromagnetic fields in the acid pull strongly enough on your skin molecules that they rip apart. A falling rock crushes you because gravity pulls it onto you. A nuclear bomb will vaporize you because of nuclear forces. Each of the fundamental forces can be very strong. The problem is that they all die off with distance. The nuclear forces die off so quickly that they are essentially zero beyond a few nanometers. Electromagnetic forces typically extend from nanometers to kilometers. Sensitive equipment can detect electromagnetic waves (light) from the edge of the observable universe, but that light is exceptionally weak. The gravity of a star technically extends throughout the universe, but its individual effect on the universe does not extend much beyond its solar system. Because of the effect of distance, the gravitational pull of Polaris on an earth-bound human is weaker than the gravitational pull of a gnat flitting about his head. Similarly, the electromagnetic waves (light) reaching the eye of an earth-bound human from Sirius is dimmer than the light from a firefly flitting by. If the stars and planets really had an effect on humans, then gnats and fireflies would have even more of an effect. Even if the gravity of the planets was strong enough to affect you, an alignment of the planets would not lead you to win the lottery for the simple reason that a literal alignment of the planets never happens in the real world.

Can horoscopes make people feel better?

Yes. But it has nothing to do with the horoscopes being right. Horoscopes make people feel better because of a psychological effect known as the placebo effect. The placebo effect is when the belief in a useless method actually makes a person feel better. It is the belief itself, and not the method, that causes the improvement. The placebo effect has been scientifically verified. If you give pills to ten sick patients containing only water, but tell them it is a powerful new drug that will help them, and then have ten sick patients not take the pills, then over time the patients taking pills will show better health. Because of the placebo effect, a new drug must not just be proven to make patients feel better. It must be proven to perform better than a placebo. In accurate medical experiments, the control group is not a collection of untreated patients. Rather, the control group is a collection of patients receiving a placebo. The placebo effect is the mechanism at work with astrology. Many people believe in astrology. When they read their horoscope and follow its advice, they feel better. But it is the belief itself and not the astrology that is making them feel better. Many pseudo-scientific treatments – from crystal healing to homoeopathy – help people through the placebo effect. Believing in a treatment that does not actually do anything may help, but believing in a treatment that does is even better. Sticking to scientifically proven treatments gives you the benefit of the belief *and* the benefit of the treatment's action. For instance, instead of reading your horoscope each morning, go for a walk. Exercise is proven to be good for the body and mind, and your belief in its effect will also help you.

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Christopher S. Baird

Associate Professor of Physics at West Texas A & M University, USA

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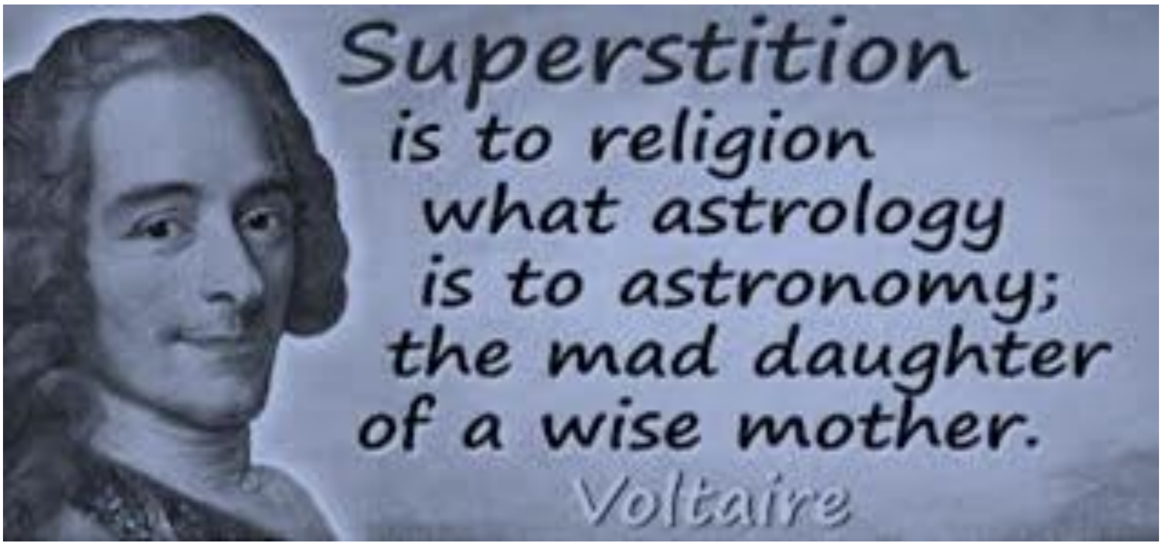

ORIGIN OF THE UNIVERSE: HOW DID IT BEGIN AND HOW WILL IT END

The mysteries surrounding the origin of the universe have captivated our minds for ages, sparking curiosity and contemplation across different eras. Whether through relaying myths, exploring space, or creating modern scientific hypotheses, humanity has sought to unravel the numerous secrets of the cosmos that envelops us.

Cosmology: The Birth of Myths and Tales

Long before scientific exploration took center stage, various civilizations around the world crafted elaborate stories to explain how the universe came into existence. These stories, rich in symbolism and metaphorical significance, provided societies with a narrative framework to comprehend the complexities of their surroundings and their own relevance.

In Egyptian cosmology, people believed that the universe emerged from the primordial waters of the creator god, Nun, and these waters formed an abyss with boundless potential and endless possibilities. The sun god, Atum, was credited with bringing structure and form to the cosmos through his creative prowess.

In a similar vein, ancient Greek cosmogony tells the tale of the primeval god Chaos giving birth to the universe, from where the gods Gaia (Earth), Uranus (Sky), and other primordial deities emerged. These ancient myths don't coherently explain any of the natural events in our universe, but they do convey cultural stories that mirror societal values, beliefs, and dreams.

The Emergence of Modern Cosmology and the Big Bang Theory

The 20th century marked a change in our comprehension of how the universe began through modern cosmology. In the 1920s, Edwin Hubble's ground breaking discovery of an expanding universe laid the groundwork for the development of what we call the Big Bang Theory, which has reshaped our understanding of cosmic development.

The Big Bang Theory suggests that about 13.8 billion years ago, the entire universe began from a dense, extremely hot single spot according to the Center for Astrophysics. This spot is known as the "singularity," and it marks the beginning of what we now know as space, time, and matter.

As space expanded and cooled down over time, subatomic particles merged to form atoms that later evolved into distant galaxies, stars, and planets. It ultimately shaped our own solar system and the cosmic structure that we have today.

The Big Bang Theory's ability to account for various observations, from cosmic microwave background (CMB) radiation to the distribution of galaxies, has established it as the primary model in cosmology. Nonetheless, like all theories, the Big Bang Theory comes with its own limitations and has sparked ongoing discussions and explorations into alternative models of cosmic evolution.

For instance, early cosmologists identified two significant issues with the Big Bang Theory: the Horizon Problem and the Flatness Problem.

The Horizon Problem and Cosmic Microwave Background Radiation

The horizon problem becomes apparent when researchers examine the uniformity and consistency of cosmic microwave background radiation. CMB radiation is the thermal radiation left over from our universe's formation when it was about 380,000 years old. This radiation occurred shortly after the Big Bang, when visible light could first move freely without obstruction.

The apparent consistency of CMB – which reflects temperature variations at a scale of one part in 100,000 – indicates that the furthest reaches of outer space were once in thermal equilibrium. In other words, the universe's most distant parts were once the same temperature, suggesting that heat was evenly distributed in all directions.

However, these regions are far apart. Considering our universe's age and the speed of light (approximately 186,000 miles per second), it should be physically impossible that these regions could have ever been close enough to interact and equilibrate directly since the inception of the Big Bang. To put it more simply, the horizon problem raises a compelling question of how the universe's distant parts could somehow end up with such similar temperatures and characteristics.

The Flatness Problem

The flatness problem, on the other hand, deals with the universe's shape and overall curvature. According to Einstein's Theory of Relativity, the universe's shape is determined by mass and energy, which is described by a curvature measure called Omega (Ω).

A universe with "Ω = 1" is flat – indicating no curvature and meeting the critical density requirement where the universe's expansion rate should eventually slow down and approach zero without actually ever reaching zero. It means that a gradual slowing down of the universe's expansion over time never stops.

Initially, the original Big Bang Theory suggested that immediately after the Big Bang, the universe should have been very close to critical density (Ω ≈ 1/flat in shape). But as time passed and the universe's expansion continued, even a minor deviation from critical density would magnify over time, resulting in a universe that is significantly curved, either "open" (Ω < 1) or "closed" (Ω > 1).

But the universe that we observe with our scientific instruments today is flat. So the question is: How is that possible?

The Early Moments of Creation: How the Universe Expanded and Quantum Fluctuations

To solve these kinds of problems, modern cosmologists have put forth several theories to better explain the universe's properties and phenomena. One of the most sobering and empirically supported theories is the cosmic inflation theory, first proposed by physicist Alan Guth during the 1980s.

According to Guth's cosmic inflation theory, there was an exponential expansion within a fraction of a second after the Big Bang. This period of inflation set the stage for the universe's observable structure and composition that we see today.

Guth's theory is consistent with observable scientific evidence. It also resolves several enduring cosmological mysteries, including the horizon problem and the flatness problem.

In regard to the horizon problem, cosmic inflation theory theorizes that the universe experienced an exponential expansion in the first fraction of a second after the Big Bang. This inflation period stretched the universe beyond its visible horizon, enabling distant regions to come into causal contact and achieve thermal equilibrium. This theory means that the expansion allowed the universe's distant areas to interact and influence each other, resulting in them reaching the same temperature.

In other words, the physics described by the cosmic inflation theory would allow the present universe to have expanded faster than the speed of light during this early inflationary period. That would have eliminated the problems of distance and time preventing thermal equilibrium.

Regarding the flatness problem, cosmic inflation theory suggests that the period of rapid and significant expansion led to an increase in the scale factor of the universe, which determines the relative sizes of spatial dimensions (the size of space itself).

As a result, any slight deviations from a flat geometry in the early universe would have been greatly stretched out and weakened during this inflationary period. In other words, the rapid expansion would have smoothed out these deviations, making the universe more uniformly flat.

During the universe's growth, the energy density linked to the inflation field became dominant over other forms of energy like radiation and matter. This dominance would have had a leveling effect on the entire universe's geometry, moving it closer to a flat configuration.

So inflationary cosmology from the 1980s provides compelling resolutions to these kinds of questions about the origin of the universe. It reshapes our comprehension of early dynamics and lays the foundations for modern cosmological theories.

This inflation is thought by researchers to have been triggered by quantum fluctuations within the fabric of space-time – a phenomenon foreseen by quantum mechanics. At these quantum levels, tiny fluctuations are believed to have been magnified during inflation, which introduced irregularities and differences that eventually developed into the first galaxies, clusters of galaxies, and macro-level cosmic formations.

Cosmic Diversity and The Multiverse Theory

With advancements in cosmology, scientists are considering the concept that our universe might just be one among many in an extensive "multiverse." This theory suggests that an infinite number of universes might exist, each with its own distinct physical laws, constants, and characteristics.

While this hypothesis is still speculative and beyond today's empirical testing capabilities, the multiverse hypothesis presents a captivating explanation for some of the universe's most puzzling aspects. For example, the precise tuning of constants and parameters in our universe to support life could find justification in a multiverse scenario where each region possesses unique properties.

In such a case, our universe would not be designed to support the existence of life as we know it, but is rather the product of chance and coincidence. There could be many other universes within the multiverse that are not capable of supporting such life.

The Universe's Eventual Demise

Now that we've talked about the earliest origins of the universe, a fair question you might be thinking is, "How will it end?" There's no way to know for sure, but scientists have some theories.

The concepts of accelerating expansion, as well as the Big Rip theory and the Big Freeze theory, offer insights into the universe's potential futures.

Accelerating Expansion

After the Big Bang Theory for the universe's beginning was firmly established, researchers inferred that the force of gravity would slow the universe's expansion over time, as all matter contained in the universe pulls on itself to reunite. They believed that gravity would eventually stop the expansion. Then, a recoil would occur and cause everything to slowly coalesces back together, perhaps back to a single point.

Researchers called this theory the Big Crunch. It even gave rise to the notion that perhaps the universe experiences a repeating cycle of rebounds as it expands and contracts over and over again as a result of competing forces trying to dominate each other.

But scientific observation of the universe's rate of expansion revealed that it is not slowing. Instead, it is increasing.

This unexpected finding, drawn from studying supernovae in the late 1990s, suggests that a mysterious force called dark energy is opposing gravity on a cosmic scale and accelerating the universe's expansion.

The presence of dark energy propelling this accelerated expansion has significant implications for what lies ahead for our universe. It suggests that galaxies will continue drifting apart at an ever-increasing pace.

The Big Rip Theory

Taking the accelerating expansion of the universe to its inevitable conclusion, the Big Rip Theory provides a vivid and dramatic picture of one possibility for our universe's fate. This theory suggests that dark energy's repulsive force grows stronger over time and can overpower all other forces, including the gravitational pull within galaxies, stars, and subatomic particles.

As the universe expands faster and faster under this scenario, the Big Rip theory foresees galaxies moving away from each other, which is already happening today. Eventually, the gravitational forces that bind galaxies, stars, planets, and atoms together may also succumb to the overpowering influence of dark energy.

This catastrophic event would result in the destruction of cosmic structures, causing matter to break down into its basic components and leading to the tearing apart of spacetime itself at the most fundamental level. Simply put, dark energy would "rip" everything in the universe to pieces.

The Big Freeze Theory

The Big Freeze Theory (also known as the Heat Death Theory) presents a more gradual and subdued fate for the universe. According to the Big Freeze, the universe will continue expanding at an increasing pace due to dark energy, causing matter and energy to gradually thin out over immense periods of time.

As galaxies drift apart and the universe grows colder and more barren, new stars will stop forming and existing ones will slowly burn out. Eventually, the universe will reach a state of maximum entropy, where all energy is uniformly dispersed with no potential for matter interaction.

In this state, called Heat Death by some theorists, the universe would become a cold, dark void. There would be no life, light, or any recognizable structure or activity.

Exploring More Cosmological Frontiers

Despite strides in unravelling the origins and evolution of the universe, cosmology continues to pose obstacles, uncertainties, and unresolved inquiries. For example, dark matter and dark energy collectively account for about 95% of the universe's total mass energy, but these components of our universe remain a complete mystery in modern astrophysics and cosmology. Even though we can infer their existence and even measure them to a degree, we know almost nothing about them.

Furthermore, the elusive origin of the singularity itself, as the starting point from which the universe appears to have emerged, continues to puzzle researchers. Current scientific hypotheses such as loop quantum gravity and string theory have attempted to merge Einstein's relativity with quantum mechanics to create a unified theory of the universe. Still, this work is incomplete at best so far.

The Search to Understand the Origin of the Universe Continues

The beginning of our universe is one of humanity's mysteries that have captivated mythologies, philosophies, and scientific endeavors. From cosmological myths depicting primal chaos to contemporary cosmological theories formulated through intricate mathematical study and calculation, our comprehension of how the universe came to exist has evolved overtime. This evolution reflects our curiosity, imagination, and determination to unravel the mysteries surrounding our own existence in our vast cosmos.

As we delve deeper into cosmic dynamics through scientific exploration, we are humbled by the vastness, intricacy, and splendour that define our ever-expanding understanding of the cosmos. Every cosmological theory, whether about the Big Bang, Cosmic Inflation, or the idea of a multiverse filled with realities, provides a fascinating perspective of the birth and evolution of the universe.

It sparks curiosity, amazement, and a deep feeling of connectedness to the cosmos at large and to each other on Earth. So, we should continue the work of our understanding of the universe and see where the truth leads us.

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Dr. Gary L.Deel
American Public University

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The question is: is the way the universe began chosen by God for reasons we can't understand, or was it determined by a law of science? I believe the second. If you like, you can call the laws of science 'God', but it wouldn't be a personal God that you could meet and ask questions.
Stephen Hawking

DOES GRAVITY TRAVEL AT THE SPEED OF LIGHT?

To begin with, the speed of gravity has not been measured directly in the laboratory—the gravitational interaction is too weak, and such an experiment is beyond present technological capabilities. The "speed of gravity" must therefore be deduced from astronomical observations, and the answer depends on what model of gravity one uses to describe those observations.

In the simple newtonian model, gravity propagates instantaneously: the force exerted by a massive object points directly toward that object's present position. For example, even though the Sun is 500 light seconds from the Earth, newtonian gravity describes a force on Earth directed towards the Sun's position "now," not its position 500 seconds ago. Putting a "light travel delay" (technically called "retardation") into newtonian gravity would make orbits unstable, leading to predictions that clearly contradict Solar System observations.

In general relativity, on the other hand, gravity propagates at the speed of light; that is, the motion of a massive object creates a distortion in the curvature of spacetime that moves outward at light speed. This might seem to contradict the Solar System observations described above, but remember that general relativity is conceptually very different from newtonian gravity, so a direct comparison is not so simple. Strictly speaking, gravity is not a "force" in general relativity, and a description in terms of speed and direction can be tricky. For weak fields, though, one can describe the theory in a sort of newtonian language. In that case, one finds that the "force" in GR is not quite central—it does not point directly towards the source of the gravitational field—and that it depends on velocity as well as position. The net result is that the effect of propagation delay is almost exactly cancelled, and general relativity very nearly reproduces the newtonian result.

This cancellation may seem less strange if one notes that a similar effect occurs in electromagnetism. If a charged particle is moving at a constant velocity, it exerts a force that points toward its present position, not its retarded position, even though electromagnetic interactions certainly move at the speed of light. Here, as in general relativity, subtleties in the nature of the interaction "conspire" to disguise the effect of propagation delay. It should be emphasized that in both electromagnetism and general relativity, this effect is not put in *ad hoc* but comes out of the equations. Also, the cancellation is nearly exact only for *constant* velocities. If a charged particle or a gravitating mass suddenly accelerates, the *change* in the electric or gravitational field propagates outward at the speed of light.

Since this point can be confusing, it's worth exploring a little further, in a slightly more technical manner. Consider two bodies—call them A and B—held in orbit by either electrical or gravitational attraction. As long as the force on A points directly towards B and vice versa, a stable orbit is possible. If the force on A points instead towards the retarded (propagation-time-delayed) position of B, on the other hand, the effect is to add a new component of force in the direction of A's motion, causing instability of the orbit. This instability, in turn, leads to a change in the mechanical angular momentum of the A-B system. But *total* angular momentum is conserved, so this change can only occur if some of the angular momentum of the A-B system is carried away by electromagnetic or gravitational radiation.

Now, in electrodynamics, a charge moving at a constant velocity does not radiate. Technically, the lowest-order radiation is dipole radiation, and the radiated power depends on the second time derivative of the electric dipole moment; two time derivatives give acceleration. So, to the extent that A's motion can be approximated as motion at a constant velocity, A cannot lose angular momentum. For the theory to be consistent, there must therefore be compensating terms that partially cancel the instability of the orbit caused by retardation. This is exactly what happens; a calculation shows that the force on A points not towards B's retarded position, but towards B's "linearly extrapolated" retarded position.

In general relativity, roughly speaking, a mass moving at a constant acceleration does not radiate. Here, the lowest order radiation is quadrupole radiation, and the radiated power depends on the *third* time derivative of the mass quadrupole moment. (The full picture is slightly more complex, since one cannot have a single, isolated accelerating mass; whatever it is that causes the acceleration also has a gravitational field, and its field must be taken into account.) For consistency, just as in the case of electromagnetism, a cancellation of the effect of retardation must occur, but it must now be even more complete—that is, it must hold to a higher power of v/c. This is exactly what one finds when one solves the equations of motion in general relativity.

While current observations do not yet provide a direct model-independent measurement of the speed of gravity, a test within the framework of general relativity can be made by observing the binary pulsar PSR 1913+16. The orbit of this binary system is gradually decaying, and this behavior is attributed to the loss of energy due to escaping gravitational radiation. But in any field theory, radiation is intimately related to the finite velocity of field propagation, and the orbital changes due to gravitational radiation can equivalently be viewed as damping caused by the finite propagation speed. (In the discussion above, this damping represents a failure of the "retardation" and "noncentral, velocity-dependent" effects to completely cancel.)

The rate of this damping can be computed, and one finds that it depends sensitively on the speed of gravity. The fact that gravitational damping is measured at all is a strong indication that the propagation speed of gravity is not infinite. If the calculational framework of general relativity is accepted, the damping can be used to calculate the speed, and the actual measurement confirms that the speed of gravity is equal to the speed of light to within 1%. (Measurements of at least one other binary pulsar system, PSR B1534+12, confirm this result, although so far with less precision.)

Are there future prospects for a direct measurement of the speed of gravity? One possibility would involve detection of gravitational waves from a supernova. The detection of gravitational radiation in the same time frame as a neutrino burst, followed by a later visual identification of a supernova, would be considered strong experimental evidence for the speed of gravity being equal to the speed of light. However, unless a very nearby supernova occurs soon, it will be some time before gravitational wave detectors are expected to be sensitive enough to perform such a test.

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Steve Carlip
Matthew Wiener and Geoffrey Landis.

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RADAR TECHNOLOGY AND ITS APPLICATIONS IN PHYSICS

Radar, an acronym for **Ra**dio **D**etection **A**nd **R**anging, is a detection system that uses radio waves to determine the distance, angle, and velocity of objects. This technology has been widely used in various fields, including physics, meteorology, aviation, and military operations.

How Radar Works

Radar systems consist of a transmitter, receiver, and antenna. The transmitter sends out radio waves, which bounces off objects and returns to the receiver. By measuring the time delay between the transmitted and received signals, radar systems can calculate the distance and velocity of objects.

The radar equation is given by:

$$R_{max} = (P_t * G_t * G_r * \lambda^2 * \sigma) / ((4 * \pi)^3 * k * T * B * F * L)$$

Where:

R_{max} = maximum range
P_t = transmitted power
G_t = transmitter antenna gain
G_r = receiver antenna gain
λ = wavelength
σ = target radar cross-section (RCS)
k = Boltzmann constant
T = system temperature
B = bandwidth
- F = noise figure
- L = system losses

This equation helps radar engineers to design and optimise radar systems for specific applications. The radar equation, also known as the radar range equation, is a mathematical formula used to calculate the maximum distance of the target that a radar system can detect. The equation takes into account various factors such as:

- Transmitted power
- Antenna gain
- Wavelength
- Target cross-sectional area (RCS)
- Receiver sensitivity
- Noise level

Types of Radars

Here are some common types of radar systems:

- Pulse Radar: Transmits short pulses of radio waves to determine target distance.
- Continuous Wave (CW) Radar: Transmits a continuous signal to measure target velocity.
- Doppler Radar (DR): Uses the Doppler effect to measure target velocity and direction.

- Phased Array Radar(PAR): Uses multiple antennas to steer and shape the radar beam electronically.
- Synthetic Aperture Radar (SAR): Uses platform motion to create high-resolution images.
- Ground-Penetrating Radar (GPR): Images subsurface structures and detects buried objects.
- Weather Radar (WR): Detects and tracks precipitation, storms, and other weather phenomena.
- Airborne Radar (AR): Used on aircraft for navigation, surveillance, and weather detection.
- Maritime Radar (MR): Used on ships for navigation, collision avoidance, and surveillance.
- Bistatic Radar (BR): Uses separate transmit and receive antennas.

These types of radar systems have various applications in fields like aviation, meteorology, defense, and more.

Advantages of Radar

➔ Long-range detection: Radar can detect objects at long ranges, making it useful for surveillance and tracking.
➔ All-weather capability: Radar can operate in various weather conditions, including rain, fog, and darkness.
➔ High accuracy: Radar systems can provide accurate measurements of distance, velocity, and angle.

Applications of Radar in Physics

◆ Weather Forecasting: Radar is used to track precipitation, storms, and other weather phenomena. Doppler radar, a type of radar that measures velocity, helps predict tornadoes and hurricanes.
◆ Atmospheric Research: Radar is used to study the upper atmosphere, including the ionosphere and magnetosphere. Scientists use radar to investigate atmospheric phenomena like aurorae and solar flares.
◆ Particle Physics: Radar technology is used in particle accelerators to detect and track subatomic particles.
◆ Astronomy: Radar astronomy uses radar waves to study celestial objects like planets, asteroids, and comets. This technique helps scientists understand the composition and properties of these objects.
◆ Geophysics: Ground-penetrating radar (GPR) is used to study the subsurface structure of the Earth. GPR helps scientists investigate geological features like faults, fractures, and underground cavities.

Particle physics and radar might seem unrelated, but, in reality, it is not so. Let's explore some connections:

Particle Physics Applications

1. Particle Detectors: Radar-like techniques are used in particle detectors to track and identify subatomic particles. These detectors often employ advanced sensors and algorithms to reconstruct particle interactions.

2. Particle Accelerators: Radar technology is used in particle accelerators to control and monitor particle beams. This ensures precise acceleration and collision of particles.

3. High-Energy Physics: Radar-inspired techniques are used in high-energy physics experiments to detect and analyze particles produced in collisions.

Radar Equation Relevance:

While the radar equation isn't directly applied in particle physics, its underlying principles are relevant:

1. Signal Detection: The radar equation's focus on signal detection and noise reduction is crucial in particle physics, where scientists seek to detect rare or faint signals.

2. Precision Measurement: The radar equation's emphasis on precise calculations and measurements is also essential in particle physics, where scientists strive to accurately measure particle properties and interactions.

Examples

1. ATLAS Experiment: The ATLAS experiment at CERN uses advanced detectors and algorithms to identify and reconstruct particle interactions, similar to radar-like techniques.

2. Particle Tracking: Particle tracking algorithms, inspired by radar tracking techniques, are used to reconstruct particle trajectories and identify particle properties.

While the radar equation itself isn't directly used in particle physics, its underlying principles and techniques have inspired innovative applications in the field.

Let's explore some mathematical connections between radar and particle physics:

Particle Detection

In particle physics, detectors measure the properties of particles produced in collisions. One way to describe this process is using the concept of cross-section (σ), similar to radar cross-section:

σ = (Number of particles detected) / (Number of particles incident)

Signal Detection
In radar and particle physics, signal detection is crucial. The signal-to-noise ratio (SNR) is a key metric:

SNR = (Signal amplitude) / (Noise amplitude)

Particle Tracking:

Particle tracking algorithms often employ mathematical techniques like Kalman filtering, which estimates the state of a system (e.g., particle position and momentum) from noisy measurements:

$x_k = F_k * x_{k-1} + w_k$

where x_k is the state vector, F_k is the state transition matrix, and w_k is the process noise.

Radar Equation Analogs:

While the radar equation isn't directly applicable, similar equations can describe particle detection and tracking:

1. Particle detection probability: $P_{det} = (\sigma * \varepsilon) / (\sqrt{(2 * \pi * \sigma_{noise}^2)})$

where ε is the detection efficiency, σ is the particle cross-section, and σ_{noise} is the noise level.

These mathematical equations illustrate the connections between radar and particle physics, highlighting the importance of signal detection, precision measurement, and mathematical modelling in both fields.

Conclusion

Radar technology has revolutionised various fields, including physics, by providing a powerful tool for detection and measurement. Its applications in weather forecasting, atmospheric research, particle physics, astronomy, and geophysics have significantly advanced our understanding of the world and universe. As radar technology continues to evolve, we can expect even more innovative applications in the future.

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C. S. Srinivasamurthy
Former Technical Officer with L.R.D.E.

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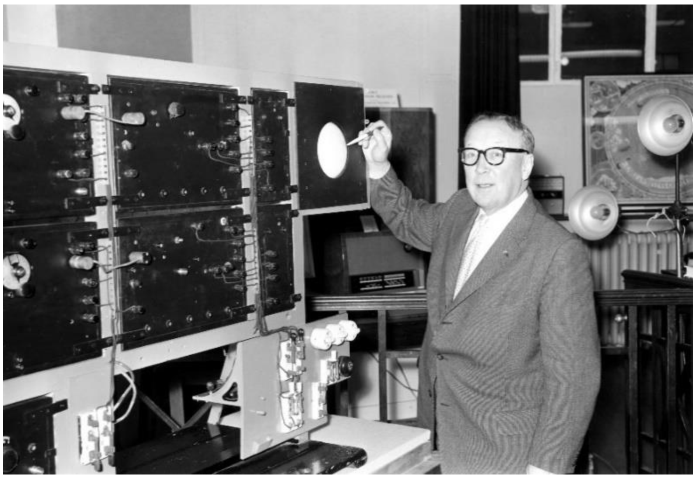

The Invisible Eyes in the Sky

A long time ago, before computers and satellites, people were trying to find ways to protect their countries from enemy airplanes. One smart scientist named **Robert Watson-Watt** had a big idea: "What if we could make a giant radio that zaps planes from the sky?"

He tried and tried, but instead of zapping anything, something amazing happened — when airplanes flew through the radio waves, they bounced back like an echo!
He shouted, “Wait! We can’t shoot the planes… but we can **see** them coming!”

That idea turned into **RADAR** — a magic-like machine that could spot planes far away, even in the dark or fog. During World War II, RADAR helped save thousands of lives by giving people time to prepare before danger arrived.
So, by accident, the scientist didn’t invent a weapon…
He invented a shield.

Source: Adapted from various historical accounts available online

INTERESTING QUOTES BY SOME FAMOUS SCIENTISTS

Words That Changed the World: Famous Quotes by Scientists

Great scientists not only made discoveries — they also left us with powerful words that continue to inspire generations. Their quotes remind us to be curious, to question, and to never stop learning.

Aristotle

"Excellence is never an accident. It is always the result of high intention, sincere effort, and intelligent execution; it represents the wise choice of many alternatives - choice, not chance, determines your destiny."

"Education is bitter, but its fruit is sweet."

"All knowledge should be subject to examination and reason."

"We are what we do repeatedly. Separate him from law and justice and he is the worst."

Galileo Galilei

"You cannot teach a man anything; you can only help him find it within himself."

Galileo, a key figure in the scientific revolution, saw learning as a personal journey. His quote suggests that true understanding comes from within. A good teacher does not simply give answers but helps students discover ideas on their own. This approach builds deep thinking and self-confidence.

Isaac Newton

"If I have seen further, it is by standing on the shoulders of giants."

Isaac Newton, one of the most important scientists in history, recognised that his work built on the ideas of others. His quote reminds us that learning is connected. Each person adds to knowledge passed down from those before, and this shared growth helps us go further in our own learning.

Charles Darwin

"It is not the strongest of the species that survive... but the one most responsive to change."

Darwin, known for the theory of evolution, saw that survival depends on adaptability. This idea applies to learning too. Students who stay open to change and new ways of thinking grow faster than those who resist. His quote teaches that flexibility and learning from change are key to progress.

Michael Faraday

"Nature is our kindest friend and best critic in experimental science if we only allow her intimations to fall unbiased on our minds."

"The important thing is to know how to take all things quietly."

This quote suggests a calm and collected approach to scientific pursuits, acknowledging that progress may require patience and a steady mind.

"I have far more confidence in the one man who works mentally and bodily at a matter than in the six who merely talk about it."

James Clerk Maxwell

"It is of great advantage to the student of any subject to read the original memoirs on that subject, for science is always most completely assimilated when it is in the nascent state..."

"Thoroughly conscious ignorance is the prelude to every real advance in science."

"statistical laws are not necessarily used as a result of our ignorance. statistical laws can reflect how things really are. there are matters that can only be treated statistically."

Albert Einstein
"Education is not the learning of facts, but the training of the mind to think."

Einstein, a physicist known for the theory of relativity, believed that learning is about thinking, not memorising. His quote encourages students to question, reason, and explore ideas with an open mind. True education, according to him, shapes how we think and solve problems, not just how much we remember.

Marie Curie
"Nothing in life is to be feared, it is only to be understood."

Marie Curie, who studied radioactivity and won two Nobel Prizes, reminds us that fear often comes from not knowing. Her quote encourages learners to face the unknown with curiosity. Understanding something deeply makes it less frightening. The more we learn, the more confident and prepared we become to face challenges.

Carl Sagan
"Somewhere, something incredible is waiting to be known."

Carl Sagan, an astronomer and science communicator, believed in the power of curiosity. His quote reminds us that there is always more to learn and discover. Whether it is in space, nature, or our own minds, new knowledge is waiting. This thought keeps learning exciting and never-ending.

Stephen Hawking
"Intelligence is the ability to adapt to change."

Stephen Hawking, a physicist who studied black holes, believed that smart people adapt well. His quote teaches us that being flexible and open to change is part of true intelligence. In both science and life, learning to adjust, accept new ideas, and keep moving forward is just as important as knowing facts.

Richard Feynman
"I would rather have questions that cannot be answered than answers that cannot be questioned."
Feynman, a Nobel-winning physicist, valued curiosity over certainty. His quote encourages us to keep asking questions, even if answers are hard to find. He believed that doubt and exploration are essential in learning. Accepting things without question limits growth, while asking "why" keeps our minds active.

Rosalind Franklin
"Science and everyday life cannot and should not be separated."

Rosalind Franklin, who helped discover the structure of DNA, believed science was part of daily life. Her quote reminds us that what we learn in science affects health, decisions, and society. Science is not just for the lab, it is all around us, and learning it helps us understand and improve the world.

Nikola Tesla
"The present is theirs; the future, for which I worked, is mine."

Nikola Tesla, inventor and engineer, was always thinking ahead. His quote reflects a belief in working now for what lies ahead. It encourages students to study not just for today but for the future. Learning is an investment, and what we gain now helps us build what comes next.

C V Raman
"You can't always choose who comes into your life but you can learn what lesson they teach."
"Ask the right questions, and nature will open the door to her secrets."
"Success can come to you by courageous devotion to the task lying in front of you."
"If someone judges you, they are wasting space in their mind."
"The essence of science is independent thinking, hard work, and not equipment."
"I am the master of my failure. ..."
"Success can come to you by courageous devotion to the task lying in front of you."
"Ask the right questions, and nature will open the door to her secrets."

Paul Dirac
"It seems that if one is working from the point of view of getting beauty in one's equations, and if one has really a sound insight, one is on a sure line of progress."
"The methods of theoretical physics should be applicable to all those branches of thought in which the essential features are expressible with numbers."

Erwin Schrödinger
"The scientist only imposes two things, namely truth and sincerity, imposes them upon himself and upon other scientists."
"If a man never contradicts himself, the reason must be that he virtually never says anything at all."

Linus Pauling
"The best way to have a good idea is to have lots of ideas."
"Satisfaction of one's curiosity is one of the greatest sources of happiness in life"
"Science is the search for the truth--it is not a game in which one tries to beat his opponent, to harm others."

Collected by: Dr. B A Kagali
Professor of physics (retd.), Bangalore University

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Witty Science Quotes

"Research is what I'm doing when I don't know what I'm doing."
— *Wernher von Braun* (Rocket scientist)
A gentle reminder that even the smartest minds figure things out as they go!

"If we knew what it was we were doing, it would not be called research, would it?"
— *Albert Einstein*
Einstein was not just brilliant, he was also delightfully honest about science being a journey full of mystery.

"Basic research is what I am doing when I am looking for something and find something else."
— *Vannevar Bush*
Sometimes, science is just a very organized way of being surprised!

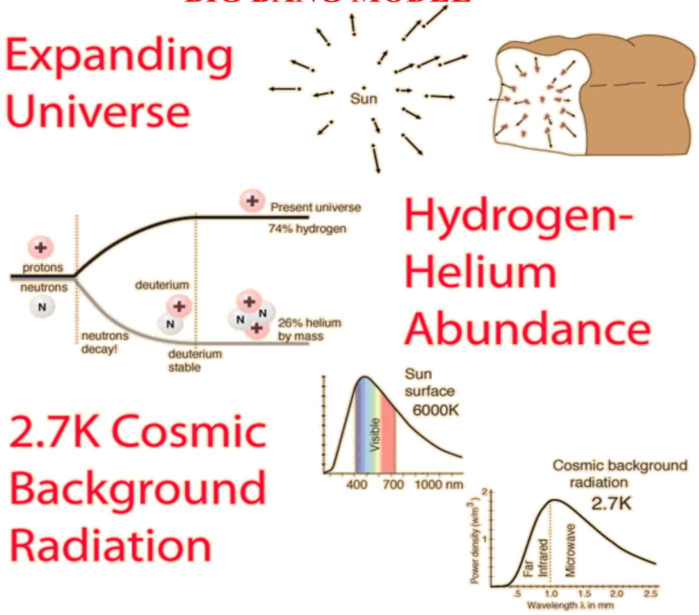
"In theory, there is no difference between theory and practice. In practice, there is."
— *Yogi Berra* (often misattributed to scientists, but loved by engineers and physicists!)

PHYSICAL KEYS TO COSMOLOGY

Physical evidence was accumulated to make reasonable models for the formation of the universe only in the latter half of the 20th century. The "**Big Bang**" model, was developed around the following three major pieces of experimental evidence

1. Expansion of the universe
2. 3K cosmic background radiation
3. Hydrogen-helium abundance.

BIG BANG MODEL

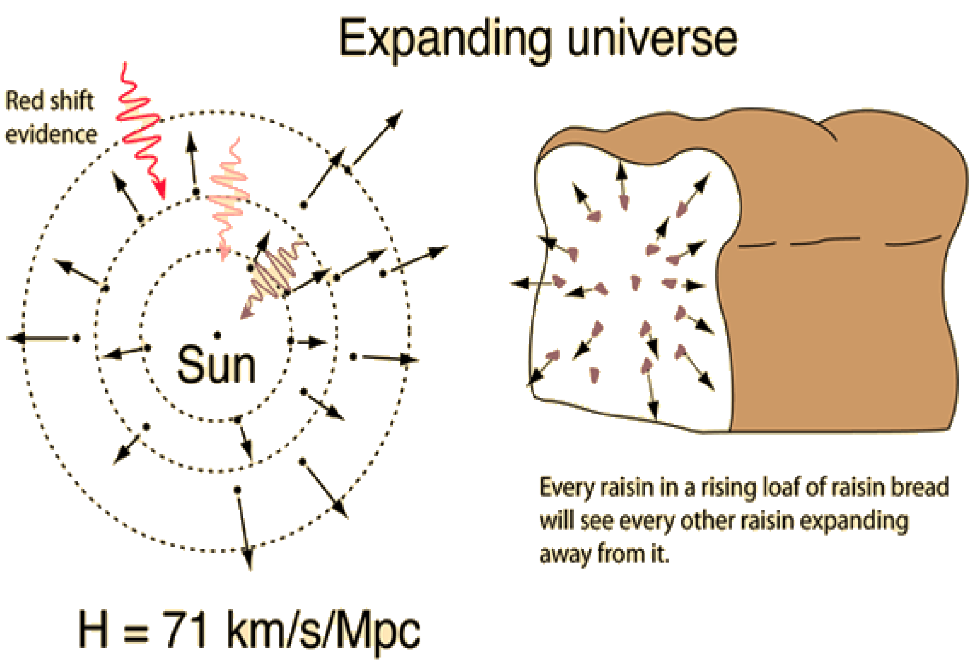


"Big Bang" *scenario from* The First Three Minutes by Steven Weinberg

Time	Temp	Energy kT	Density (water=1)	What's happening
.02 s	10^{11} K	8.6 MeV	4×10^{7}	The universe is mostly light. Electrons and positrons are created from light (pair-production) and destroyed at about equal rates. Protons and neutrons being changed back and forth, so about equal numbers. Only about one neutron or proton for each 10^{9} photons.
.11 s	3×10^{10} K	2.6 MeV		Free neutrons decaying into protons, so there begins to be an excess of protons over neutrons.
1.09 s	10^{10} K	860 keV	4×10^{5}	Primeval fireball becomes transparent to neutrinos, so they are decoupled. It is still opaque to light and electromagnetic radiation of all wavelengths, so they are still contained. Electron-positron annihilation now proceeding faster than pair-production.
13.8 s	3×10^{9} K	260 keV		Below pair-production threshold.
3 m 2 s	10^{9} K	86 keV		Electrons and positrons nearly all gone. Photons and neutrinos are main constituents of the universe in terms of energy. Neutron decay leaves 86% protons, 14% neutrons but these represent a small fraction of the energy of the universe.

3 m 46 s	0.9x 10^9 K	78 keV		Deuterium is now stable, so all the neutrons quickly combine to form deuterium and then helium. There is no more neutron decay since neutrons in nuclei are stable. Helium is about 26% by mass in the universe from this early time. Nothing heavier formed since there is no stable produce of mass 5.
34 m 40 s	3 x 10^8 K	26 keV	10	Nuclear processes are stopped, expansion and cooling continues. About one in 10^9 electrons left because of a slight excess of electrons over positrons in the primeval fireball.
7x 10^5 yrs	3000K	0.26 eV		Cool enough for hydrogen and helium nuclei to collect electrons and become stable atoms. Absence of ionized gas makes universe transparent to light for the first time.
10^{10} yrs	3 K			Living beings begin to analyze this process.

1. EXPANSION OF THE UNIVERSE



The distant galaxies we see in all directions are moving away from the Earth, as evidenced by their red shifts. Hubble's law describes this expansion.

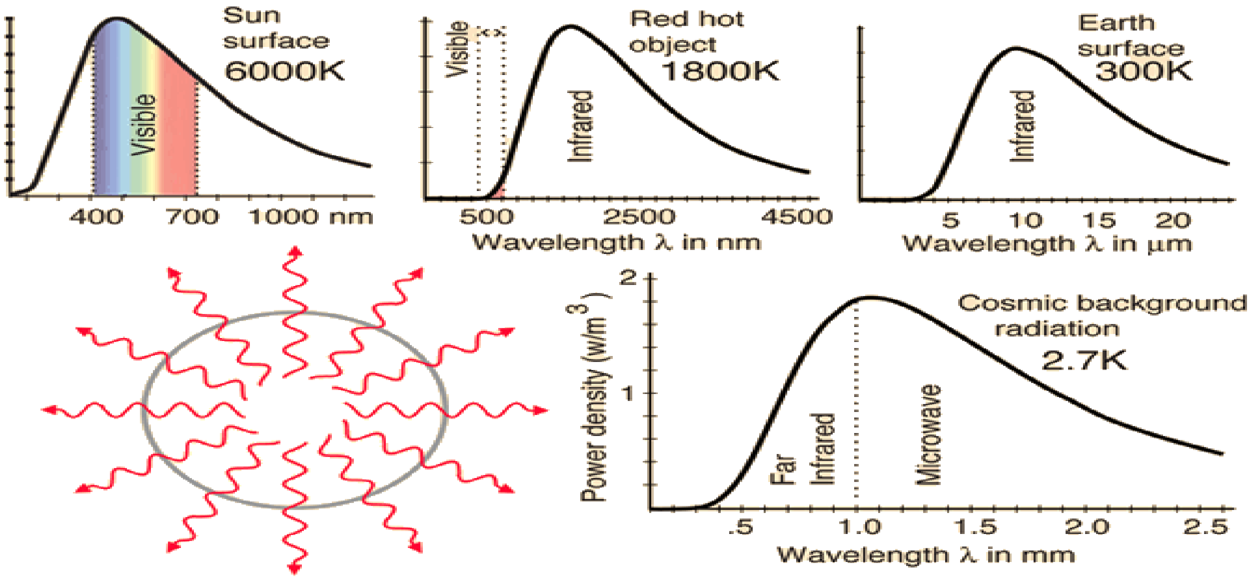
1Mpc= 3.26 million light years which is 9.46 trillion kilometer or 300,000 kilometers distance, light travels in one year or in one second respectively.

H= Hubble constant which describes the rate at which the universe is expanding & expressed as the speed of a galaxy's recession (moving away) divided by its distance.

The fact that we see other galaxies moving away from us does not imply that we are the center of the universe! All galaxies will see other galaxies moving away from them in an expanding universe unless the other galaxies are part of the same gravitationally bound group or cluster of galaxies. A rising loaf of raisin bread is a good visual model: each raisin will see all other raisins moving away from it as the loaf expands.

The fact that the universe is expanding then raises the question "Will it always expand?" Since the action of gravity works against the expansion, then if the density were large enough, the expansion would stop and the universe would collapse in a "big crunch". This is called a *closed universe*. If the density were small enough, the expansion would continue forever. This is called an *open universe*. At a certain precise *critical density*, the universe would asymtotically approach zero expansion rate, but never collapse. Remarkably, all evidences indicate that the universe is very close to the critical density. Discussions about the expansion of the universe often refer to a density parameter Ω which is the density divided by the critical density, such that Ω = 1 represents the critical density condition

2. 3K COSMIC BACKGROUND RADIATION



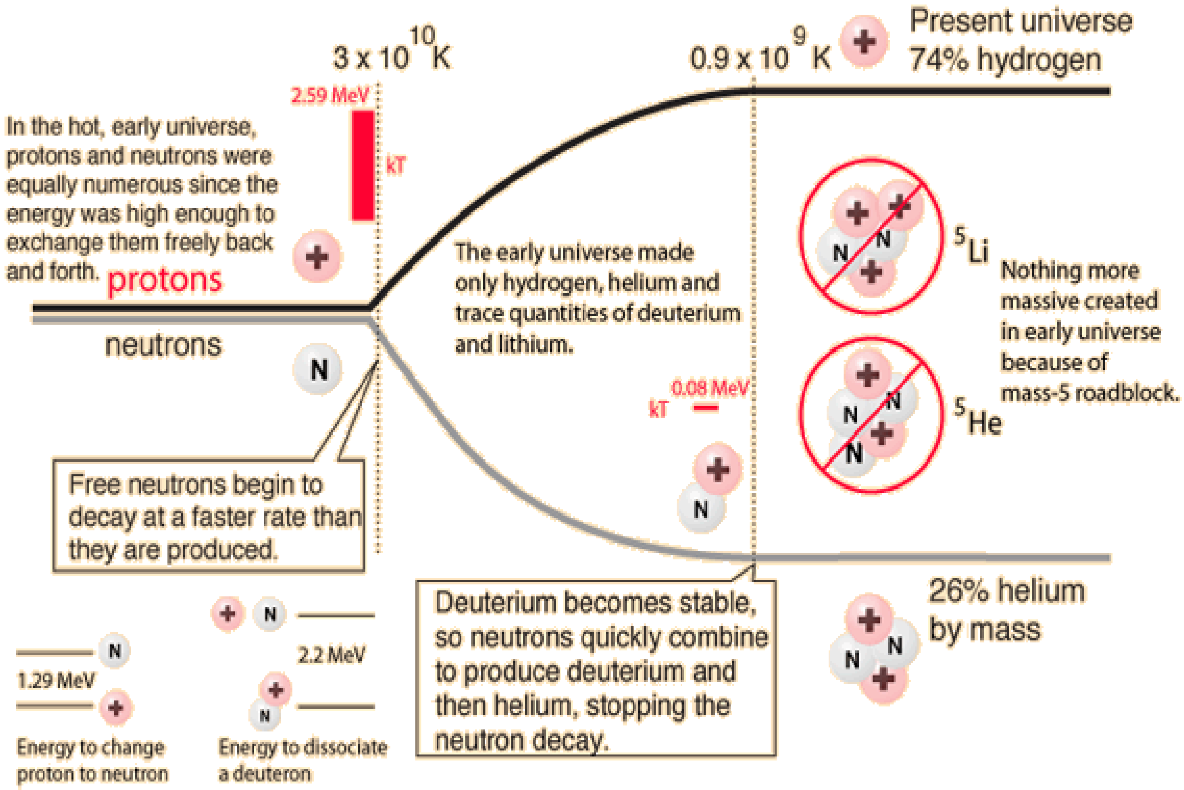
The blackbody radiation is seen as a remnant of the transparency point at which the expanding universe dropped below about 3000K so that radiation could escape.

A uniform background radiation in the microwave region of the spectrum is observed in all directions in the sky. Currently it is commonly called the **3K Cosmic Microwave Background radiation** or just **3K CMBR**, refering to its Wien peak in the microwave region. It shows the wavelength dependence of a "blackbody" radiator at about 3 Kelvins temperature. The discovery of the 3K CMBR was one of the crucial steps leading to the calculation of the standard "Big Bang" model of cosmology. It provides the information on the estimation of relative populations of particles and photons. Research using the Far Infrared Absolute Spectrophotometer (FIRAS) onboard the COBE satellite has given a temperature of 2.725 +/- 0.002 K. Previous experiments had shown some anisotropy of the background radiation due to the motion of the solar system, but COBE collected data showing fluctuations in the background. Some fluctuations in the background are necessary in big bang cosmology to give enough non-uniformity for galaxies to form. The more recent WMAP mission gave a much higher resolution picture of the anisotropies in the 3K CMBR .The precision of the mapping of the 3K CMBR was improved with the Planck satellite, giving the best current values for the descriptive parameters.

The data for the round figure of 10^9 photons per nuclear particle is the "most important quantitative conclusion to be drawn from the measurements of 3K CMBR ..."(Weinberg p66-70). This allowed the conclusion that galaxies and stars could not have started forming until the temperature dropped below 3000K. Then atoms could form and remove the opacity of the expanding universe; light could get out and relieve the radiation pressure. Star and galaxy formation could not occur until clouds of gas overcome a critical "Jean's mass" which is the minimum mass a cloud of gas must have for gravity to overcome radiation pressure to cause a cloud to collapse and potentially to form stars and galaxies. With atom formation and a transparent universe, the Jeans mass dropped to about 10^{-6} the mass of a galaxy, allowing gravitational clumping, which is the process where gravity causes matter to be drawn together and accumulate, leading to the formation of dense regions or clumps. This is the fundamental mechanism in the formation of structures in the universe, like stars and galaxies, as well as smaller objects like planetesimals.

3. HYDROGEN-HELIUM ABUNDANCE

Hydrogen and helium account for nearly all the nuclear matter in today's universe. This is consistent with "big bang" model. The process of forming the hydrogen and helium and other trace constituents is often called "big bang nucleosynthesis". Schramm's figures for relative abundances indicate that helium is about 25% by mass and hydrogen about 73% with all other elements constituting less than 2%. Carroll & Ostlie give 23 to 24% helium. There is a window of uncertainty, but it is clear that hydrogen and helium make up 98% plus of the ordinary matter in the universe. This high percentage of helium argues strongly for the Big Bang model, since other models gave a very small percentage of helium. Since there is no known process that significantly changes this percentage, it is taken to be the percentage that existed at the time when the deuteron became stable in the expansion of the universe. This percentage is significant as a test of cosmological models. Basically, the hydrogen-helium abundance helps us to model the expansion rate of the early universe. If it had been faster, there would be more neutrons and more helium. If it had been slower, more of the free neutrons would have decayed before the deuterium stability point and there would be less helium.



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Dr. Rudraswamy.B

Professor (retired), Dept. of Physics

Bangalore University, Bengaluru 560056

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WHO WAS ALHAZEN?

His full name was, Abu Ali Al Hasan Ibn Al Haytham. But in the literature, he is usually referred to as “Alhazen”. He lived in a place named Basra in what is now Iraq during the time, which is somewhat of mid- period of the Middle Ages. Historians put his period approximately as 965 to 1038. There are many versions of his biography. I am presenting here one version in which I cannot be sure of its authenticity either in its parts or in its fullness. What is important for us as Physicists is the end part in this story.

The story begins as follows; he seems to be a mischievous guy, notorious in playing tricks. During his time, Basra was under the Egyptian ruler, a Caliph, named ‘Al Hakim’. Al Hakim used to face a formidable problem frequently. The problem was as below.

The great river Nile, flows through Egypt in its final part of the journey where it discharges into the Mediterranean Sea. Though Nile is the primary water source for Egypt, its flash floods were the cause of great misery for the Egyptians and was also naturally a headache for Al Hakim. Our man Alhazen wanted to make use of the situation by falsely claiming that, he can devise a machine when placed in the river Nile, would regulate the flow so that, there would never be any flash floods. Somehow he made his claim reach the notice of the king and the king trusted him and employed him on a salary to do the great job. Alhazen Started enjoying a regular salary without doing anything. Days passed, months rolled and nothing tangible really was appearing (obviously) and disasters due to flash flood continued as usual. It didn’t take long for the Caliph to realize that, Alhazen has taken him for a ride. Realizing that he had been tricked, he became furious. Alhazen had played not just a dirty trick but a dangerous one indeed. What it means of falling into the anger of the Calipha?! That too facing an angry Al Hakim is the ultimate of its type. In the history of the world, two kings are well known for their ghastly cruelty. One was the Roman emperor ‘Caligula’ (AD from 12 to 41) and the other one was the Russian emperor ‘Ivan the Terrible’ (1530 – 1584). In the time in between these two, if there was any king known for his cruelty, it was Al Hakim. Furious Al Hakim ordered Alhazen that the machine be built at once, if not, he would put Alhazen to death in some complicated fashion! Now Alhazen realized the intensity of the problem that he had drawn upon himself by playing a terrible trick on the Calipha. But this trickster went on to play the next trick! He started acting that he had gone mad! It was not an easy trick but it worked nevertheless. When the king got the news that Alhazen has gone totally mad, he thought it was quite useless to deal with this case any further and better to ignore the mad man.

Day in and day out Alhazen was to keep up his show of madness year after year till Al Hakim died in 1021. Perhaps, Alhazen’s madness persisted for nearly 20 years! However, his agile mind was not idle at all during this period of his disguise. He has been able to focus his mind on many things of far-reaching importance in Physics. After the time of Al Hakim, when Alhazen could afford to be sane during the rest of his life, he furthered his investigations analytically and arrived at conclusions of far reaching importance that propelled Physics farther to a great distance. We know that, during medieval ages, the progress of knowledge had come to a standstill for inexplicable reasons. In those days of darkness, there used to be some glimmers now and then showing up largely in the middle east. Practically it was just the Arabs who were in a position to contribute to the progress of knowledge. Among them, Alhazen was the bright torch that radiated light in the dead of darkness. His path-breaking discoveries were so great that, he became the most important physicist of the entire medieval period. In essence, he was the physicist over a thousand years.

Until the time of Alhazen, people believed world-wide that, things cannot be seen by our eyes merely when light falls upon them. People thought that, after the object is illuminated by a light source, in order that it could be seen by a person, a kind of rays starting from the eyes of the viewing person should also be incident on the illuminated object (this proposition is believed to have been made by the Greek philosopher Plato). Perhaps this was due to the fact that, there were many who couldn't see despite having the normal eyes (actually there was no lens in their pupil and people were not aware of the presence of such a biological lens). Since People were not able to understand why they can't see, they reasoned out that, eyes of such a person was incapable of emitting those rays. If a person could see an illuminated object, it's because, these rays starting from the eyes were also incident on the same object. Came along with this idea, the concept of evil eyed persons the rays from whose eyes would spoil the food when they look at it, cause bad things like attack of fever to a baby when the baby was seen by such people etc.,.

People also believed that, the magnification they see by looking through a lens and the distortion of the image seen in concave and convex mirrors were all due to the little imps living in the lens and mirrors.

Alhazen explained that, magnifications/distortions are caused due to the curvatures of the surfaces and not because of any inherent property of the substance making it up. He also discussed about the formation of the rainbow.

He was of the basic view that, we have the sight of an object because of the light reflected by its illumination. He is said to have constructed parabolic mirrors (we know, parabolic mirrors have the capability of bringing into point focus an incident beam of parallel rays).

It's incredible that he said, above the earth we have an atmosphere of a certain height and even estimated it to a distance in his own way (that works out to some 10 miles) beyond which the atmosphere doesn't exist. It's great!

During the Renaissance period, his work was translated into Latin and also published and propagated across Europe. It even influenced Kepler

Listening to Dr. Salam's speech, I understood that Alhazen had investigated and analyzed the concept of atoms.

Dr. S.P. Basavaraju
Professor of Physics (retd.), BIT, Bengaluru

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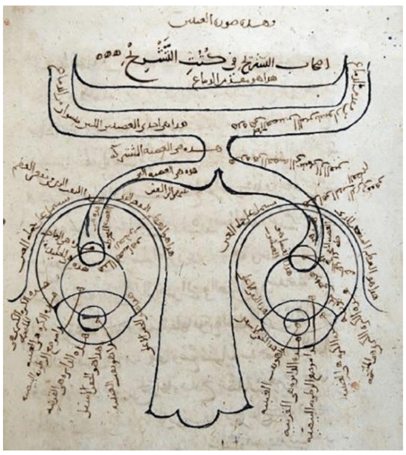

The structure of the human eye according to Ibn al-Haytham, late 11th century

SHOULD WE TRUST OUR SENSES?

Should we believe what we see? At first glance, it seems reasonable. After all, "seeing is believing"—or so the saying goes. But what if our senses are only showing us part of the truth? What if what we see is not what is, but what was?

Take a moment to look up at the night sky. With the naked eye, you can see hundreds of stars twinkling above. You may be witnessing them as they are right now. But in reality, you're seeing those stars as they were in the past.

Light does not travel instantaneously—it moves at a finite speed: approximately 299,792 kilometers per second. When an object emits or reflects light, that light travels outward in all directions. A tiny fraction of it eventually reaches your eyes, allowing you to see the object. But because light takes time to travel, there is always a delay between the moment light leaves the object and the moment it reaches you. This means you are always looking at things as they were, not as they are.

For example, if you are observing a star that is a hundred light-years away, you are seeing how that star looked a hundred years ago. In the time it took for its light to reach you, that star could have changed dramatically—or even ceased to exist. In this sense, some of the stars we see in the sky today may already be dead. We are looking at the light of something that no longer exists. Some stars, then, are like ghosts—faint echoes of the past still shining in the present.

This phenomenon is not limited to far-off celestial bodies. Even when you look in a mirror, you're not seeing your reflection in real-time. The light takes a few microseconds to travel from your face to the mirror and back to your eyes. It's an imperceptible delay, but a delay nonetheless.

The Moon is about one light-second away from Earth. So, when you look at the Moon, you are seeing it as it was one second ago. The Sun is roughly eight light-minutes away, which means that every time you look at it, you're witnessing the Sun as it was eight minutes in the past.

All of this leads to a fascinating and somewhat unsettling realization: we are always living in the past—or at least perceiving it. Our senses, limited by the speed of light, cannot show us the absolute present. When you look at an object, you are not truly seeing the object itself. You are seeing the light that reflects off of it and enters your eyes. Consider a white cup on a table. Under white light, it appears white. Under a red light, it appears red. Shine blue light on it, and it looks blue. So, what is the real colour of the cup?

The answer: it has no fixed colour. An object appears a certain colour based on the light it reflects and the sensitivity of the observer's eyes. Human eyes are sensitive only to the visible part of the electromagnetic spectrum, which is a very narrow slice. Other creatures perceive the world differently—bees can see ultraviolet light, and snakes can detect infrared. To them, the cup might appear entirely different, or even glow in ways we cannot comprehend. So, is there an absolute, "true" colour of the cup? No. Colour is not a property of the object itself; it is a perception created by the interaction of light and the observer. It exists only in the mind of the beholder.

Descartes wanted to find a foundation for knowledge so solid that it could not be doubted. So, he began by questioning everything. He noticed that our senses can deceive us. Optical illusions, dreams, and hallucinations—all prove that seeing is not always believing. He asked, "What if everything I perceive is false?" He even imagined a powerful evil demon that could be tricking him into believing in a false world, much like a simulation. So, what cannot be doubted? His conclusion: “I think, therefore I am.” Even if everything else is false, the very act of questioning or thinking proves that there is a mind thinking. That is the one truth he could be sure of. Our senses might be lying. The only thing we can be certain of is that we are conscious beings—thinkers.

Plato uses a metaphorical story to illustrate how our perception of reality can be flawed if it's based solely on what we see. Imagine a group of people who have been imprisoned in a dark cave since birth. They are chained in such a way that they can only look at the wall in front of them. Behind them is a fire, and between the fire and the prisoners is a walkway where objects are moved. These objects cast shadows on the wall in front of the prisoners.

Because the prisoners have never seen anything else, they believe these shadows are reality. One prisoner escapes and leaves the cave. At first, the sunlight blinds him, but eventually he sees the real world—objects, the sun, and reality itself.
He realizes the shadows were mere illusions. If he returns to the cave to free the others, they will not believe him. They will think he is deluded.

Most people live their lives, mistaking shadows for reality. Our senses give us a limited, distorted view of the world. True understanding comes not just from seeing, but from questioning and seeking deeper truths.

Ajay S.
Research scholar,Dept. of Physics
MS Ramaiah University of Applied Sciences, Bengaluru

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A Cup of Coffee and the Confused Scientist

Once, a famous scientist walked into his lab, completely lost in thought. His assistant handed him a steaming cup of coffee.
The scientist took a sip and immediately made a face.
"Ugh! This tastes terrible. Did you forget the sugar?"
The assistant replied, “Sir… that’s your sample for today’s chemical experiment. Your real coffee is on the other table.”
The scientist paused, blinked, and said,
“Well… I suppose this proves that appearances — and aromas — can be deceiving!”

Moral of the story

Just because something looks, smells, or even tastes right… doesn’t always mean it is! That’s why science tests, measures, and questions — because our senses sometimes play practical jokes on us!

ಉಪಗ್ರಹಗಳಲ್ಲಿ ಸಂವೇದಕಗಳು

ಇಸ್ರೋದ ಚಂದ್ರಯಾನ-3 ಯೋಜನೆ ಭಾರತದ ಹಿರಿ-ಕಿರಿಯರಲ್ಲಿ ಬಾಹ್ಯಾಕಾಶ ಅನ್ವೇಷಣೆಗಳ ಬಗ್ಗೆ ವಿಶೇಷ ಕುತೂಹಲ ಮೂಡಿಸಿದೆ. ಚಂದ್ರಯಾನ-3 ಉಪಗ್ರಹದಿಂದ ಬೇರ್ಪಟ್ಟ ವಿಕ್ರಮ್ ಲ್ಯಾಂಡರ್ ಚಂದ್ರನನ್ನು ಸ್ಪರ್ಶಿಸುತ್ತಿದ್ದಂತೆ ಭಾರತವು, ಚಂದ್ರನ ದಕ್ಷಿಣ ಧ್ರುವದ ಸಮೀಪದಲ್ಲಿ ಇಳಿದು, ವಿಶಿಷ್ಟ ಸಾಧನೆ ಮಾಡಿದ ಮೊದಲ ದೇಶವಾಯಿತು. ಹೌದಲ್ಲವೇ.. ಅದೊಂದು ಕ್ಲಿಷ್ಟಕರವಾದ ಕೆಲಸ… ಇಷ್ಟು ಕರಾರುವಾಕ್ಕಾಗಿ ಚಂದಿರನ ಅಂಗಳದಲ್ಲಿ ಇಳಿಯಲು ಹೇಗೆ ಸಾಧ್ಯವಾಯಿತು? ಈ ಕೆಲಸದಲ್ಲಿ ವಿಕ್ರಮ್ ಲ್ಯಾಂಡರನಲ್ಲಿ ಅಳವಡಿಸಿರುವ ಗಣಕಯಂತ್ರವು ವಿವಿಧ ಉಪಕರಣಗಳು ನೀಡುವ ಪಥ ಸಂಚಲನೆ ಮಾಹಿತಿಯನ್ನು ವಿಶ್ಲೇಷಿಸಿ ಇಳಿಯ ಬೇಕಾದ ಜಾಗ, ಅದು ಇರುವ ದೂರ, ವೇಗ ಎಷ್ಟಿರಬೇಕು ಮತ್ತಿತರ ಮಾಹಿತಿಗಳನ್ನು ಕ್ರೂಢೀಕರಿಸಿ ಸುರಕ್ಷಿತವಾಗಿ ಇಳಿಯುವಂತೆ ಮಾರ್ಗದರ್ಶನ ನೀಡಿತು. ವಿಕ್ರಮ್ ಲ್ಯಾಂಡರನಲ್ಲಿ ಇರುವ ವಿವಿಧ ಉಪಕರಣಗಳು ಸಂವೇದನೆಯ ಮೂಲಕ ನೀಡುವ ಮಾಹಿತಿಯು, ಪಥ ನಿರ್ದೇಶನ ಮತ್ತು ನಿರ್ವಹಣೆ ಕಾರ್ಯದಲ್ಲಿ ಬಹುಮುಖ್ಯ ಪಾತ್ರ ವಹಿಸಿತು. ಇದೇ ರೀತಿ ಚಂದ್ರಯಾನ-3 ಭೂಮಿಯಿಂದ ಬಾನಿಗೆ ಚಿಮ್ಮಿ ಬಾಹ್ಯಾಕಾಶದಲ್ಲಿ ಅನೇಕ ದಿನಗಳ ಕಾಲ ಚಲಿಸಿ ಚಂದಿರನ ಬಳಿ ತಲುಪುವವರೆಗೆ ಮತ್ತು ಚಂದಿರನ ಸುತ್ತ ಸುತ್ತುವಾಗ ಸರಿಯಾದ ಪಥ-ಸ್ಥಾನ-ಸ್ಥಿತಿಯಲ್ಲಿ ಇರುವಂತೆ ನೋಡಿಕೊಳ್ಳುವಲ್ಲಿ ಅನೇಕ ಸಂವೇದಕಗಳು ನೀಡುವ ಸೂಚನೆಗಳು ಮಹತ್ತರವಾದ ಪಾತ್ರ ವಹಿಸಿವೆ.

ಈ ಲೇಖನದಲ್ಲಿ ಉಪಗ್ರಹದ ಸ್ಥಾನ-ಸ್ಥಿತಿ, ಉಪಗ್ರಹದ ಅಕ್ಷಗಳು, ಉಪಗ್ರಹದಲ್ಲಿ ಸಂವೇದಕಗಳು ಏಕೆ ಬೇಕು ಮತ್ತು ಉಪಗ್ರಹದಲ್ಲಿ ಯಾವ ಯಾವ ಸಂವೇದಕಗಳನ್ನು ಅಳವಡಿಸಿರುತ್ತಾರೆ ಎನ್ನುವುದನ್ನು ತಿಳಿದುಕೊಳ್ಳೋಣ.

ಉಪಗ್ರಹ

ಯಾವುದೇ ಒಂದು ಗ್ರಹದ ಸುತ್ತ ಸುತ್ತುವ ಆಕಾಶಕಾಯವನ್ನು ಉಪಗ್ರಹವೆಂದು ಕರೆಯುತ್ತಾರೆ. ಚಂದ್ರನು ಭೂಮಿಯ ನೈಸರ್ಗಿಕ ಉಪಗ್ರಹ. ಮಾನವ ನಿರ್ಮಿತ ಆಕಾಶಕಾಯಗಳು **1957** ರಿಂದ ಭೂಮಿ ಮತ್ತಿತರ ಕೆಲವು ಗ್ರಹಗಳ ಸುತ್ತ ಸುತ್ತಲು ಆರಂಭಿಸಿದವು. ಇವುಗಳನ್ನು ಕೃತಕ ಉಪಗ್ರಹಗಳೆಂದು ಕರೆಯುತ್ತಾರೆ. ಆದರೆ ಈ ಲೇಖನದಲ್ಲಿ ಕೃತಕ ಉಪಗ್ರಹಗಳನ್ನು 'ಉಪಗ್ರಹ'ಗಳೆಂದೇ ಕರೆಯಲಾಗಿದೆ. ಉಪಗ್ರಹಗಳು ನೀಡುವ ಅನೇಕ ಮಾಹಿತಿಗಳು, ನಮಗೆ ಗೊತ್ತಿಲ್ಲದಂತೆ, ದಿನ ನಿತ್ಯದ ವಿವಿಧ ಉದ್ದೇಶಗಳಿಗೆ ಬಳಕೆಯಾಗುತ್ತಿವೆ. ದೂರಸಂಪರ್ಕ, ದೂರದರ್ಶನ, ಹವಾಮಾನದ ಸ್ಥಿತಿ-ಗತಿ, ಸಮುದ್ರದಲ್ಲಿರುವ ಜಲಚರಗಳ ಮಾಹಿತಿ, ಭೂ ಸಂಪನ್ಮೂಲಗಳ ಮಾಹಿತಿ…. ಒಂದೇ, ಎರಡೇ….ಇವೆಲ್ಲವುಗಳು ಉಪಗ್ರಹಗಳ ಮೂಲಕ ನಮ್ಮನ್ನು ತಲುಪುತ್ತವೆ. ಇದಲ್ಲದೆ ಉಪಗ್ರಹಗಳು ವಿವಿಧ ವೈಜ್ಞಾನಿಕ ಅನ್ವೇಷಣೆಗಳಿಗೂ ಬಳಸಲ್ಪಡುತ್ತಿವೆ. ಅವುಗಳು ನೀಡುವ ಹೊಸ ಹೊಸ ಮಾಹಿತಿಗಳು ವಿಶ್ವದ ಬಗ್ಗೆ ನಮಗೆ ಗೊತ್ತಿರದ ಅನೇಕ ವಿಷಯಗಳ ಬಗ್ಗೆ ಅರಿವು ಮೂಡಿಸುತ್ತಿದೆ. ಈ ಎಲ್ಲ ಮಾಹಿತಿಗಳನ್ನು ಪಡೆಯಲು ವಿವಿಧ ರೀತಿಯ ಉಪಕರಣಗಳನ್ನು ಹೊತ್ತೊಯ್ದ ಉಪಗ್ರಹಗಳು ವಿವಿಧ ಕಕ್ಷೆಗಳಲ್ಲಿ ಸುತ್ತುತ್ತಿರಬೇಕು, ಪೂರ್ವ ನಿರ್ಧಾರಿತವಾದಷ್ಟು ವಾಲಿರಬೇಕು, ಭೂಮಿ, ಇತರ ಗ್ರಹಗಳು ಅಥವಾ ಮತ್ತಿತರ ಆಕಾಶಕಾಯಗಳನ್ನು ಸದಾಕಾಲ ನೋಡುತ್ತಿರಬೇಕು. ಇಷ್ಟೆಲ್ಲಾ ಇದ್ದಾಗ ಮಾತ್ರ ನಿಖರವಾದ ಮಾಹಿತಿಗಳು ನಮಗೆ ಸಿಗುತ್ತವೆ. ಉಪಗ್ರಹಗಳು ಸ್ವಲ್ಪ ಆ ಕಡೆ-ಈ ಕಡೆ ಕದಲಿದರೂ, ಸ್ಥಾನ ಪಲ್ಲಟವಾದರೂ ನಮಗೆ ತಲುಪಬೇಕಾದ ಮಾಹಿತಿ ತಲುಪಲು ಸಾಧ್ಯವಾಗುವುದಿಲ್ಲ.

ಹಾಗಾದರೆ ಬಾಹ್ಯಾಕಾಶದ ನಿರ್ವಾತದಲ್ಲಿ ಯಾವುದೇ ಉಪಗ್ರಹಗಳು ಅವುಗಳಿಗೆ ನಿಗದಿಪಡಿಸಿದ ನಿರ್ದಿಷ್ಟ ಸ್ಥಾನ-ಸ್ಥಿತಿಯಲ್ಲಿ ಹೇಗಿರುತ್ತವೆ? ಹೌದು… ಈ ಕೆಲಸಕ್ಕಾಗಿ ಅವುಗಳಲ್ಲಿ ಸಂವೇದಕಗಳೆಂಬ 'ಕಿವಿ-ಕಣ್ಣು'ಗಳನ್ನು ಅಳವಡಿಸಿರುತ್ತಾರೆ! ನಿಮಗೆಲ್ಲ ಗೊತ್ತೇ ಇದೆ.. ನಮ್ಮ ಸುತ್ತ-ಮುತ್ತಲಿನ ವಿಷಯವನ್ನು ಅರಿಯುವಲ್ಲಿ ನಮ್ಮ ಇಂದ್ರಿಯಗಳು ಬಹುಮುಖ್ಯ ಪಾತ್ರ ವಹಿಸುತ್ತವೆ. ಪಂಚೇಂದ್ರಿಯಗಳಾದ ಕಣ್ಣು, ಕಿವಿ, ಮೂಗು, ನಾಲಿಗೆ ಮತ್ತು ಚರ್ಮ ನಮಗೆ ವಿವಿಧ ರೀತಿಯ ಸಂವೇದನೆಗಳನ್ನು ನೀಡುತ್ತವೆ. ಕಣ್ಣಿನ ಮೂಲಕ ನೋಡುತ್ತೇವೆ, ಕಿವಿಯ ಮೂಲಕ ಕೇಳುತ್ತೇವೆ, ಮೂಗಿನ ಮೂಲಕ ವಾಸನೆ ಗ್ರಹಿಸುತ್ತೇವೆ, ನಾಲಿಗೆಯ ಮೂಲಕ ರುಚಿಯನ್ನು ಆಸ್ವಾದಿಸುತ್ತೇವೆ ಮತ್ತು ಚರ್ಮದ ಮೂಲಕ ಸ್ಪರ್ಶ ಜ್ಞಾನವನ್ನು ಪಡೆಯುತ್ತೇವೆ. ಕಣ್ಣು ಮತ್ತು ಕಿವಿಗಳು ಬೆಳಕು ಮತ್ತು ಶಬ್ದಗಳನ್ನು ಗ್ರಹಿಸುವ ಮೂಲಕ ದೂರಸಂವೇದಕಗಳಾಗಿ ಕೆಲಸ ನಿರ್ವಹಿಸುತ್ತವೆ. ನಾವು ಹೇಗೆ ನಮ್ಮ ಇಂದ್ರಿಯಗಳ ಮೂಲಕ ಸಂವೇದನೆಯನ್ನು ಪಡೆದು ಅದಕ್ಕನುಗುಣವಾಗಿ ಕಾರ್ಯ ನಿರ್ವಹಿಸುತ್ತೇವೆಯೋ ಅದೇ ರೀತಿ ಉಪಗ್ರಹಗಳ ಅನೇಕ ಚಟುವಟಿಕೆಗಳು ಕೂಡಾ ಅವುಗಳಲ್ಲಿ ಅಳವಡಿಸಿರುವ ವಿವಿಧ ಸಂವೇದಕಗಳು ನೀಡುವ ಮಾಹಿತಿಗಳನ್ನು ಆಧರಿಸಿರುತ್ತವೆ.

ಸಂವೇದಕಗಳು ಎಂದರೇನು?: ಯಾವುದೇ ಒಂದು ಭೌತಿಕ ಪರಿಮಾಣವನ್ನು ಅಳೆದು ಅದನ್ನು ಓದಬಲ್ಲ ಸಂಕೇತವಾಗಿ ಮಾರ್ಪಡಿಸುವ ಪರಿವರ್ತಕಗಳನ್ನು ಸಂವೇದಕಗಳೆಂದು ಕರೆಯಬಹುದು. ಸಂವೇದಕಗಳು ಉತ್ಪಾದಿಸುವ ಸಂಕೇತಗಳು ಅಥವಾ ಅವುಗಳು ಪಡೆಯುವ ಶಕ್ತಿ ಮೂಲಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ಅವುಗಳನ್ನು ಆರು ವಿಧವಾಗಿ ವಿಂಗಡಿಸಬಹುದು. 1] ಯಾಂತ್ರಿಕ (mechanical) ಸಂವೇದಕ, 2] ಉಷ್ಣ (thermal) ಸಂವೇದಕ, 3] ವಿದ್ಯುತ್ (electric) ಸಂವೇದಕ, 4] ಕಾಂತೀಯ (magnetic) ಸಂವೇದಕ, 5] ವಿಕಿರಣ (radiation) ಸಂವೇದಕ ಮತ್ತು 6] ರಾಸಾಯನಿಕ

(chemical) ಸಂವೇದಕ. ಸಂವೇದಕಗಳು ಭೌತಿಕ ಪರಿಮಾಣವನ್ನು ಅಳೆಯುವುದರ ಹೊರತಾಗಿ ಅವುಗಳನ್ನು ದಾಖಲಿಸುವ, ಸೂಚಿಸುವ ಮತ್ತು ಅವುಗಳಿಗೆ ಪ್ರತಿಕ್ರಿಯಿಸುವ ಸಾಮರ್ಥ್ಯವನ್ನೂ ಹೊಂದಿರುತ್ತವೆ. ದಿನನಿತ್ಯ ನಮಗೆ ಗೊತ್ತಿಲ್ಲದಂತೆ ಹಲವಾರು ಸಂವೇದಕಗಳನ್ನು ನಾವು ಬಳಸುತ್ತೇವೆ. ಉದಾಹರಣೆಗೆ: ಉಷ್ಣತಾಮಾಪಕ, ತೂಕ ಅಳೆಯುವ ಯಂತ್ರ, ದಿಕ್ಸೂಚಿ ಇತ್ಯಾದಿ.

ಉಪಗ್ರಹಗಳ ಸ್ಥಾನ-ಸ್ಥಿತಿ (attitude) ಎಂದರೇನು?: ಸಾಮಾನ್ಯವಾಗಿ ಗಗನನೌಕೆಯ ಚಲನೆ ಮತ್ತು ಅದು ತನ್ನ ಅಕ್ಷದ ಸುತ್ತ ತಿರುಗುವುದನ್ನು ಅದರ ಸ್ಥಾನ, ವೇಗ ಮತ್ತು ವಾಲುವಿಕೆಯ ಮೂಲಕ ನಿರ್ಧರಿಸಲಾಗುತ್ತದೆ. ಬಾಹ್ಯಾಕಾಶದಲ್ಲಿ ಒಂದು ಉಪಗ್ರಹ ಯಾವ ಸ್ಥಾನ ಮತ್ತು ಸ್ಥಿತಿಯಲ್ಲಿ ಇದೆ ಎಂದು ತಿಳಿದುಕೊಳ್ಳುವುದು ಅವುಗಳ ಕಾರ್ಯನಿರ್ವಹಣೆಯಲ್ಲಿ ಬಹು ಮುಖ್ಯವಾಗಿದೆ. ಆಂಗ್ಲ ಭಾಷೆಯಲ್ಲಿ ಇದನ್ನು satellite attitude determination ಎಂದು ಹೇಳುತ್ತಾರೆ. ಶಬ್ದಕೋಶದಲ್ಲಿ attitude ಶಬ್ದಕ್ಕೆ 'ಪ್ರವೃತ್ತಿ' ಎನ್ನುವ ಅರ್ಥವಿದೆ. ಆದರೆ ಈ ಶಬ್ದಾರ್ಥವು ಭೂಮಿಯಲ್ಲಿನ ವಸ್ತುಗಳಿಗೆ ಹೆಚ್ಚು ಸಮಂಜಸವಾಗಿದೆ. ಆದರೆ ಬಾಹ್ಯಾಕಾಶದಲ್ಲಿರುವ ಗಗನನೌಕೆಗಳಿಗೆ 'ಸ್ಥಾನ-ಸ್ಥಿತಿ' ಎನ್ನುವ ಶಬ್ದವು ಹೆಚ್ಚು ಸೂಕ್ತವಾಗಿರುವುದರಿಂದ ಈ ಹೊತ್ತಿಗೆಯಲ್ಲಿ ಅದನ್ನೇ ಬಳಸಲಾಗಿದೆ.

ಉಪಗ್ರಹಗಳಲ್ಲಿ ಸಂವೇದಕಗಳು ಏಕೆ ಬೇಕು?

ಉಡಾವಣಾ ವಾಹನದ (ರಾಕೆಟ್) ಮೂಲಕ ಅಂತರಿಕ್ಷದೆಡೆಗೆ ಪಯಣ ಆರಂಭಿಸುವ ಉಪಗ್ರಹದ ಪ್ರತಿಯೊಂದು ಹಂತದ ಕಾರ್ಯಾಚರಣೆಯ ಬಗ್ಗೆ ಮಾಹಿತಿ ನೀಡಲು

ಉಡಾವಣಾ ವಾಹಕದಿಂದ ಬೇರ್ಪಟ್ಟ ನಂತರ ಉಪಗ್ರಹವನ್ನು ನಿಗದಿತ ಕಕ್ಷೆಗೆ ಸೇರಿಸಲು

ಉಪಗ್ರಹದಲ್ಲಿ ಅಳವಡಿಸಿರುವ ವಿವಿಧ ಉಪಕರಣಗಳ ಮೂಲಕ ಭೂಮಿ ಅಥವಾ ಇತರ ಆಕಾಶಕಾಯಗಳ ಮಾಹಿತಿ ಪಡೆದುಕೊಳ್ಳಲು

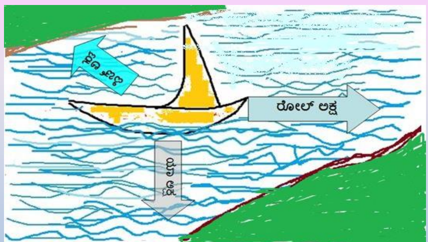
ಉಪಗ್ರಹದ ಜೀವಿತಾವಧಿಯವರೆಗೆ ಬೇರೆ-ಬೇರೆ ಕಾರ್ಯ ನಿರ್ವಹಿಸಲು

ಉಪಗ್ರಹದ ಸ್ಥಾನ-ಸ್ಥಿತಿ ಮತ್ತು ಆರೋಗ್ಯದ (ಉಷ್ಣತೆ, ಒತ್ತಡ) ಬಗ್ಗೆ ಅರಿಯುಲು.

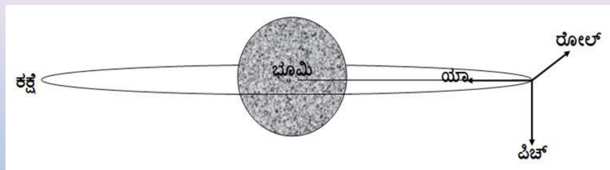
ಉಪಗ್ರಹದಲ್ಲಿನ ಸಂವೇದಕಗಳ ಬಗ್ಗೆ ವಿವಿರವಾಗಿ ತಿಳಿದುಕೊಳ್ಳುವುದಕ್ಕೂ ಮೊದಲು, ಉಪಗ್ರಹಗಳ ಅಕ್ಷಗಳು, ಅವುಗಳ ಸ್ಥಾನ-ಸ್ಥಿತಿಯನ್ನು ನಿರ್ಧರಿಸುವ ಬಗ್ಗೆ, ಕೆಲವು ಮಾಹಿತಿಗಳನ್ನು ಸಂಕ್ಷಿಪ್ತವಾಗಿ ತಿಳಿದುಕೊಳ್ಳೋಣ.

ಉಪಗ್ರಹದ ಅಕ್ಷಗಳು: ನಿಮಗೆಲ್ಲ ಗೊತ್ತೇ ಇದೆ.... ನಾವು ಭೂಮಿಯ ಮೇಲೆ ಸಾಮಾನ್ಯವಾಗಿ ಯಾವುದೇ ವಸ್ತುವಿನ ಸ್ಥಾನವನ್ನು ಗುರುತಿಸುವಾಗ ಎಕ್ಸ್ (x), ವೈ (y) ಮತ್ತು ಝಡ್ (z) ಎಂಬ ಮೂರು ನಿರ್ದೇಶಾಂಕಗಳನ್ನು ಬಳಸುತ್ತೇವೆ. ಇದೇ ರೀತಿ ಬಾಹ್ಯಾಕಾಶದಲ್ಲಿರುವ ಉಪಗ್ರಹವನ್ನು ಗುರುತಿಸಲು ಮೂರು ಅಕ್ಷಗಳಾದ ಯಾ (yaw), ರೋಲ್ (roll) ಮತ್ತು ಪಿಚ್ (pitch) ಗಳನ್ನು ಬಳಸಲಾಗುತ್ತದೆ. ಇವುಗಳನ್ನು ಅನುಕ್ರಮವಾಗಿ ವಿಚಲನಾಕ್ಷ, ಸುತ್ತುವ ಅಕ್ಷ, ಮತ್ತು ಸ್ಥಾನಾಕ್ಷ ಎಂದು ಕರೆಯಬಹುದು.

ಈ ಮೂರು ಅಕ್ಷಗಳ ಬಗ್ಗೆ ತಿಳಿದುಕೊಳ್ಳಲು ನದಿಯ ಒಂದು ದಡದಿಂದ ಇನ್ನೊಂದು ದಡದೆಡೆಗೆ ಸಾಗುತ್ತಿರುವ ದೋಣಿಯನ್ನು ಉದಾಹರಣೆಯಾಗಿ ತೆಗೆದುಕೊಳ್ಳೋಣ (ಚಿತ್ರ-1). ದೋಣಿ ಸಾಗುತ್ತಿರುವ ದಿಕ್ಕು ರೋಲ್ ಅಕ್ಷಕ್ಕೆ ಸಮವಾಗಿರುತ್ತದೆ. ದೋಣಿ ಸಾಗುತ್ತಿರುವಾಗ ದಿಕ್ಕನ್ನು ಬದಲಿಸಬೇಕಾದಾಗ ಗಣನೆಗೆ ಬರುವ ಅಕ್ಷವೇ 'ಯಾ' ಅಕ್ಷ. ಈ ಅಕ್ಷವು ದೋಣಿಯ ತಳದಿಂದ ನದಿಯ ಆಳದೆಡೆಗೆ ಮುಖ ಮಾಡಿರುತ್ತದೆ. ದಡದಿಂದ ದೋಣಿಯನ್ನು ಸೇರಿಸುವ ರೇಖೆಯು ಪಿಚ್ ಅಕ್ಷವಾಗಿರುತ್ತದೆ. ಭೂಮಿಯನ್ನು ಸುತ್ತುವ ಉಪಗ್ರಹದ ಅಕ್ಷಗಳನ್ನು ಚಿತ್ರ-2 ರಲ್ಲಿ ಗಮನಿಸಬಹುದು.



ಚಿತ್ರ-1: ನದಿಯಲ್ಲಿ ಸಾಗುತ್ತಿರುವ ಹಾಯಿ ದೋಣಿ



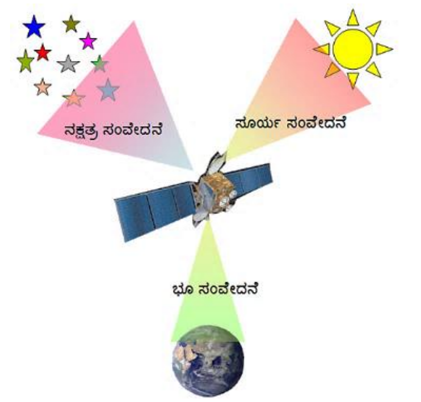
ಚಿತ್ರ-2: ಉಪಗ್ರಹದ ಅಕ್ಷಗಳು

ಯಾ (ವಿಚಲನಾಕ್ಷ): ಭೂ ಕೇಂದ್ರ ಮತ್ತು ಉಪಗ್ರಹವನ್ನು ಜೋಡಿಸುವ ರೇಖೆಯು ಯಾ ಅಕ್ಷ/ ವಿಚಲನಾಕ್ಷವಾಗಿದೆ. ಇದು ಭೂ ಕೇಂದ್ರ ಮತ್ತು ಉಪಗ್ರಹವನ್ನು ಜೋಡಿಸುವ ಕಕ್ಷೆಯ ತ್ರಿಜ್ಯದೊಂದಿಗೆ ಹೊಂದಿಕೊಳ್ಳುತ್ತದೆ. ರೋಲ್ (ಸುತ್ತುವ ಅಕ್ಷ): ಉಪಗ್ರಹದ ವೇಗದ ದಿಕ್ಕಿನ ಸದಿಶ ಪರಿಮಾಣವನ್ನು ಸೂಚಿಸುವ ರೇಖೆಯೆ ರೋಲ್ ಅಕ್ಷ/ ಸುತ್ತುವ ಅಕ್ಷ

ಆಗಿದೆ. ರೋಲ್ ಅಕ್ಷವು ಉಪಗ್ರಹದ ಪಥದ ಸ್ಪರ್ಶ ರೇಖೆ(tangent)ಯಾಗಿದೆ. ಯಾ ಮತ್ತು ರೋಲ್ ಒಂದಕ್ಕೊಂದು ಲಂಬವಾಗಿರುತ್ತವೆ. ಪಿಚ್ (ಸ್ಥಾನಾಕ್ಷ): ಯಾ ಮತ್ತು ರೋಲ್ ಅಕ್ಷದ ಸಮತಲಕ್ಕೆ ಲಂಬವಾಗಿರುವ ಅಕ್ಷ.

ಸ್ಥಾನ-ಸ್ಥಿತಿಯ ನಿಯಂತ್ರಣ ಏಕೆ, ಹೇಗೆ?: ಬಾಹ್ಯಾಕಾಶದಲ್ಲಿ ಇರುವ ಉಪಗ್ರಹಗಳು ವಿವಿಧ ರೀತಿಯ ಸೆಳೆತಕ್ಕೆ ಒಳಗಾಗುತ್ತವೆ (ಉದಾಹರಣೆಗೆ ಕೆಳ ಕಕ್ಷೆಯಲ್ಲಿರುವ ಗಗನನೌಕೆಯು ಅಲ್ಲಿನ ವಾತಾವರಣದ ಸೆಳೆತಕ್ಕೆ ಒಳಗಾಗಿರುತ್ತದೆ). ಈ ಕಾರಣಗಳಿಂದಾಗಿ ಅಕ್ಷೆಯಲ್ಲಿ ವಿವಿಧ ದೋಷಗಳು (errors) ಕಂಡುಬರುತ್ತವೆ. ಇದನ್ನು ಸ್ಥಾನ-ಸ್ಥಿತಿ ದೋಷವೆಂದು ಕರೆಯುತ್ತಾರೆ. ಸ್ಥಾನ-ಸ್ಥಿತಿ ದೋಷಗಳು ಉಂಟಾದಾಗ ಉಪಗ್ರಹಳಿಂದ ಸಿಗಬೇಕಾದ ಸೇವೆಗಳಲ್ಲಿ ವ್ಯತ್ಯಯವಾಗುತ್ತದೆ, ಉದಾಹರಣೆಗೆ ದೂರಸಂವೇದನಾ ಚಿತ್ರಗಳು ದೋಷಪೂರಿತವಾಗಬಹುದು, ದೂರದರ್ಶನದ ಸಂಕೇತಗಳು ಸಿಗದೇ ಕಾರ್ಯಕ್ರಮ ವೀಕ್ಷಣೆಯಲ್ಲಿ ಅಡಚಣೆ ಬರಬಹುದು. ಈ ರೀತಿ ವ್ಯತ್ಯವಾದಾಗ ಉಪಗ್ರಹಗಳನ್ನು ಮೂಲಸ್ಥಾನಕ್ಕೆ ತರುವಂತಹ ಪ್ರಕ್ರಿಯೆಯನ್ನು ಅಥವಾ ಈ ರೀತಿ ಯಾವುದೇ ವ್ಯತ್ಯಯ ಉಂಟಾಗದಂತೆ ಉಪಗ್ರಹಗಳನ್ನು ನಿಯಂತ್ರಿಸುವ ಕೆಲಸವನ್ನು ಸ್ಥಾನ-ಸ್ಥಿತಿ ನಿಯಂತ್ರಣ ಎಂದು ಹೇಳಬಹುದು. ಉಪಗ್ರಹದಲ್ಲಿ ಅಳವಡಿಸಿರುವ ದೂರದರ್ಶಕಗಳು, ಕ್ಯಾಮರಾ ಮತ್ತಿತರ ಉಪಕರಣಗಳ ಕಾರ್ಯನಿರ್ವಹಣೆಯು ಸ್ಥಾನ-ಸ್ಥಿತಿಯನ್ನು ಅವಲಂಬಿಸಿರುವುದರಿಂದ ನಿಖರವಾದ ಸ್ಥಾನ-ಸ್ಥಿತಿಯ ನಿಯಂತ್ರಣವು ಅತ್ಯವಶ್ಯಕವಾಗಿದೆ.

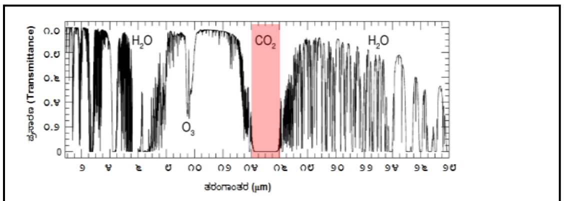
ಉಪಗ್ರಹಗಳ ಸ್ಥಾನ-ಸ್ಥಿತಿಯನ್ನು ಹೇಗೆ ನಿರ್ಧರಿಸಬಹುದು?: ಗಗನದಲ್ಲಿರುವ ವಸ್ತುಗಳ ಸ್ಥಾನ-ಸ್ಥಿತಿಯನ್ನು ನಿರ್ಧರಿಸಲು ಪ್ರಮುಖವಾಗಿ ಭೂಮಿ, ಸೂರ್ಯ ಮತ್ತು ನಕ್ಷತ್ರಗಳನ್ನು ಆಧಾರವಾಗಿ ಇಟ್ಟುಕೊಳ್ಳುತ್ತಾರೆ. ಸ್ಥಾನ-ಸ್ಥಿತಿಯನ್ನು ನಿರ್ಧರಿಸಲು ಯಾವ ಆಕಾಶಕಾಯಗಳನ್ನು ಬಳಸಿಕೊಳ್ಳುತ್ತೇವೆಯೋ ಅವುಗಳಿಗನುಗುಣವಾಗಿ ವಿವಿಧ ಸಂವೇದಕಗಳನ್ನು ತಯಾರಿಸಲಾಗುತ್ತದೆ (ಚಿತ್ರ-3). ಭೂಮಿ, ಸೂರ್ಯ ಮತ್ತು ನಕ್ಷತ್ರಗಳಲ್ಲದೆ ಕೆಲವೊಮ್ಮೆ ಭೂಮಿಯ ಕಾಂತಕ್ಷೇತ್ರ ಮತ್ತು ಉಪಗ್ರಹದ ಒಳಗೆ ಅಳವಡಿಸಿರುವ ಭ್ರಮಣದರ್ಶಕಗಳನ್ನೂ (gyroscope) ಸಹ ಸ್ಥಾನ-ಸ್ಥಿತಿ ನಿರ್ಧರಿಸಲು ಬಳಸಿಕೊಳ್ಳಲಾಗುತ್ತದೆ. ಸ್ಥಾನ-ಸ್ಥಿತಿ ನಿರ್ಧಾರ ಮಾಡಲು ಬಳಸಿಕೊಳ್ಳುವ ಆಧಾರಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ಸಂವೇದಕಗಳನ್ನು ಭೂ ಸಂವೇದಕ (Earth Sensor), ಸೂರ್ಯ ಸಂವೇದಕ (Sun Sensor), ನಕ್ಷತ್ರ ಸಂವೇದಕ (Star Sensor), ಕಾಂತೀಯ ಸಂವೇದಕ (Magnetic Sensor) ಎಂದು ವಿಂಗಡಿಸಬಹುದು.



ಚಿತ್ರ-3: ಉಪಗ್ರಹದ ಸಂವೇದನೆಗೆ ಬಳಸುವ ಪ್ರಮುಖ ಆಧಾರಗಳು

ಭೂ ಸಂವೇದಕಗಳು: ಭೂಮಿಯನ್ನು ಸುತ್ತುವಂತಹ ಉಪಗ್ರಹಗಳಿಗೆ ಭೂಮಿ ಒಂದು ಬಹು ದೊಡ್ಡ ಬಾಹ್ಯಾಕಾಶ ಕಾಯ. ಅದರಲ್ಲೂ ಕೆಳ ಕಕ್ಷೆಯಲ್ಲಿರುವ ಉಪಗ್ರಹಗಳಿಗೆ ಅದು ಸರಿಸುಮಾರು 40 % ಆಕಾಶವನ್ನು ಆವರಿಸಿರುತ್ತದೆ. ಸ್ಥಾನ-ಸ್ಥಿತಿಯ ಮಾಹಿತಿ ಪಡೆಯಲು ಈ ಉಪಗ್ರಹಗಳಿಗೆ ಭೂಮಿಯು ಒಂದು ಬಹುಮುಖ್ಯ ಆಕರವಾಗಿದೆ. ಭೂ ಸಂವೇದಕಗಳು ದೃಗ್ಗೋಚರ ತರಂಗಾಂತರಗಳ ಮೇಲೆ ಅವಲಂಬಿತವಾಗಿ ಇರದಿರುವುದರಿಂದ ಇವುಗಳನ್ನು ರಾತ್ರಿಯಲ್ಲೂ ಸಹ ಬಳಸಬಹುದು. ಈ ಸಂವೇದಕ ನೀಡುವ ಸಂಜ್ಞೆಯನ್ನು ಆಧರಿಸಿ ಉಪಗ್ರಹಗಳು ಭೂಮಿಯೆಡೆಗೆ ಮುಖ ಮಾಡಿವೆಯೇ ಇಲ್ಲವೇ ಎಂಬುದನ್ನು ನಿರ್ಧರಿಸಲಾಗುತ್ತದೆ.

ಬಾಹ್ಯಾಕಾಶದಿಂದ ಭೂಮಿಯ ರೋಹಿತ ಪಟ್ಟಿಯನ್ನು ನೋಡಿದರೆ, ಭೂಮಿಯು 14- 16 µm ತರಂಗಾಂತರ ಬಂಧದಲ್ಲಿ ಸ್ಥಿರವಾದ ಉಷ್ಣಅವಗೆಂಪು (thermal Infrared) ಕಿರಣಗಳನ್ನು ನಿರಂತರವಾಗಿ ಹೊರಚೆಲ್ಲುತ್ತಿರುತ್ತದೆ (ಚಿತ್ರ-4). ಆದಕಾರಣ ಈ ತರಂಗಾಂತರ ವ್ಯಾಪ್ತಿಯಲ್ಲಿ ಕೆಲಸ ಮಾಡುವ ಉಷ್ಣಅವಗೆಂಪು ಸಂವೇದನಾ ತತ್ವವನ್ನು ಅವಲಂಬಿಸಿರುವ ಶೋಧಕಗಳನ್ನು ಭೂಸಂವೇದನೆಯಲ್ಲಿ ಬಳಸಲಾಗುತ್ತದೆ. ಇವುಗಳು ಬಿಸಿಯಾಗಿರುವ ಭೂಮಿಯ ಮೇಲ್ಮೈ (300 ಕೆಲ್ವಿನ್) ಮತ್ತು ತಂಪಾಗಿರುವ ಬಾಹ್ಯಾಕಾಶದ (4 ಕೆಲ್ವಿನ್) ಉಷ್ಣತೆಯ ವ್ಯತ್ಯಾಸವನ್ನು ತುಲನೆ ಮಾಡುತ್ತವೆ. ಅವಗೆಂಪು ಕಿರಣಗಳನ್ನು ಗ್ರಹಿಸಲು ವಿವಿಧ ರೀತಿಯ ಶೋಧಕಗಳಾದ ಉಷ್ಣಯುಗ್ಮ (thermocouple), ಪೈರೋ-ವಿದ್ಯುತ್ (pyroelectric) ಸಾಧನ, ಉಷ್ಣಗ್ರಾಹಿ ರೋಧಕ (thermistor) ಮತ್ತು ಬೋಲೋಮಿಟರ್ (bolometer) ಗಳನ್ನು ಉಪಯೋಗಿಸಲಾಗುತ್ತದೆ.



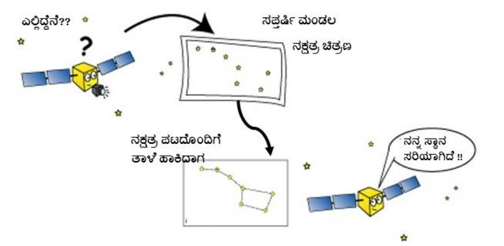
ಚಿತ್ರ-4: ಬಾಹ್ಯಾಕಾಶದಿಂದ ಕಂಡು ಬರುವ ಭೂಮಿಯ ವಾತಾವರಣದ ಮೂಲಕ ಹಾದು ಹೋಗುವ ರೋಹಿತ

ಉಪಗ್ರಹಗಳ ವಿಧ ಹಾಗೂ ಅವುಗಳು ಸುತ್ತುತ್ತಿರುವ ಕಕ್ಷೆಗನುಗುಣವಾಗಿ ಭೂ ಸಂವೇದಕಗಳನ್ನು 1] ಭೂಮೇಲ್ಮೈ ಸಂವೇದಕ (horizon crossing sensor) 2] ಶೋಧನಾ ಭೂ ಸಂವೇದಕ (scanning earth sensor) 3] ಸ್ಥಿರ ಭೂ ಸಂವೇದಕ (static earth sensor) ಎಂದು ವಿಂಗಡಿಸಬಹುದು.

ಸೂರ್ಯ ಸಂವೇದಕಗಳು: ಈ ಸಂವೇದಕಗಳು ಸೂರ್ಯ ಹೊರಸೂಸುವ ದೃಗ್ಗೋಚರ (visible) ವಿದ್ಯುತ್-ಕಾಂತೀಯ ವಿಕಿರಣಗಳನ್ನು ವಿಶ್ಲೇಷಿಸುವ ಮೂಲಕ ಉಪಗ್ರಹದ ಸ್ಥಾನಿಕ ಮಾಹಿತಿಗಳನ್ನು ಒದಗಿಸುತ್ತವೆ. ಇವುಗಳು 'ಸಿಲಿಕಾನ್' ನಿಂದ ಮಾಡಲ್ಪಟ್ಟ ಸೌರಕೋಶ (solar cell) ಅಥವಾ ವಿದ್ಯುದಂಶ ಯುಗ್ಮ ಸಾಧನಗಳನ್ನು (charge couple device- CCD) ಶೋಧಕವಾಗಿ ಬಳಸುತ್ತವೆ. ಕಾರ್ಯ ವೈಶಾಲ್ಯತೆಯ ಕಾರಣದಿಂದ ಸೂರ್ಯ ಸಂವೇದಕಗಳನ್ನು ಬಹುತೇಕ ಎಲ್ಲಾ ಉಪಗ್ರಹಗಳಲ್ಲಿ ಅಳವಡಿಸಲಾಗಿರುತ್ತದೆ. ಭೂಮಿಗೆ ಹೋಲಿಸಿದರೆ ಸೂರ್ಯನ ಕೋನೀಯ ತ್ರಿಜ್ಯ (angular radius) ಅತ್ಯಂತ ಕಿರಿದಾಗಿದ್ದು (0.267° @ ಒಂದು ಜ್ಯೋತಿರ್ವರ್ಷ) ಯಾವುದೇ ಕಕ್ಷೆಗಳಿಗೆ ಸೀಮಿತವಾಗಿಲ್ಲ. ಆದ್ದರಿಂದ ಸೂರ್ಯನನ್ನು ಒಂದು ಸ್ಥಿರ ಆಧಾರ ಬಿಂದುವಾಗಿ ಪರಿಗಣಿಸಲಾಗುತ್ತದೆ. ಇದರಿಂದಾಗಿ ಸೂರ್ಯ ಸಂವೇದಕಗಳ ವಿನ್ಯಾಸ, ಗಣಕೀಕರಣ ಮತ್ತು ತಂತ್ರಾಂಶಗಳ ಅಭಿವೃದ್ಧಿ ಸುಲಭವಾಗಿರುತ್ತದೆ. ಪ್ರಖರವಾದ ಸೂರ್ಯನ ಬೆಳಕು ಲಭ್ಯವಿರುವುದರಿಂದ ಕಡಿಮೆ ವಿದ್ಯುತ್ ಬಳಸುವ ಸರಳ ಹಾಗು ವಿಶ್ವಾಸಾರ್ಹ ಸೂರ್ಯ ಸಂವೇದಕಗಳನ್ನು ತಯಾರಿಸಲು ಸಾಧ್ಯವಾಗಿದೆ. ಸೂರ್ಯ ಸಂವೇದಕಗಳನ್ನು ಕೇವಲ ಸ್ಥಾನ-ಸ್ಥಿತಿ ನಿರ್ಧಾರ ಮಾಡುವಲ್ಲಿ ಮಾತ್ರವಲ್ಲದೆ ಸೂಕ್ಷ್ಮ ಉಪಕರಣಗಳ ಸಂರಕ್ಷಣೆಯಲ್ಲಿ, ಸೌರ ಫಲಕಗಳ ಸ್ಥಾನ ನಿರ್ಧರಿಸುವಲ್ಲಿ, ಹಾಗೂ ಆನ್-ಬೋರ್ಡ್ (on-board) ಸ್ಥಾನ-ಸ್ಥಿತಿ ನಿಯಂತ್ರಣ ವ್ಯವಸ್ಥೆಯಲ್ಲಿ ಬಳಸಲಾಗುತ್ತದೆ.

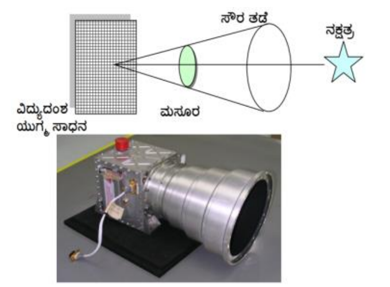
ಸೂರ್ಯ ಸಂವೇದಕಗಳನ್ನು 1] ಅನುರೂಪಕ ಸೂರ್ಯ ಸಂವೇದಕ (analog Sun sensor) 2] ಸೂರ್ಯನ ಇರುವು ತಿಳಿಸುವ ಸಂವೇದಕ (Sun presence sensor) ಮತ್ತು 3] ಅಂಕೀಯ ಸೂರ್ಯ ಸಂವೇದಕ (digital Sun sensor) ಎಂದು ವಿಂಗಡಿಸಬಹುದು. ಇದಲ್ಲದೆ ಸೂರ್ಯ ಸಂವೇದಕಗಳನ್ನು ಅವುಗಳು ಅಳವಡಿಸಿರುವ ಜಾಗ, ಅವುಗಳ ಕಾರ್ಯಕ್ಷೇತ್ರಕ್ಕನುಗುಣವಾಗಿ 4ಪೈ ಸೂರ್ಯ ಸಂವೇದಕ ಮತ್ತು ಸೌರಫಲಕ ಸೂರ್ಯ ಸಂವೇದಕ (solar panel Sun sensor) ಎಂದೂ ವಿಂಗಡಿಸಬಹುದು.

ನಕ್ಷತ್ರ/ತಾರಾ ಸಂವೇದಕಗಳು: ನೀವೆಲ್ಲರೂ ರಾತ್ರಿಯಲ್ಲಿ ಆಕಾಶವನ್ನು ನೋಡಿರುತ್ತಿರಲ್ಲವೇ? ಅಲ್ಲಿ ಅಸಂಖ್ಯಾತ ತಾರೆಗಳು ಮಿನುಗುತ್ತಿರುತ್ತವೆ. ಇವುಗಳನ್ನು ನಾವು ಸ್ಥಿರವಾದ ಆಕಾಶಕಾಯಗಳು ಎಂದು ಪರಿಗಣಿಸುತ್ತೇವೆ. ವಿಜ್ಞಾನಿಗಳು ಇವುಗಳನ್ನು ಪಟ್ಟಿ ಮಾಡಿ 'ನಕ್ಷತ್ರ ಪಟ' (star catalog) ವನ್ನು ತಯಾರಿಸಿದ್ದಾರೆ. ಉಪಗ್ರಹದಲ್ಲಿ ಅಳವಡಿಸಿರುವ ತಾರಾ ಸಂವೇದಕಗಳು ಬಾಹ್ಯಾಕಾಶದಲ್ಲಿ ಗೋಚರಿಸುವ ನಕ್ಷತ್ರಗಳ ಬೆಳಕಿನ ಸಾಮರ್ಥ್ಯವನ್ನು ಅಳೆಯುತ್ತವೆ. ತಾರಾ ಸಂವೇದಕದಲ್ಲಿರುವ ಸಂಸ್ಕರಣ (processor) ವಿಭಾಗವು ನಕ್ಷತ್ರಗಳ ಬೆಳಕನ್ನು ವಿದ್ಯುನ್ಮಾನ ಸಂಕೇತಗಳಾಗಿ ಪರಿವರ್ತಿಸುತ್ತದೆ. ಈ ರೀತಿ ಪಡೆದ ಮಾಹಿತಿಯನ್ನು ಗಣಕಯಂತ್ರದಲ್ಲಿ ಶೇಖರಿಸಿರುವ ರಚನೆಗಳ ಮೂಲಕ ವಿಶ್ಲೇಷಿಸಲಾಗುತ್ತದೆ. ಇಲ್ಲಿಂದ ಪಡೆದ ದತ್ತಾಂಶಗಳನ್ನು ಈಗಾಗಲೇ ಲಭ್ಯವಿರುವ ನಕ್ಷತ್ರ ಪಟದೊಂದಿಗೆ ತಾಳೆ ಹಾಕಿ ಉಪಗ್ರಹದ ಸ್ಥಾನ-ಸ್ಥಿತಿಯಲ್ಲಿರುವ ವ್ಯತ್ಯಾಸವನ್ನು ಗುರುತಿಸಲಾಗುತ್ತದೆ (ಚಿತ್ರ-5). ಉಪಗ್ರಹದ ಸ್ಥಾನ-ಸ್ಥಿತಿಯನ್ನು ಅಳೆಯಲು ಎರಡರಿಂದ ಹತ್ತು ನಕ್ಷತ್ರಗಳನ್ನು ಬಳಸಿಕೊಳ್ಳಲಾಗುತ್ತದೆ.



ಚಿತ್ರ-5: ನಕ್ಷತ್ರ ಸಂವೇದಕವನ್ನು ಬಳಸಿಕೊಂಡು ಉಪಗ್ರಹದ ಸ್ಥಾನ-ಸ್ಥಿತಿಯನ್ನು ಹೇಗೆ ಸರಿಪಡಿಸಹಬುದು ಎನ್ನುವುದನ್ನು ತಿಳಿಸುವ ಚಿತ್ರ

ನಕ್ಷತ್ರಗಳಿಂದ ಬರುವ ಬೆಳಕು ತುಂಬಾ ದುರ್ಬಲವಾಗಿರುವುದರಿಂದ ಇತರೆ ಮೂಲಗಳಿಂದ (ಮುಖ್ಯವಾಗಿ ಸೂರ್ಯ) ಬರುವ ಬೆಳಕು ನಕ್ಷತ್ರ ಸಂವೇದಕಗಳ ಕಾರ್ಯನಿರ್ವಹಣೆಗೆ ಅಡ್ಡಿಯನ್ನುಂಟು ಮಾಡುತ್ತದೆ. ಹಾಗಾಗಿ ಇತರೆ ಬೆಳಕಿನ ಮೂಲಗಳನ್ನು ತಡೆಯಲು ಸೌರತಡೆಯನ್ನು (Baffle) ಅಳವಡಿಸಲಾಗುತ್ತದೆ (ಚಿತ್ರ-6). ಈ ಸೌರ ತಡೆಗಳ ಒಳಗೆ ಲೇಪಿಸಿರುವ ಬೆಳಕಿನ ಹೀರುವಿಕೆಯ ಲೇಪನವು ಅನುಪಯುಕ್ತ ಬೆಳಕು ಶೋಧಕವನ್ನು ತಲುಪದಂತೆ ತಡೆಯುತ್ತದೆ. ಮಸೂರದ ಮೂಲಕ ಹಾದು ಹೋದ ಬೆಳಕು ವಿಶಾಲವಾದ ವಿದ್ಯುದಂಶ ಯುಗ್ಮ ಸಾಧನ (large area CCD) ವನ್ನು ಬಳಸಿ ಮಾಡಿದ ಶೋಧಕದ ಮೇಲೆ ತಾರಾ ಛಾಯೆಯನ್ನು ಮೂಡಿಸುತ್ತದೆ.



ಚಿತ್ರ-6 : ನಕ್ಷತ್ರ ಸಂವೇದಕದ ರೇಖಾಚಿತ್ರ ಮತ್ತು ನಕ್ಷತ್ರ ಸಂವೇದಕ

ಇತರೆ ಸಂವೇದಕಗಳಿಗೆ ಹೋಲಿಸಿದರೆ ತಾರಾ ಸಂವೇದಕಗಳು ಅತ್ಯಂತ ನಿಖರವಾಗಿ ಸ್ಥಾನ-ಸ್ಥಿತಿಯಲ್ಲಿ ಕಂಡುಬರುವ ವ್ಯತ್ಯಾಸವನ್ನು ಗುರುತಿಸುತ್ತವೆ. ಆದರೆ ಉಳಿದ ಸಂವೇದಕಗಳಿಗೆ ಹೋಲಿಸಿದರೆ ಇವುಗಳ ತಯಾರಿಕಾ ವೆಚ್ಚವು ಅಧಿಕವಾಗಿದೆ, ತೂಕವು ಸಹ ಹೆಚ್ಚಾಗಿದೆ ಅಲ್ಲದೆ ಈ ಸಂವೇದಕಗಳು ತಮ್ಮ ಕಾರ್ಯನಿರ್ವಹಣೆಗೆ ಹೆಚ್ಚಿನ ವಿದ್ಯುತ್ತನ್ನು ಬಳಸುತ್ತವೆ.

ಕಾಂತೀಯ ಸಂವೇದಕಗಳು: ಕಾಂತೀಯ ಸಂವೇದಕಗಳನ್ನು ಭೂಮಿಯ ಸುತ್ತ ಆವರಿಸಿರುವ ಕಾಂತಕ್ಷೇತ್ರದ ದಿಕ್ಕು ಮತ್ತು ಪ್ರಮಾಣಗಳನ್ನು ಅಳೆಯಲು ಬಳಸಿಕೊಳ್ಳುತ್ತಾರೆ. ಕಾಂತಕ್ಷೇತ್ರದ ತೀವ್ರತೆ ಭೂಮಿಯಿಂದ ದೂರ ಹೋದಂತೆ ದೂರದ ಮೂರು ಪಟ್ಟು ಕಡಿಮೆಯಾಗುತ್ತಾ ಹೋಗುತ್ತದೆ. ಅಂದರೆ ಭೂಮಿಯಿಂದ R ಅಂತರದಲ್ಲಿ ಕಾಂತಕ್ಷೇತ್ರವನ್ನು ಅಳೆದರೆ ಅದು $1/R^3$ ಕ್ಕೆ ಸಮನಾಗಿರುತ್ತದೆ. ಆದಕಾರಣ ಸಾಮಾನ್ಯವಾಗಿ ಕೆಳ ಕಕ್ಷೆಯಲ್ಲಿರುವ ಉಪಗ್ರಹಗಳಲ್ಲಿ ಮಾತ್ರ ಇವುಗಳನ್ನು ಬಳಸುತ್ತಾರೆ. ಭೂಮಿಯ ಕಾಂತಕ್ಷೇತ್ರ ಕೆಳ ಕಕ್ಷೆಯಲ್ಲಿ ಸರಿ ಸುಮಾರು ೦.೫ ಗಾಸ್ ಆಗಿರುತ್ತದೆ. ಭೂಮಿಯ ಕಾಂತಕ್ಷೇತ್ರದ ವ್ಯತ್ಯಾಸವನ್ನು ಪರಸ್ಪರ ಲಂಬವಾಗಿರುವ ಮೂರು ಅಕ್ಷಗಳಲ್ಲಿ ಅಳೆಯುತ್ತಾರೆ. ಕಾಂತೀಯ ಸಂವೇದಕಗಳು ನೀಡುವ ಸ್ಥಾನ-ಸ್ಥಿತಿಯ ನಿಖರತೆ ಉಳಿದೆಲ್ಲ ಸಂವೇದಕಗಳ ನಿಖರತೆಗೆ ಹೋಲಿಸಿದರೆ ಕಡಿಮೆಯಿರುತ್ತದೆ.

ಭ್ರಮಣದರ್ಶಕಗಳು: ಭ್ರಮಣದರ್ಶಕ ಉಪಕರಣದಲ್ಲಿ ಅಳವಡಿಸಿರುವ ಚಕ್ರವು ತನ್ನ ಅಕ್ಷದ ಸುತ್ತ ವೇಗವಾಗಿ ಸುತ್ತುತ್ತಿರುತ್ತದೆ ಹಾಗೂ ಆ ಅಕ್ಷದಲ್ಲಾಗಿರುವ ಬದಲಾವಣೆಯನ್ನು ಗುರುತಿಸುತ್ತದೆ ಮತ್ತು ಅದಕ್ಕೆ ಪ್ರತಿಕ್ರಿಯಿಸುತ್ತದೆ. ಭ್ರಮಣದರ್ಶಕದಲ್ಲಿ ಚಿಕ್ಕದಾದ ಮೂರು ಚಕ್ರಗಳನ್ನು ಅಳವಡಿಸಿರುತ್ತಾರೆ. ಪ್ರತಿಯೊಂದು ಚಕ್ರವು ಒಂದೊಂದು ಅಕ್ಷವನ್ನು ಪ್ರತಿನಿಧಿಸುತ್ತದೆ. ಭ್ರಮಣದರ್ಶಕದ ಮೂಲ ತತ್ವದ ಪ್ರಕಾರ ಒಂದು ವಸ್ತುವು ತನ್ನ ಅಕ್ಷದ ಸುತ್ತ ಸುತ್ತುತ್ತಿರುವಾಗ, ಯಾವುದೇ ಒಂದು ಬಾಹ್ಯ ಶಕ್ತಿಯು ಅಕ್ಷದ ದಿಕ್ಕನ್ನು ಬದಲಾಯಿಸಲು ಪ್ರಯತ್ನಿಸಿದರೆ ಅದಕ್ಕೆ ಪ್ರತಿಕ್ರಿಯೆ ವ್ಯಕ್ತವಾಗುತ್ತದೆ. ಈ ತತ್ವದ ಆಧಾರದ ಮೇಲೆ ಪ್ರತಿ ಚಕ್ರವು ತನ್ನ ಅಕ್ಷದಲಾಗುವ ಬದಲಾವಣೆಗಳ ಮೂಲಕ ಉಳಿದೆರಡು ಅಕ್ಷದಲ್ಲಿ ತೋರುವ ಸ್ಥಾನ-ಸ್ಥಿತಿ ದೋಷವನ್ನು ಗುರುತಿಸುತ್ತದೆ.

ನಾವು ಕಲಿಯುವ ಪ್ರತಿಯೊಂದು ವಿಷಯಗಳಿಗೆ ಮತ್ತು ನಿಸರ್ಗಕ್ಕೆ ಪ್ರತ್ಯಕ್ಷ ಅಥವಾ ಪರೋಕ್ಷ ಸಂಬಂಧವಿದೆ. ನಿಸರ್ಗ ನಮ್ಮೆಲ್ಲ ಸಂಶೋಧನೆಗಳ ತವರು. ಅದು ತನ್ನ ಒಡಲಲ್ಲಿ ಅನೇಕಾನೇಕ ಗುಟ್ಟುಗಳನ್ನು ಬಚ್ಚಿಟ್ಟುಕೊಂಡಿದೆ. ಮಾನವನ ಪ್ರಯೋಗಶೀಲ ಮನೋಭಾವದ ಬೆಳವಣಿಗೆಯಿಂದ ನಿಸರ್ಗದ ಸೋಜಿಗಗಳನ್ನು ತಿಳಿದುಕೊಳ್ಳಲು, ರಹಸ್ಯಗಳನ್ನು ಭೇದಿಸಲು ಅನೇಕ ಅಧ್ಯಯನಗಳು, ಹೊಸ ಹೊಸ ಸಂಶೋಧನೆಗಳು ನಡೆದವು. ಉಪಗ್ರಹದಲ್ಲಿನ ಸಂವೇದಕಗಳು ಮಾನವನು ವಿಜ್ಞಾನ-ತಂತ್ರಜ್ಞಾನಗಳನ್ನು ಬಳಸಿಕೊಂಡು ಪ್ರಯೋಗಗಳನ್ನು ನಡೆಸಿ ಕಂಡುಕೊಂಡ ಉತ್ತರದ ಪರಿಣಾಮಗಳಾಗಿವೆ. ಉಪಗ್ರಹ ಭೂಮಿಯನ್ನು ನೋಡುತ್ತಿರಲಿ, ಚಂದ್ರನೆಡೆಗೆ ಸಾಗುತ್ತಿರಲಿ, ಮಂಗಳನೆಡೆಗೆ ಪಯಣ ಆರಂಭಿಸುತ್ತಿರಲಿ ಎಲ್ಲೆಡೆ ಬೇಕು ಅದಕ್ಕೆ ಸಂವೇದಕದ ಸಹಾಯ. ಉಪಗ್ರಹದ ಅಸ್ತಿತ್ವವನ್ನು ಸಾರುವ ಪ್ರತಿ ಹಂತದಲ್ಲೂ ಸಂವೇದಕಗಳ ಪಾತ್ರ ಮಹತ್ವದ್ದಾಗಿದೆ. ಬಹುದೂರದ ಬಾನಿನಲ್ಲಿ ಸ್ಥಿರವಾದ ಸ್ಥಾನ-ಸ್ಥಿತಿಯಲ್ಲಿ ಉಪಗ್ರಹ ಇರುವಂತೆ ಮಾಡುವಲ್ಲಿ, ಭೂ-ಕೇಂದ್ರ ಮತ್ತು ಉಪಗ್ರಹದ ನಡುವೆ ಸಂಕೇತ ರವಾನಿಸಿ ಸಮನ್ವಯ ಸಾಧಿಸುವಲ್ಲಿ ಸಂವೇದಕಗಳು ಹಿರಿದಾದ ಪಾತ್ರವನ್ನು ನಿಭಾಯಿಸುತ್ತವೆ.

ಡಾ. ಗಿರೀಶ ಮಂಜುನಾಥ ಗೌಡ
ಇಸ್ರೋದ ವಿದ್ಯುತ್-ದ್ಯುತಿ ವ್ಯವಸ್ಥೆಗಳ ಪ್ರಯೋಗಾಲಯದಲ್ಲಿ ವಿಜ್ಞಾನಿ
ತೆಳು ಪದರ ವಿಭಾಗದ ಮುಖ್ಯಸ್ಥ

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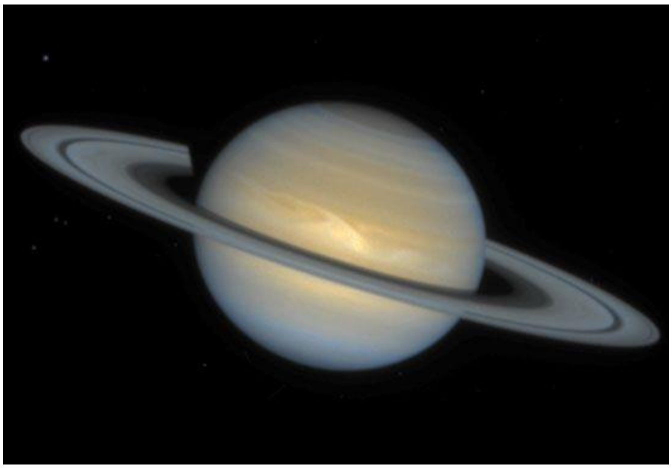
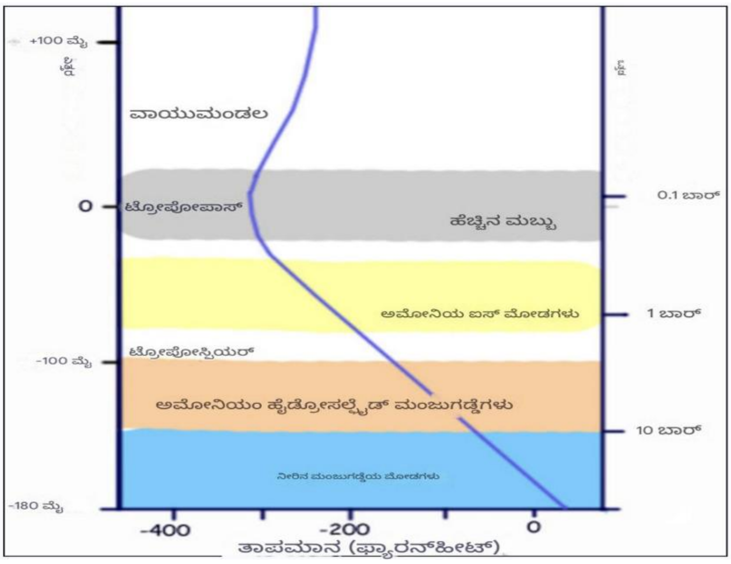
ಶನಿ ಗ್ರಹದ ವೈವಿಧ್ಯತೆ



ಚಿತ್ರ 1 ಶನಿ ಗ್ರಹ

ಸೂರ್ಯಮಂಡಲದ ಆರನೇ ಗ್ರಹವಾದ ಶನಿಯು ತನ್ನ ಸುತ್ತಲೂ ಸುಂದರ ಮತ್ತು ವಿಸ್ತಾರವಾದ ಉಂಗುರವನ್ನು ಹೊಂದಿದೆ. ಇದು ಸೂರ್ಯನಿಂದ ಸರಾಸರಿ 1.43 ಶತಕೋಟಿ ಕಿ.ಮೀ. ದೂರದಲ್ಲಿದ್ದು, ಗುರುಗ್ರಹದ ನಂತರ ಸೌರಮಂಡಲದಲ್ಲಿ 2ನೇ ಅತಿ ದೊಡ್ಡ ಗ್ರಹವಾಗಿದೆ. ವೀಕ್ಷಿಸಲು ತಿಳಿ ಹಳದಿ ಬಣ್ಣದಿಂದ ಕೂಡಿದ್ದು ಹಳದಿ, ಕಂದು ಪಟ್ಟೆಗಳಿಂದ ಕೂಡಿದೆ. ಶನಿಯು ಭೂಮಿಯಂತೆ ಧ್ರುವಗಳಲ್ಲಿ ಚಪ್ಪಟೆಯಾಗಿದ್ದು ಸಮಭಾಜಕದಲ್ಲಿ ಉಬ್ಬಿಕೊಂಡಿದೆ. ಇದು ನೀರಿಗಿಂತ ಕಡಿಮೆ ಸಾಂದ್ರತೆಯುಳ್ಳ ಏಕೈಕ ಗ್ರಹವಾಗಿದ್ದು, ನೀರಿನಲ್ಲಿ ತೇಲಬಹುದಾದ ಗ್ರಹವಾಗಿದೆ. ಒಳಭಾಗದಲ್ಲಿ 11,700 ಡಿಗ್ರಿ ಸೆಲ್ಸಿಯಸ್ ತಾಪಮಾವನ್ನು ಹೊಂದಿದ್ದು ಹೊರಭಾಗದ ವಾತಾವರಣವು ಕಡಿಮೆ ಉಷ್ಣತೆಯಿಂದ ಕೂಡಿದ್ದು ಸರಾಸರಿ –178 ಡಿಗ್ರಿ ಸೆಲ್ಸಿಯಸ್ ತನಕವೂ ಇರುತ್ತದೆ. ಶನಿಗ್ರಹವು ತಾನು ಸೂರ್ಯನಿಂದ ಪಡೆಯುವ ಶಾಖಕ್ಕಿಂತ ಹೆಚ್ಚು ಶಾಖವನ್ನು ಬಾಹ್ಯಾಕಾಶಕ್ಕೆ ಹೊರಹಾಕುತ್ತದೆ. ಇದರ ಸುತ್ತಲೂ 274 ಚಂದಿರರು ಅಥವಾ ಚಂದ್ರರು (ಸ್ವಾಭಾವಿಕ ಉಪಗ್ರಹಗಳು) ಸುತ್ತುತ್ತಿದ್ದು, ಸೂರ್ಯಮಂಡಲದಲ್ಲೇ ಅತಿ ಹೆಚ್ಚು ಚಂದಿರರು ಇರುವ ಗ್ರಹವಾಗಿದೆ. ಶನಿಯು ತನ್ನ ಅಕ್ಷದ ಮೇಲೆ ವೇಗವಾಗಿ ಗಿರಕಿ ಹೊಡೆಯುತ್ತಿದ್ದು ಒಂದು ಬಾರಿ ತಿರುಗಲು 16 ಭೂ ಘಂಟೆಗಳ ಕಾಲ ತೆಗೆದುಕೊಳ್ಳುತ್ತದೆ. ಒಂದು ಬಾರಿ ಸೂರ್ಯನನ್ನು ಸುತ್ತಲು ಸುಮಾರು 29.4 ಭೂ ವರ್ಷಗಳು ಅಥವಾ 10,756 ಭೂ ದಿನಗಳು ಬೇಕು. ನಾಸಾ ಹೇಳುವಂತೆ ಶನಿ ಗ್ರಹದ ಸಮಭಾಜಕ ವ್ಯಾಸವು ಭೂಮಿಗಿಂತ 9.5 ಪಟ್ಟು ದೊಡ್ಡದಾಗಿದೆ ಮತ್ತು ಇದರ ಗಾತ್ರದಲ್ಲಿ ಸುಮಾರು 764 ಭೂಮಿಯನ್ನು ಹಿಡಿಸಬಲ್ಲದು.

ಶನಿ ಗ್ರಹದ ವಾಯುಮಂಡಲ

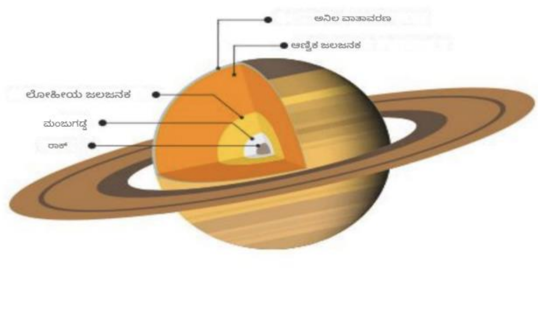


ಚಿತ್ರ 2 ಶನಿಯ ವಾಯುಮಂಡಲ

ಹಬಲ್ ಬಾಹ್ಯಾಕಾಶ ದೂರದರ್ಶಕದ ವೀಕ್ಷಣೆಯಂತೆ ಶನಿ ಗ್ರಹದ ವಾತಾವರಣವು 75% ಜಲಜನಕ 20% ಹೀಲಿಯಂ ಮತ್ತು ಉಳಿದ ಭಾಗ ಮೀಥೇನ್, ಅಮೋನಿಯಾ ಮತ್ತು ನೀರಿನ ಮಂಜುಗಡ್ಡೆಯಿಂದ ಕೂಡಿದೆ. ಶನಿಯ ಉಂಗುರಗಳು ತಮ್ಮದೇ ಆದ ವಾಯುಮಂಡಲವನ್ನು ಹೊಂದಿವೆ.

1994ರಲ್ಲಿ ಹಬಲ್ ಬಾಹ್ಯಾಕಾಶ ದೂರದರ್ಶಕದಲ್ಲಿ ವೀಕ್ಷಿಸಿದಂತೆ 1800 ಕಿ.ಮೀ. (500 ಮೈಲಿ) ವೇಗದ ಮೋಡಗಳಲ್ಲಿ ಬೀಸುವ ಬಿರುಗಾಳಿಯು ಬಹಳ ಹಿರಿದಾಗಿದ್ದು ಅದು ಭೂಮಿಯ ಗಾತ್ರಕ್ಕಿಂತ ದೊಡ್ಡದಾಗಿದೆ. –250 ಡಿಗ್ರಿ ಸೆಲ್ಸಿಯಸ್(–507.6 ಡಿಗ್ರಿ ಫ್ಯಾರನ್‌ಹೀಟ್) ಉಷ್ಣಾಂಶದಲ್ಲಿರುವ ಅಮೋನಿಯಾ ಐಸ್ ಮೋಡವು ವಾತಾವರಣದ ಕೆಳ ಭಾಗದಲ್ಲಿ ಇರುವುದು ಕಂಡುಬಂದಿದೆ.

ಶನಿಯ ವಾತಾವರಣವನ್ನು ಮೂರು ವಲಯಗಳಾಗಿ ವಿಭಾಗಿಸಬಹುದು (ಚಿತ್ರ 2). ಮೇಲ್ಭಾಗದ ಮಜಲಿನ ಟ್ರೋಪೋಸ್ಫಿಯರ್‌ನಲ್ಲಿ ಗೋಚರಿಸುವ ಮೋಡವು ಅಮೋನಿಯಾದಿಂದ ತುಂಬಿದ್ದು, ಉಷ್ಣಾಂಶವು –250 ಡಿಗ್ರಿ ಸೆಲ್ಸಿಯಸ್ (507.6 ಡಿಗ್ರಿ ಫ್ಯಾರನ್‌ಹೀಟ್) ಇರುತ್ತದೆ. ಎರಡನೇ ಕೆಳಮಜಲಿನಲ್ಲಿ ಅಮೋನಿಯಂ ಹೈಡ್ರೊಸಲ್ಫೈಡ್ ಮೋಡಗಳು ಟ್ರೋಪೋಸ್ಫಿಯರ್‌ನ ಕೆಳಗೆ 170 ಕಿ.ಮೀ.(106.25 ಮೈಲಿ) ವರೆಗೆ ಇದ್ದು –70 ಡಿಗ್ರಿ ಸೆಲ್ಸಿಯಸ್ (–106.25 ಡಿಗ್ರಿ ಫ್ಯಾರನ್‌ಹೀಟ್) ಉಷ್ಣಾಂಶದಲ್ಲಿ ಇರುತ್ತದೆ. ಅತ್ಯಂತ ಕೆಳಭಾಗದ ಮಜಲಿನಲ್ಲಿ ಉಷ್ಣಾಂಶವು ಸೊನ್ನೆ



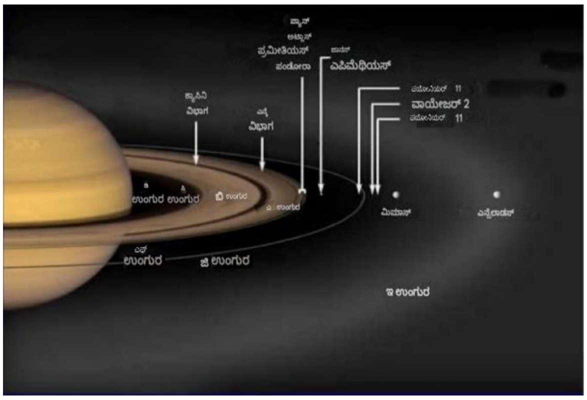
ಚಿತ್ರ 3 ಶನಿಗ್ರಹದ ಒಳಭಾಗ

ಡಿಗ್ರಿ ಸೆಲ್ಸಿಯಸ್ (32 ಡಿಗ್ರಿ ಫ್ಯಾರನ್‌ಹೀಟ್) ಇರುತ್ತದೆ. ಈ ಪದರದಲ್ಲಿ ಜಲಜನಕದ ಒತ್ತಡವು ಹೆಚ್ಚಾಗುತ್ತಾ ಶನಿಗ್ರಹದ ಮೇಲ್ಮೈಯಲ್ಲಿ ಒತ್ತಡ ಅತಿಯಾಗಿ ದ್ರವ ಲೋಹದ ಜಲಜನಕವು ರೂಪುಗೊಳ್ಳುತ್ತದೆ. ಈ ಗ್ರಹದ ಒಳ ಆಳಕ್ಕೆ ಹೋದಂತೆ ಜಲಜನಕವು ಅತೀವ ಒತ್ತಡಕ್ಕೊಳಗಾಗಿ ದ್ರವರೂಪದ ಜಲಜನಕವು ಲೋಹರೂಪವನ್ನು ತಾಳುತ್ತದೆ (ಚಿತ್ರ 3). ಮೇಲ್ಮೈಯು ಮಂಜುಗಡ್ಡೆಯಿಂದ ಮತ್ತು ಒಳಭಾಗ ಅತಿ ಉಷ್ಣತೆಯಿಂದ ಕೂಡಿದ್ದು, ಒಳಭಾಗದ ಕೇಂದ್ರದಲ್ಲಿ ಕಲ್ಲು ಬಂಡೆಗಳಿಂದ ನಂತರ ದ್ರವ ಮತ್ತು ಲೋಹ ರೂಪದ ಜಲಜನಕದಿಂದ ಕೂಡಿದ ಗ್ರಹವಾಗಿದೆ.

ವರ್ಷದ ಬಹುತೇಕ ಕಾಲಗಳಲ್ಲಿ ಶನಿಯು ಉಂಗುದೊಂದಿಗೆ ನೋಡಲು ಚೆನ್ನಾಗಿ ಕಂಡರೂ, ಸೂರ್ಯನಿಗೆ ವಿರುದ್ಧ ದಿಕ್ಕಿನಲ್ಲಿದ್ದಾಗ ಅದರ ಉಂಗುರಗಳನ್ನು ಹೆಚ್ಚು ಸ್ಫುಟವಾಗಿ ಪ್ರಕಾಶಮಾನವಾಗಿರುವುದನ್ನು ನೋಡಬಹುದು. ಶನಿಯು ಸೂರ್ಯನ ಸುತ್ತ ಒಂದು ಬಾರಿ ಪ್ರದಕ್ಷಿಣೆ ಮಾಡಲು ಸುಮಾರು 29.46 ಭೂಮಿಯ ವರ್ಷವನ್ನು ತೆಗೆದುಕೊಳ್ಳುತ್ತದೆಯಾದ್ದರಿಂದ ಅದು 2005ರಲ್ಲಿ ಅದರ ಉಂಗುರಗಳು ಸ್ಫುಟವಾಗಿ ಹೆಚ್ಚು ಪ್ರಕಾಶಮಾನವಾಗಿ ಕಂಡಿತ್ತು, ಮುಂದೆ 2031ರ ನಂತರವೇ ಹೆಚ್ಚು ಪ್ರಕಾಶಮಾನವಾಗಿ ಕಾಣುವುದು.

ಶನಿ ಗ್ರಹದ ಉಂಗುರಗಳು

1610ರಲ್ಲಿ ಮೊದಲ ಬಾರಿಗೆ ಗೆಲಿಲಿಯೋ ಗೆಲಿಲಿ ತಾನು ರೂಪಿಸಿದ ದೂರದರ್ಶಕದಿಂದ ಶನಿ ಗ್ರಹವನ್ನು ವೀಕ್ಷಿಸಿದನು. ಅದರ ಸುತ್ತಲೂ ಇರುವುದು ಉಂಗುರಗಳೆಂದು ಗುರುತು ಹಿಡಿಯಲಾಗದೆ, ಗ್ರಹದ ಎರಡು ಭಾಗಗಳೂ ಕಣ್ಣು, ಕಿವಿಯಂತಹ ಆಕಾರಗಳಿಂದ ಕೂಡಿವೆಯೆಂದು ಭಾವಿಸಿದನು. ನಂತರ 1655ರಲ್ಲಿ ಕ್ರಿಸ್ಟಿಯನ್ ಹೈಗನ್ಸ್ ಶನಿಯು ಹಲವಾರು ಉಂಗುರಗಳಿಂದ ಕೂಡಿದೆಯೆಂದು ಸಂಶೋಧಿಸಿದರು, ಅಲ್ಲದೆ ಸುತ್ತಲೂ ತಿರುಗುತ್ತಿರುವ ಶನಿಯ ದೊಡ್ಡ ಚಂದಿರ 'ಟೈಟಾನ್'ಅನ್ನು ಕಂಡುಹಿಡಿದರು. ನಂತರ 1675ರಲ್ಲಿ ಜಿ. ಡಿ. ಕ್ಯಸಿನಿ ಎಂಬ ವಿಜ್ಞಾನಿಯು, ಶನಿಯ ಸುತ್ತ ಅನೇಕ ಉಂಗುರಗಳಿದ್ದು ಅವುಗಳ ನಡುವೆ ಅಂತರ(gap)ಗಳಿವೆಯೆಂದು ಸಂಶೋಧಿಸಿದರು. ಮುಂದೆ ಇವುಗಳಲ್ಲಿ ಅತಿ ದೊಡ್ಡ ಎರಡನ್ನು ಕ್ಯಸಿನಿ ಮತ್ತು ಎನ್ಕೆ ಅಂತರಗಳೆಂದು ಕರೆಯಲಾಯಿತು. ಇವುಗಳನ್ನು ಭೂಮಿಯ ದೂರದರ್ಶಕದಿಂದಲೂ ನೋಡಬಹುದು. ಅವುಗಳೂ ಕೂಡ ಅನೇಕ ಚಿಕ್ಕ ಅಂತರ($small\ gaps$)ಗಳಿಂದ ಕೂಡಿರುವುದು ವಾಯೇಜರ್ ಉಪಗ್ರಹದಿಂದ ತಿಳಿದುಬಂದಿದೆ.



ಚಿತ್ರ 4 ಶನಿ ಗ್ರಹದ ಉಂಗುರಗಳು

ಶನಿಗ್ರಹದ ಉಂಗುರಗಳು ಅದರ ವಾತಾವರಣದಿಂದ ಆಚೆಗೂ ವಿಸ್ತರಿಸಿ ಗ್ರಹದ ಸುತ್ತ ಸುತ್ತುತ್ತಿರುವ ಹಿಮಾವೃತ ಮತ್ತು ಕಲ್ಲಿನ ಶಿಲಾಖಂಡರಾಶಿಗಳ ವ್ಯವಸ್ಥೆಯಾಗಿದೆ. ಈ ಉಂಗುರಗಳು ಘನ ರೂಪದ ದೊಡ್ಡ ವಸ್ತುವಾಗಿರದೆ, ಸೂಕ್ಷ್ಮ ಕಣಗಳಿಂದ ಹಿಡಿದು ಮೀಟರ್ ಗಾತ್ರದ ವಸ್ತುಗಳಾಗಿದ್ದು ಪ್ರತಿಯೊಂದೂ ಸ್ವತಂತ್ರವಾಗಿ ಶನಿಗ್ರಹದ ಸುತ್ತ ಪರಿಭ್ರಮಿಸುತ್ತಿವೆ. ಈ ಉಂಗುರಗಳು ತೆಳುವಾಗಿ, 200 ಮೀ. ದಪ್ಪವಿದ್ದು, 281,000 ಕಿ.ಮೀ. ವರೆಗೂ ವಿಸ್ತರಿಸಿದೆ. ಕ್ಯಾಸಿನಿ ಬಾಹ್ಯಾಕಾಶ ನೌಕೆಯು ಉಂಗುರಗಳಲ್ಲಿ ತಮ್ಮದೇ ಆದ ಆಮ್ಲಜನಕವುಳ್ಳ ವಾಯುಮಂಡಲವನ್ನು ಹೊಂದಿದೆಯೆಂದು ಸಂಶೋಧಿಸಿದೆ.

ಛಿದ್ರವಾದ ಚಂದಿರರು, ಮುರಿದ ಕ್ಷುದ್ರಗ್ರಹಗಳು, ಧೂಮಕೇತುಗಳ ಅವಶೇಷಗಳು ಎಲ್ಲವೂ ಗ್ರಹದ ಗುರುತ್ವಾಕರ್ಷಣೆಯಿಂದ ಉಂಗುರಗಳಾಗಿ ರೂಪುಗೊಂಡಿವೆ. ಈ ಉಂಗುರಗಳು ಶನಿಗ್ರಹಕ್ಕಿಂತ ಈಚಿನವು. ವಿಜ್ಞಾನಿಗಳ ಸಂಶೋಧನೆಯಂತೆ ಶನಿಗ್ರಹವು 4.5 ಶತಕೋಟಿ ವರ್ಷಗಳ ಹಿಂದಿನವುಗಳಾದರೆ ಅದರ ಉಂಗುರಗಳು 0.4 ಶತಕೋಟಿ ವರ್ಷಗಳ ಹಿಂದಿನವುಗಳಾಗಿವೆ. ಈ ಉಂಗುರಗಳ ಮೇಲೆ ನಿರಂತರವಾಗಿ ಶನಿಗ್ರಹದಿಂದ ಬೀಳುತ್ತಿರುವ ಮಂಜುಗಡ್ಡೆಯ ಮಳೆಯ ಪರಿಣಾಮವಾಗಿ ಅವುಗಳು ಶಿಲಾಖಂಡ ರಾಶಿಗಳನ್ನು ಕಳೆದುಕೊಳ್ಳುತ್ತಿವೆ.

ನಾಸಾದ ಕ್ಯಾಸಿನಿ ಬಾಹ್ಯಾಕಾಶ ನೌಕೆಯು ಶನಿಯ ಬಳಿ ಹತ್ತು ವರ್ಷಗಳ ತಿರುಗಾಟದ ಸಮೀಕ್ಷೆಯಂತೆ, ಶನಿ ಗ್ರಹದ ಉಂಗುರಗಳು ಒಂದು ಸಂಕೀರ್ಣವಾದ ರಚನೆಯೆಂದೇ ಹೇಳಬಹುದು. ಅದರದಂತೆ ಉಂಗುರಗಳನ್ನು ಗ್ರಹದ ಹೊರಮೇಲ್ಮೈಯಿಂದ ಡಿ, ಸಿ, ಬಿ, ಎ, ಎಫ್, ಜಿ ಮತ್ತು ಇ ಎಂದು ಗುರುತಿಸಲಾಗಿದೆ (ಚಿತ್ರ 4). ಡಿ ಉಂಗುರವು ಶನಿಗ್ರಹಕ್ಕೆ ಅತಿ ಹತ್ತಿರವಾಗಿ ಮಂದ ಪ್ರಕಾಶವಾಗಿದೆ. ಭೂಮಿಯಲ್ಲಿನ ದೂರದರ್ಶಕದಲ್ಲಿ ಎ, ಬಿ, ಸಿ ಉಂಗುರಗಳನ್ನು ಕಾಣಬಹುದು. 'ಕ್ಯಾಸಿನಿ' ವಿಭಾಗವು ಎ ಮತ್ತು ಬಿ ಉಂಗುರಗಳಿಗೆ ಒಂದು ದೊಡ್ಡ ಅಂತರವನ್ನು ಸೃಷ್ಟಿಸಿದೆ. ಚಿಕ್ಕ ಎಫ್ ಉಂಗುರದನಂತರ ಎರಡು ಸಣ್ಣ ಚಂದ್ರರು ಇದ್ದು ದೊಡ್ಡ ಅಂತರದನಂತರ ಮಂದ ಪ್ರಕಾಶದ ಜಿ ಮತ್ತು ಇ ಉಂಗುರಗಳಿವೆ. ಇ ಉಂಗುರವು ಅತಿ ಮಂದ ಪ್ರಕಾಶವಾಗಿದೆ. ಆದರೆ ಇದು ಒಂದು ದಶಲಕ್ಷ ಕಿ.ಮೀ.ಅಗಲದವರೆಗೆ ಇದ್ದು ಸೂರ್ಯಮಂಡಲದಲ್ಲೇ ದೊಡ್ಡದೆನಿಸಿದೆ. ಕ್ಯಾಸಿನಿ ವೀಕ್ಷಿಸಿದಂತೆ ಎನ್ಸೆಲಾಡಸ್ ಚಂದಿರನು ತನ್ನಿಂದ ಇ ಉಂಗುರದ ಮೇಲೆ ದ್ರವ್ಯವನ್ನು ಹೊರಹಾಕುತ್ತಿರುವುದರಿಂದ ಭೂಮಿಯಲ್ಲಿ ಈ ಉಂಗುರವು ಬಹಳ ಮಂದ ಪ್ರಕಾಶದಿಂದ ಕಾಣುತ್ತಿರುವುದಾಗಿ ತಿಳಿದುಬಂದಿದೆ.

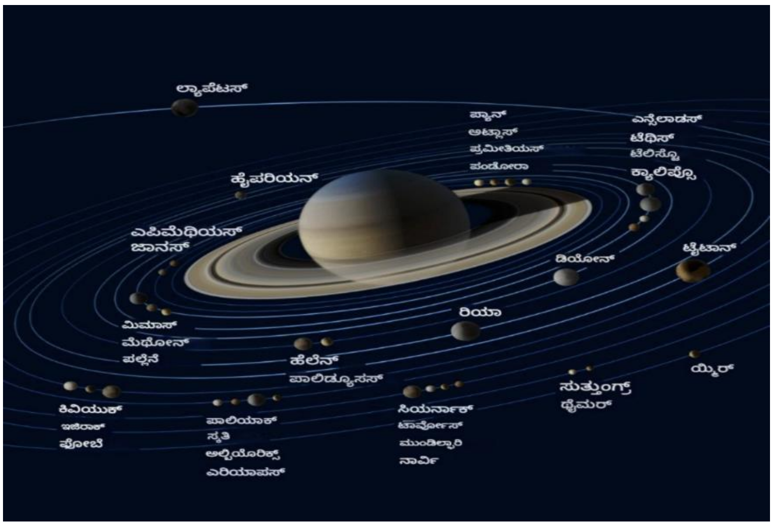
ಶನಿಗ್ರಹದ ಚಂದಿರರು

ಶನಿಗ್ರಹದ ಒಟ್ಟು 274 ಚಂದಿರರಿದ್ದು 131 ಚಂದಿರರು 50 ಕಿ.ಮೀ. ವ್ಯಾಸಕ್ಕಿಂತಲೂ ಕಡಿಮೆ ಇವೆ. ಅತಿ ಹತ್ತಿರದಿಂದ ಅನುಗುಣವಾಗಿ ಇರುವ ಕೆಲವು ಚಂದ್ರರು ಹೀಗಿವೆ. ಪ್ಯಾನ್, ಅಟ್ಲಾಸ್, ಪ್ರೊಮಿಥಿಯಸ್, ಪಂಡೋರ, ಎಪಿಮೆಥಿಯಸ್, ಜನಸ್, ಮಿಮಾಸ್, ಎನ್ಸಿಲಾಡಸ್, ಥೆತ್ಯಾಸ್, ಡಿಯೋನೆ, ರೇಹ, ಟೈಟನ್, ಹೈಪರಾನ್, ಲಪಿಟಸ್ ಮುಂತಾದ 274 ಚಂದ್ರರಿದ್ದಾರೆ (ಚಿತ್ರ 5). ಶನಿಯ ಚಂದಿರರಲ್ಲಿ 'ಟೈಟಾನ್'($TITAN$) ಶನಿಗ್ರಹವನ್ನು ಸುತ್ತುತ್ತಿರುವ ಅತಿದೊಡ್ಡ ಚಂದಿರನಾಗಿದ್ದು ಸೂರ್ಯಮಂಡಲದ ಬುಧ ಗ್ರಹಕ್ಕಿಂತಲೂ ದೊಡ್ಡ ಗಾತ್ರವಿದೆ. ಶನಿಗ್ರಹದ ಅತಿ ಚಿಕ್ಕ ಚಂದಿರನೆಂದರೆ 'ಅರಿನ' ($ARENA$). ಮತ್ತೊಂದು ಚಂದಿರನಾದ ಎನ್ಸೆಲಾಡಸ್ ($ENCELACTUS$) ದಪ್ಪ ಹಿಮಾವೃತ ಪದರದಿಂದ ಆವೃತವಾಗಿದ್ದು, ಅದರ ಕೆಳಗೆ ಸಾಗರಗಳಿರುವುದು ಪತ್ತೆಯಾಗಿದೆ. ಭವಿಷ್ಯದಲ್ಲಿ ಟೈಟಾನ್, ಅರಿನ ಮತ್ತು ಎನ್ಸೆಲಾಡಸ್ ಹೆಚ್ಚಿನ ಆದ್ಯತೆಯುಳ್ಳ ವೈಜ್ಞಾನಿಕ ಸಂಶೋಧನೆಯ ತಾಣವಾಗಿದೆ. ಶನಿಗ್ರಹದ ಎರಡನೇ ದೊಡ್ಡ ಚಂದಿರನಾದ 'ರಿಯಾ' ($RHEA$)ದಲ್ಲಿ ಸೂಕ್ಷ್ಮ ಉಂಗುರಗಳನ್ನು ಗುರುತಿಸಿದ್ದಾರೆ.

ಪ್ಯಾನ್: ಇದು ಶನಿಗ್ರಹದ ಅತಿ ಹತ್ತಿರದ ಚಂದ್ರನಾಗಿದ್ದು, 133.58 ಕಿ.ಮೀ. ಕಕ್ಷೆಯ ತ್ರಿಜ್ಯದಿಂದ ಶನಿಯನ್ನು ಸುತ್ತುತ್ತಿದೆ.

ಟೈಟಾನ್– $TITAN$: ಶನಿಗ್ರಹದ ಅತಿ ದೊಡ್ಡ ಚಂದಿರನಾಗಿದ್ದು ಸೂರ್ಯಮಂಡಲದಲ್ಲೇ ಗಾತ್ರದಲ್ಲಿ ಎರಡನೇ ದೊಡ್ಡ ಚಂದಿರ ಮತ್ತು ಬುಧ ಗ್ರಹಕ್ಕಿಂತಲೂ ದೊಡ್ಡದಾಗಿದೆ. ಶನಿಗ್ರಹದ ಸುತ್ತ ಸುತ್ತುತ್ತಿರುವ 274 ಚಂದ್ರರ ದ್ರವ್ಯರಾಶಿಯಲ್ಲಿ ಪ್ರತಿಶತ 96 ಭಾಗವನ್ನು ಟೈಟಾನ್ ಹೊಂದಿದೆ. ಉಳಿದ ಕೇವಲ ಪ್ರತಿಶತ 4 ಭಾಗವನ್ನು ಉಳಿದ ಚಂದ್ರರಲ್ಲಿ ಹಂಚಿಹೋಗಿವೆ. ಇದನ್ನು 1655ರಲ್ಲಿ ಕ್ರಿಶ್ಚಿಯನ್ ಹೈಗನ್ಸ್ ತನ್ನ ದೂರದರ್ಶಕದಿಂದ ಕಂಡುಹಿಡಿದರು. ಗ್ರೀಕ್ ಪುರಾಣದ ಹೆಸರಾದ ಟೈಟಾನ್‌ನ ವ್ಯಾಸವು 5150 ಕಿ.ಮೀ. ಇದ್ದು, ಒಳಭಾಗವು ಪ್ರತಿಶತ 80 ಭಾಗವು ಕಲ್ಲು ಬಂಡೆಗಳಿಂದ ತುಂಬಿದೆ. ನಾಸಾ ಸಂಶೋಧನೆಯಂತೆ, ಸೂರ್ಯಮಂಡಲದಲ್ಲೇ ಭೂಮಿಯ ಹೊರತಾಗಿ ಈ ಚಂದಿರನಲ್ಲಿ ವಾತಾವರಣವಿರುವುದು ಪತ್ತೆಯಾಗಿದೆ. ಟೈಟಾನ್‌ನ ಮೇಲ್ಮೈಯಲ್ಲಿ ದ್ರವರೂಪದ ಹೈಡ್ರೋಕಾರ್ಬನ್‌ಗಳಾದ ಮೀಥೇನ್ ಮತ್ತು ಈಥೇನ್‌ಗಳ ನದಿ, ಸರೋವರ ಮತ್ತು ಸಮುದ್ರಗಳಿರುವುದು ಸಂಶೋಧನೆಯಿಂದ ತಿಳಿದುಬಂದಿದೆ. ಅಲ್ಲದೆ ಇದರ ಮೇಲಿನ ನೀರು ಘನೀಕರಿಸಿದ್ದು ಅದರ ಕೆಳ ಭಾಗದಲ್ಲಿ ಸಮುದ್ರದ ಹರಿವಿದೆ ಎಂಬುದು ವಿಜ್ಞಾನಿಗಳ ಸಿದ್ಧಾಂತ. ಜೀವಿಗಳು ಉಗಮವಾಗಲು ಅವಶ್ಯವಿರುವ ಎಲ್ಲ ವಾತಾವರಣ ಮತ್ತು ಪರಿಸರ ವ್ಯವಸ್ಥೆ ಇದೆ ಎಂದು ನಾಸಾದ ಗ್ರಹ ವಿಜ್ಞಾನ ವಿಭಾಗದ ನಿರ್ದೇಶಕ ಲೋರಿ ಗ್ಲೇಜ್ ತಿಳಿಸಿದ್ದಾರೆ.

ಟೈಟಾನ್‌ನ ವಾತಾವರಣದಲ್ಲಿ ಸಾರಜನಕವು ಹೆಚ್ಚಿನ ಅಂಶದಲ್ಲಿ ಪತ್ತೆಯಾಗಿದೆ. ಇದಕ್ಕೆ ಕಾರಣ 2014ರ ನಾಸಾ ಸಂಶೋಧನೆ ಹೇಳುವಂತೆ ಸೌರಮಂಡಲದಿಂದ ಆಚೆ ಇರುವ ಓರ್ಟ್ ಮೋಡ($Oort\ Cloud$)ದಲ್ಲಿರುವ ಧೂಮಕೇತುಗಳು ಟೈಟಾನ್‌ನ ಹತ್ತಿರ ಬಂದಾಗ ಅವುಗಳಲ್ಲಿನ ಸಾರಜನಕವು ಟೈಟಾನ್ ವಾತಾವರಣದಲ್ಲಿ ಸೇರಿಹೋಗಿವೆ.



ಚಿತ್ರ 5 ಶನಿಗ್ರಹದ ಕೆಲವು ಚಂದಿರರು

ಎನ್ಸೆಲಾಡಸ್ (**$Enceladus$**): ಇದು ಶನಿ ಗ್ರಹದ ಎರಡನೇ ಹತ್ತಿರದ ಚಂದಿರ ಮತ್ತು ಆರನೇ ದೊಡ್ಡ ಚಂದಿರ. ಶನಿಯ ಎಲ್ಲಾ ಚಂದಿರರಲ್ಲಿ ಅತಿ ಪ್ರಕಾಶಮಾನವಾಗಿದ್ದು, ಇದನ್ನು 1789ರಲ್ಲಿ ಇಂಗ್ಲೀಷ್ ಖಗೋಳವಿಜ್ಞಾನಿಯಾದ ವಿಲಿಯಂ ಹರ್ಷಿಲ್ ಕಂಡುಹಿಡಿದರು. 500 ಕಿ.ಮೀ. ವ್ಯಾಸವನ್ನು ಹೊಂದಿರುವ ಈ ಚಂದಿರನ ಒಳಭಾಗದ ಸರಾಸರಿ ಸಾಂದ್ರತೆಯು ನೀರಿಗಿಂತ ಹೆಚ್ಚಾಗಿ ಇರುವುದರಿಂದ ಒಳಭಾಗವು ಮಂಜುಗಡ್ಡೆಯಲ್ಲದ ವಸ್ತುಗಳನ್ನು ಹೊಂದಿದೆ. ಮೇಲ್ಮೈಯಲ್ಲಿ ನೀರಿನ–ಮಂಜುಗಡ್ಡೆ, ಇಂಗಾಲಾಮ್ಲ, ಹೈಡ್ರೊ–ಕಾರ್ಬನ್, ಅಮೋನಿಯಾ ಮತ್ತು ಅನೇಕ ಜೀವರಾಸಾಯನಿಕ ವಸ್ತುಗಳನ್ನು ಹೊಂದಿದೆ. ಮೇಲ್ಮೆಯ ಕೆಳತಳದಲ್ಲಿ ಸಾಗರವಿರುವ ಪುರಾವೆಗಳು ಸಿಕ್ಕಿವೆ. ಇಲ್ಲಿ ಜೀವರಾಸಾಯನಿಕ ಅಣುಗಳಿರುವುದರಿಂದ ಜೀವಾಣುಗಳಿರುವ ಸಾಧ್ಯತೆಗಳಿವೆ.

1981ರಲ್ಲಿ ಅಮೇರಿಕದ ವಾಯೇಜರ್ ಉಪಗ್ರಹವು ಎನ್ಸೆಲಾಡಸ್‌ಗೆ 87000 ಕಿ.ಮೀ.ಗಳಷ್ಟು ಹತ್ತಿರದಲ್ಲಿ ಸುತ್ತುತ್ತಾ ಅದರ ಛಾಯಾಚಿತ್ರಗಳನ್ನು ಕಳುಹಿಸಿ ಸಂಶೋಧನೆಗೆ ಸಹಾಯಮಾಡಿತು. 2005ರಲ್ಲಿ ಕ್ಯಾಸಿನಿ ಉಪಗ್ರಹವು ಅನೇಕ ಉಪಯುಕ್ತ ಮಾಹಿತಿ ಒದಗಿಸಿತು. ಇದರಿಂದ ಚಿಲುಮೆಯಾಕಾರದಲ್ಲಿ ಹೊಗೆಯನ್ನುಗುಳುತ್ತಾ ನೀರು ಬರುವ ಮಾಹಿತಿಯನ್ನು ಒದಗಿಸಿದೆ.

ತೆತ್ಯಾಸ್ ($TETHYS$): ತೆತ್ಯಾಸ್‌ಅನ್ನು 1684ರಲ್ಲಿ ಇಟಲಿಯ ಜಿ.ಡಿ. ಕೈಸಿನಿ ಎಂಬ ಖಗೋಳವಿಜ್ಞಾನಿ ಕಂಡುಹಿಡಿದರು. ಇದು ಶನಿಗ್ರಹದ ಮೂರನೇ ಕಕ್ಷೆಯ ಚಂದಿರ ಮತ್ತು ಐದನೇ ದೊಡ್ಡ ಚಂದಿರನಾಗಿದೆ. ಅನೇಕ ಕುಳಿ ಮತ್ತು ಕೊಳ್ಳಗಳಿಂದ ಕೂಡಿದ ತೆತ್ಯಾಸ್ ಬಂಡೆ ಮತ್ತು ನೀರಿನ ಮಂಜುಗಡ್ಡೆಯಿಂದ ಕೂಡಿದೆ. 1066 ಕಿ.ಮೀ. ವ್ಯಾಸವನ್ನು ಹೊಂದಿರುವ ಇದು ಶನಿಯ ಸುತ್ತ ಒಂದು ಸುತ್ತು ಬರುವ ವೇಳೆಗೆ ಶನಿಯ ಮತ್ತೊಂದು ಚಂದಿರನಾದ ಮಿಮಾಸ್ ಎರಡು ಸುತ್ತು ಬರುತ್ತದೆ. ತೆತ್ಯಾಸ್‌ಗೆ ಟೆಲಿಸ್ಟೊ ಮತ್ತು ಕಲಿಪ್ಸೊ ಎಂಬ ಎರಡು ಚಂದಿರರಿದ್ದು ತೆತ್ಯಾಸ್‌ನ ಟ್ರೋಜಾನ್ ಚಂದಿರ ಎನಿಸಿಕೊಂಡಿದೆ. ಟ್ರೋಜಾನ್ ಅಂದರೆ ಚಿಕ್ಕ ವಸ್ತುಗಳು ದೊಡ್ಡ ವಸ್ತುವಿನ ಕಕ್ಷೆಯನ್ನೇ ಸ್ಥಿರವಾಗಿ ಅನುಸರಿಸುವುದು.

ಡಿಯೋನ್ ($DIONE$): ಇದನ್ನೂ ಸಹ 1684ರಲ್ಲಿ ಇಟಲಿಯ ಜಿ. ಡಿ. ಕೈಸಿನಿ ಎಂಬ ಖಗೋಳವಿಜ್ಞಾನಿಯೇ ಕಂಡುಹಿಡಿದರು. ಇದು ಶನಿಯ ನಾಲ್ಕನೇ ಚಂದಿರನಾಗಿದ್ದು, ಸಿಲಿಕೇಟ್ ಬಂಡೆಗಳಿಂದ ಕೂಡಿದ ಮೇಲ್ಮೈಯಲ್ಲಿ ಹಿಮದ ಗಡ್ಡೆಗಳಿಂದ ತುಂಬಿದೆ. ಡಿಯೋನ್ ಶನಿಗ್ರಹ ಸುತ್ತುವ ಕಕ್ಷೆಯು, ಭೂಮಿಯ ಚಂದಿರರ ಕಕ್ಷೆಯ ದೂರದಷ್ಟೇ ಇದೆ. ಇದು ಅನೇಕ ಕುಳಿಗಳಿಂದ ಕೂಡಿದ್ದು, ಮೇಲ್ಮೈಯ ಕೆಳಭಾಗದಲ್ಲಿ ನೀರಿನ ಸಮುದ್ರದಿಂದ ಕೂಡಿದೆ. ಇದು 'ಟ್ರೋಜಾನ್ ಚಂದಿರರ($TROJAN\ MOONS$) ಗುಂಪಿಗೆ ಸೇರಿದೆ. ಹೆಲೆನೆ ($HELENE$) ಮತ್ತು ಪೊಲಿಡಿಯೂಸಿಸ್ ($polydeuces$) ಗಳು ಡಿಯೋನ್‌ಅನ್ನು ಅನುಸರಿಸಿ ಅದರ ಟ್ರೋಜಾನ್ ಚಂದಿರಗಳು ಎನಿಸಿಕೊಂಡಿವೆ.

ರೇಹ ($REHA$): ರೇಹ ಶನಿಗ್ರಹದ ಐದನೇ ಮತ್ತು ಎರಡನೇ ದೊಡ್ಡ ಚಂದಿರನಾಗಿದ್ದು, 1528 ಕಿ.ಮೀ. ಸರಾಸರಿ ವ್ಯಾಸವನ್ನು ಹೊಂದಿದೆ. ಇದನ್ನೂ 1672ರಲ್ಲಿ ಜಿ. ಡಿ. ಕೈಸಿನಿ ಎಂಬ ಖಗೋಳವಿಜ್ಞಾನಿಯೇ 10.4 ಮೀ. ದೂರದರ್ಶಕದಿಂದ ಕಂಡುಹಿಡಿದರು. 2008ರಲ್ಲಿ ನಾಸಾ ವಿಜ್ಞಾನಿಗಳು, ಶನಿಗ್ರಹದಂತೆ ರೇಹ ಸುತ್ತಲೂ ಕೆಲವು ಕ್ಷೀಣವಾಗಿ ಕಾಣುವ ಉಂಗುರಗಳಿವೆಯೆಂದು ಸಂಶೋಧಿಸಿದ್ದಾರೆ. ರೇಹದ ಸಾಂದ್ರತೆಯು ಕಡಿಮೆ ಇರುವುದರಿಂದ 3/4 ಭಾಗ ಹಿಮಗಡ್ಡೆಯಿಂದಲೂ ಮತ್ತು 1/4 ಭಾಗ ಕಲ್ಲುಬಂಡೆಗಳಿಂದಲೂ ಕೂಡಿದೆಯೆಂದು ತಿಳಿದುಬಂದಿದೆ. ಇದು ತನ್ನ ಅಕ್ಷದಮೇಲೆ ತಿರುಗುವ ವೇಗ ಮತ್ತು ಶನಿಯನ್ನು ಸುತ್ತುವ ವೇಗ ಒಂದೇ ಆಗಿರುವುದರಿಂದ, ಇದರ ಒಂದೇ ಗೋಳಾರ್ಧವು ಶನಿಯನ್ನು ಮುಖ ಮಾಡಿರುತ್ತದೆ. 2010ರ ನಾಸಾ ಸಂಶೋಧನೆಯಂತೆ ರೇಹದ ವಾತಾವರಣವು ಆಮ್ಲಜನಕ ಮತ್ತು ಇಂಗಾಲದಡೈಆಕ್ಸೈಡ್‌ಗಳನ್ನು 5:2 ಪ್ರಮಾಣದಲ್ಲಿ ಹೊಂದಿದೆ.

ಐಯಪಿಟಸ್ ($IAPETUS$): ಐಯಾಪಿಟಸ್ ಶನಿಗ್ರಹದ ಮೂರನೇ ದೊಡ್ಡ ಚಂದಿರ. ಇದನ್ನೂ 1671ರಲ್ಲಿ ಡಿ. ಕೈಸಿನಿ ಎಂಬ ಖಗೋಳವಿಜ್ಞಾನಿಯೇ ಕಂಡುಹಿಡಿದರು. 1468 ಕಿ.ಮೀ. ವ್ಯಾಸವನ್ನು ಹೊಂದಿದ್ದು ರೇಹದಂತೆ ಇದೂ ಕೂಡಾ ಮೇಲ್ಭಾಗ ಹಿಮಗಡ್ಡೆಯಿಂದಲೂ ಒಳಭಾಗ ಕಲ್ಲು ಬಂಡೆಯಿಂದಲೂ ಕೂಡಿದೆ. ಐಯಪಿಟಸ್‌ನ ಒಂದು ಭಾಗವು ಮತ್ತೊಂದಕ್ಕಿಂತ ಹೆಚ್ಚು ಕತ್ತಲೆಯಿಂದ ಕೂಡಿದೆ. ಇದರ ಸಮಭಾಜಕ ವೃತ್ತದಲ್ಲಿ 10 ಕಿ.ಮೀ. ಎತ್ತರದ ಪರ್ವತಗಳ ಶ್ರೇಣಿಗಳನ್ನು ಕಾಣಬಹುದೆಂದು ಅವು ಸೂರ್ಯಮಂಡಲದಲ್ಲೇ ಎತ್ತರವಾದವುಗಳೆಂದು ತಿಳಿದುಬಂದಿದೆ.

ಮಿಮಾಸ್ ($MIMAS$): ಶನಿಗ್ರಹದ ಏಳನೇ ದೊಡ್ಡ ಚಂದಿರನಾದ ಮಿಮಾಸ್ 396.4 ಕಿ.ಮೀ. ವ್ಯಾಸವನ್ನು ಹೊಂದಿದ್ದು 1789ರಲ್ಲಿ ವಿಲಿಯಂ ಹರ್ಷಿಲ್ ಕಂಡುಹಿಡಿದರು. ಇದನ್ನು ಸ್ಯಾಟರನ್1 ಎಂದೂ ಕರೆಯುವರು. ಏಕೆಂದರೆ ಅದನ್ನು ಕಂಡುಹಿಡಿದ ಸಮಯದಲ್ಲಿ ಮಿಮಾಸ್ ಚಂದಿರನು ಅದುವರೆಗೆ ಕಂಡುಹಿಡಿದ ಎಲ್ಲಾ ಚಂದಿರರಿಗಿಂತ ಅತ್ಯಂತ ಹತ್ತಿರದ ಕಕ್ಷೆಯನ್ನು ಹೊಂದಿತ್ತು. ತನ್ನದೇ ಆದ ಗುರುತ್ವಾಕರ್ಷಣೆಯಿಂದ ಮಿಮಾಸ್ ಗೋಳಾಕಾರವನ್ನು ಹೊಂದಿದೆ. ಇದು ನೀರಿನಿಂದ ಕೂಡಿದ ಮಂಜುಗಡ್ಡೆ ಮತ್ತು ಸ್ವಲ್ಪ ಬಂಡೆಯಿಂದ ಕೂಡಿದೆ. ಇದು ದೊಡ್ಡದಾದ 'ಹರ್ಷಿಲ್' ಎಂಬ ಕುಳಿಯಿಂದ ಕೂಡಿದೆ. ಈ ಚಂದಿರನು ತಿರುಗುವಾಗ ಅನುರಣನ ($Resonance$)ಉಂಟಾಗಿ 'ಕ್ಯಾಸಿನಿ ವಿಭಾಗ' ಎಂಬ ಶನಿಗ್ರಹದ ಉಂಗುರಗಳು 'ರಿಂಗ್ ಎ' ಮತ್ತು 'ರಿಂಗ್ ಬಿ' ಎಂಬ ವಿಭಾಗವಾಗುತ್ತವೆ. 2024ರ ಸಂಶೋಧನೆಯಂತೆ ಇದರ 20ರಿಂದ 30 ಕಿ.ಮೀ. ಕೆಳಗೆ ಸಾಗರವಿರುವುದು ಪತ್ತೆಯಾಗಿದೆ. ನಾಸಾ ವೀಕ್ಷಣೆಯ ಪ್ರಕಾರ, ಈ ಚಂದಿರನನ್ನು ಒಂದು ಗೊತ್ತಾದ ಕೋನದಿಂದ ವೀಕ್ಷಿಸಿದರೆ ಅಂತರಿಕ ಶಾಖದ ವೈಪರೀತ್ಯಗಳಿಂದ ಸೂಪರ್ ಲೇಸರ್‌ನಂತೆ ಕಾಣುತ್ತಾ 'ಡೆತ್ ಸ್ಟಾರ್'ಅನ್ನು ಹೋಲುವ ಆಕಾರವನ್ನು ತಾಳುತ್ತದೆ.

ಹೈಪರೈಯಾನ್ ($HYPERION$): ಇದು ಶನಿಯ ಎಂಟನೇ ದೊಡ್ಡ ಚಂದಿರ, ಸ್ಪಾಂಜ್‌ನಂತೆ ಇದ್ದು ಗೋಳಾಕಾರದಲ್ಲಿರದೆ ಆಲೂಗಡ್ಡೆಯ ಆಕಾರದಲ್ಲಿದೆ. ಇದು ಸೂರ್ಯಮಂಡಲದಲ್ಲೇ ಅನಿಯಮಿತ ಆಕಾರದ ಅತಿ ದೊಡ್ಡ ಚಂದಿರನಾಗಿದೆ. ಆಗಸದ ಉಲ್ಕೆಗಳ ಘರ್ಷಣೆಯಿಂದ ಹೈಪರೈಯಾನ್‌ನಲ್ಲಿ ಅನೇಕ ಕುಳಿಗಳನ್ನು ಕಾಣಬಹುದು. 2005ರ ನಾಸಾದ ಕೈಸಿನಿ–ಉಪಗ್ರಹದ ಛಾಯಾ ಚಿತ್ರದಿಂದ ಹೈಪರೈಯಾನ್ ನಮ್ಮ ಭೂಮಿಯ ಚಂದಿರನಂತೆ ಸ್ಟಾಟಿಕ್ ಛಾರ್ಜ್ ಆದ ಮೇಲ್ಮೈಯನ್ನು ಹೊಂದಿದೆಯೆಂದು ತಿಳಿದುಬಂದಿದೆ.

ಶನಿಗ್ರಹದಲ್ಲಿ ವಜ್ರ

ಸೂರ್ಯಮಂಡಲದಲ್ಲಿರುವ ಅನಿಲದೈತ್ಯಗಳಾದ ಗುರು, ಶನಿ, ಯುರಾನಸ್ ಮತ್ತು ದೂರದ ಬಾಹ್ಯಗ್ರಹಗಳು ಮತ್ತು ಕೆಲವು ನಕ್ಷತ್ರಗಳು ತಮ್ಮಲ್ಲಿ ವಜ್ರವನ್ನು ಸೃಷ್ಟಿಸಿ ಮತ್ತಷ್ಟು ಪ್ರಕಾಶತೆಯಿಂದ ಹೊಳೆಯುತ್ತಿವೆ. 1981ರಲ್ಲಿ ಮಾರ್ವಿನ್ ರಾಸ್ ಎಂಬ ಖಗೋಳವಿಜ್ಞಾನಿಯು ಮಂಜಿನಿಂದ ಕೂಡಿರುವ ಸೂರ್ಯಮಂಡಲದ ದೈತ್ಯಗ್ರಹಗಳಲ್ಲಿ ವಜ್ರವಿರುವುದಾಗಿ ಪ್ರಸ್ತಾಪಿಸಿದ್ದರು. ಶನಿಯಲ್ಲಿನ ವಾತಾವರಣದ ತೀವ್ರ ಒತ್ತಡ ಮತ್ತು ಉಷ್ಣಾಂಶದ ಪರಿಸ್ಥಿತಿಯಿಂದ ಅದರಲ್ಲಿರುವ ಹೆಚ್ಚಿನ ಅಂಶವಾದ ಮೀಥೇನ್ ಅನಿಲವು ವಿಭಜನೆಯಾಗಿ ಇಂಗಾಲದ ಧಾತುವನ್ನು ಬಿಡುಗಡೆ

ಮಾಡುತ್ತದೆ. ಬಿಡುಗಡೆಯಾದ ಇಂಗಾಲವು ತೀವ್ರ ಒತ್ತಡ ಮತ್ತು ಉಷ್ಣಾಂಶದ ಪರಿಣಾಮವಾಗಿ, ಅದರ ಬಹುರೂಪಗಳಾದ ಗ್ರಾಫೈಟ್ ಮತ್ತು ವಜ್ರವಾಗಿ ರೂಪಿತವಾಗುತ್ತದೆ. ಹೀಗೆ ಉತ್ಪತ್ತಿಯಾದ ವಜ್ರವು ವಾತಾವರಣದಿಂದ ಶನಿ ಗ್ರಹದ ಮೇಲ್ಮೈಯನ್ನು ಪ್ರವೇಶಿಸುವ ಮುಂಚಿತವಾಗಿ ಅಲ್ಲಿನ ವಾತಾವರಣದ ಉಷ್ಣಾಂಶದಿಂದ ಕರಗಿ ದ್ರವರೂಪದ ವಜ್ರದ ಮಳೆಯು ಶನಿ ಗ್ರಹದ ಮೇಲ್ಮೆಯಲ್ಲಿ ಬೀಳುತ್ತದೆಯೆಂದು ವಿಜ್ಞಾನಿಗಳ ಸಂಶೋಧನೆ ಹೇಳುತ್ತದೆ.

ಭೂಮಿಯ ವಾತಾವರಣದೊಡನೆ ಆವೇಶಗೊಂಡ ಕಣಗಳ $(charged\ particles)$ ಪರಸ್ಪರ ಕ್ರಿಯೆಯಿಂದ ಉತ್ತರ ಮತ್ತು ದಕ್ಷಿಣ ಧ್ರುವಗಳಲ್ಲಿ ಸಂಭವಿಸುವ ಅರೋರಾಗಳಂತೆ, ಶನಿ ಮತ್ತು ಗುರು ಗ್ರಹಗಳಲ್ಲೂ ಅರೋರಾಗಳು ಸಂಭವಿಸುತ್ತವೆ.

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ಶನಿಯ ಅಧಿಪತ್ಯ

ಶನಿ ಶನಿಯೆನ್ನದಿರಿ ವಜ್ರದ ಮಳೆ ಸುರಿಸುತಿಹನು
ಸೂರ್ಯ ಮಂಡಲದಲ್ಲವನು ಆರನೇ ಗ್ರಹವಾಗಿಹನು।।
ಮಂಜು ಕಲ್ಲುಗಳ ಉಂಗುರಗಳ ತೊಡಿಸಿಹರು ಹಲವಾರು
ಮಿನುಗುತಿಹನವನು ಸೂರ್ಯನ ಎದುರ ದಿಕ್ಕಿನಲವನು।।
ಅವನ ಸುತ್ತ ತಿರುಗುತಿಹರು ಚಂದಿರರು ಇನ್ನೂರೆಪ್ಪತ್ನಾಲ್ಕು
ಅವುಗಳಲಿ ಮುಖ್ಯರು ಟೈಟಾನ್, ಎನ್ಸಿಲಾಡಸ್, ಥೆತ್ಯಾಸ್, ಡಿಯೋನ್, ರೇಹ।।
ಕೆಲವು ಚಂದಿರರೊಡನೆ ಟ್ರೋಜನ್ ಚಂದಿರರಿಹರು
ನೀರ ಮೇಲೆ ತೇಲಬಹುದವನ ಕಡಿಮೆ ಸಾಂದ್ರತೆಯಲಿ।।
ಕಳುಹಿಸಿಹರು ಭೂಮಿಯಿಂದ ಕ್ಯಾಸಿನಿ, ವಾಯೆಜರ್ ಸಂಶೋಧಕಗಳ
ಜೀವಿಗಳಿಗೆ ಇರುವುದವನ ಚಂದಿರ ಟೈಟಾನ್‌ನಲ್ಲಿ ನೀರು।।
ಒಂದು ಬಾರಿ ಸೂರ್ಯನನ್ನು ಸುತ್ತಲವಗೆ
ಇಪ್ಪತ್ತೊಂಬತ್ ಭೂ ವರ್ಷಗಳು।।
ಒಂದು ಬಾರಿ ತನ್ನ ಅಕ್ಷದ ಮೇಲೆ ತಿರುಗಲವಗೆ
ಬೇಕು ಹದಿನಾರು ಭೂ ದಿನಗಳು।।
ಚಿತ್ರಗಳನು ಕಳುಹಿಸಿಹುದು ಹಬಲ್ ಸಂಶೋಧನೆಗೆಂದು
ಶನಿಯ ಅಧ್ಯಯನ ನಡೆಯುತಿದೆ ಇದೀಗ।।

ಡಾ. ಶಾರದಾ ನಾಗಭೂಷಣ

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Recent Scientific Discoveries

1. **Water on the Moon's Surface (2020):** NASA confirmed the presence of water molecules on the Moon's surface, even in sunlit areas. This discovery is crucial for future lunar exploration and establishing a sustainable human presence there.

2. **New Exoplanet Atmosphere (2023):** Scientists observed an exoplanet called WASP-121b with a highly inflated atmosphere containing heavy metals like magnesium and iron, providing clues about planetary formation and weather systems outside our solar system.

3. **Quantum Entanglement Over Long Distances (2021):** Researchers achieved quantum entanglement over a record distance of 6,200 km between satellite and ground stations, advancing quantum communication security.

4. **Plastic-Eating Enzymes (2022):** Scientists engineered enzymes capable of breaking down plastics much faster than before, offering promising solutions for combating plastic pollution.

5. **Advances in Artificial Intelligence (2024):** AI models like GPT-4 have become more powerful and nuanced, aiding scientific research in fields like materials science, climate modelling, and drug discovery.

ACTIVITIES OF KPA MEMBERS (1 May – 31 July 2025)

Activities of H D Ananda from 01 Apr 2025 onwards

Programs for engineering students, college students, and teachers on:

- **Quantum Computing (including "Quantum Computing for Teachers" and "Quantum Computing for High School Students")**
- **Quantum Computing & Its Applications in AI, ML, and DL**
- **Fundamentals of Satellites and Rockets**
- **Physics in Play at Satellite Control Stations – Master Control Facility, ISRO**
- **Overview of the Indian Space Programme**

GSSS College of Engineering for Women Mysore on 02 Apr 2025

Oxford College of Engineering Bengaluru on 08 May 2025

BET Convent RR Nagar, Bengaluru on 14th June 2025

SDC Independent PU College, Kolar on 22 May 2025

Agastya International Foundation Kuppam on 27th June

Activities of Dr. B A Kagali

1. Two talks delivered to teachers at Siddaganga Public School, Bengaluru, on the topics: a. The Scientific Method and b. Methods of teaching science on 12th May, 2025.
2. Lecture on 'Artificial Intelligence and its applications' delivered to college teachers at Hospet, 13th May 2025
3. Talk on 'Quantum Science and Technologies' presented on 18th July, 2025 at Gadag.

Gadag Workshop

Activities of Dr.B S Srikanta and Dr.T Shivalingaswamy

As a part of the Lecture programs by KPA, a program was organised at BGS High School, Mysore, on 23rd July 2025. Dr B S Srikanta and Dr Shivalinga Swamy participated in the program as resource persons. Lecture cum Demonstration on electricity and an introductory talk on Classical Physics, Quantum Physics and Quantum Computers were conducted. Students exhibited their curiosity and enthusiasm to learn and understand new concepts to a considerable high level. Response from students was overwhelming.

Prof. Srikanta

Dr, Shivalingaswamy

Activities of Dr.Paniveni U Shankar

Dr. Paniveni visited Sri. Vivekananda High School, Mooganahundi, Jayapura Hobli, at the outskirts of Mysore She has been donating to that school in her capacity every year for a long time. On 19th June 2025, when she went to the school, she gave some donations, participated in a teaching activity and recorded a couple of light classical songs for a group of students who could sing well. She also distributed Kits, sponsored by another great lady, to the teachers.

LIST OF WEBINARS HELD BY KPA (1 May – 31 July, 2025)

NO.	SPEAKER	TOPIC	DATE
1	Dr.Hariharan N	Analysis of Brain Signals	04.05.2025
2	Dr.K S Mallesh	Deutsch algorithm	11.05.2025
3	Dr.D K Srivastava	Science Beyond CERN	18.05.2025
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9	Dr. Paniveni U.Shankar	The Sun and Supergranules	29.06.2025
10	Dr. Revanasiddappa M	Radiation Pollution and its impacts	05.07.2025
11	Dr. R Nagendra	Seismic Profile Analysis	13.07.2025