2023

MACROCOSM

A PHYSICS MAGAZINE

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TEACHER EDITOR'S NOTE

Dear Readers,

It gives me immense pleasure to present this edition of our departmental magazine, a vibrant tapestry of ideas, discoveries, and creativity woven together by the brilliant minds of our students and contributors. From the mysteries of quantum mechanics to the grandeur of cosmic exploration, this issue is a testament to the boundless curiosity that defines the spirit of physics.

Science is not confined to textbooks or laboratories—it thrives in kitchens, dances in celestial choreography, and even whispers in the verses of poetry. This edition beautifully captures that essence, blending rigorous research with imaginative storytelling. Whether it's Stephen Hawking's theories on aliens, the marvels of the James Webb Space Telescope, or India's lunar ambitions, each article invites you to see the universe through a lens of wonder and inquiry.

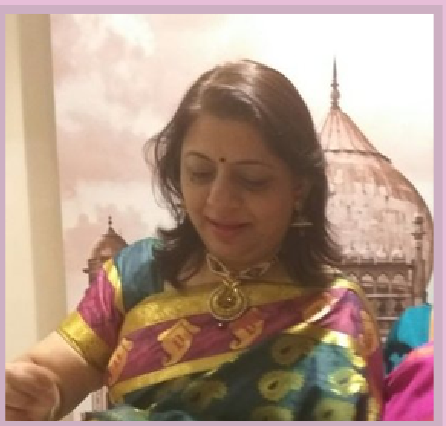
Special appreciation goes to our student editors and writers for their dedication. The inclusion of Women in Science and artistic tributes to legends like Dr. Asima Chatterjee and Purnima Sinha adds depth, reminding us that science is a collective human endeavor.

As you flip through these pages—whether solving the Astro-Puzzle, exploring Strange Facts About the Solar System, or simply losing yourself in Midnight Stargazing—I hope you feel the same excitement that drives every physicist: the thrill of asking, "What if?"

Keep questioning, keep dreaming, and let physics light your way.

Punita Verma
Chief Teacher Editor

MEET THE TEAM



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TALES

SCIENCE IN ***KITCHEN***

Two friends Jay and Om were cooking Maggi inside the kitchen. Jay asked Om-" Hey have you ever wondered how this raw packet turns into a delicious bowl of Maggi". Om said- " Yeah I think about that too, but never got any satisfactory actions". Jay said-"well let me explain"

First, we put a vessel on the stove and then turn it on. The stove starts burning and transfers heat to the vessel which is at room temperature (lower temperature than the stove).

Then we pour water into the vessel, the vessel transfers the heat it gets from the stove to the molecules of water that increase its kinetic energy and make it warm and then slowly it reaches its boiling point. While it's reaching its boiling point, we can see that some of the water on the surface is turning into vapour. Reaching boiling point simply means that the pressure exerted by the formed vapour becomes equal to the atmospheric pressure.

This is a good time to add Maggi. The Maggi is dry so when we put it in the hot water, the water starts flowing inside it. Now you may ask why the water molecules flow in this manner.

The answer is simple water flows from where it is more to the place where it is less, hence inside the dry Maggi. Over time, the Maggi absorbs enough water and becomes soft.

Now we add our masala to make it tasty and wait for the rest of the water to evaporate.

Our Maggi is readyyy!!!

'Isn't it easy?', asked Jay.

Om said, 'Sure it is. Now let's enjoy.'

-Suruchi
BSc. Physics Hons.

SWIMMING?

If you love science but swimming scares you,
you'll find it very helpful

If you love science but swimming scares you, you'll find it very helpful - as I did when I was learning swim – to think about newtons three law of motion. Among the most fundamental rules of physics, these three basic principles are enough to explain completely the movement of almost every single object you are ever likely to come across.

The first law outlines the concept of inertia. It says that things stay still or move steadily (at the same speed) unless something pushes or pulls them (unless some kind of force is applied). The second and third laws are of more interest.

The second law explains the connection between force and acceleration: if you push or pull something, it starts moving (if it was still to begin with) or goes faster (if it was moving already); the bigger the force you apply, the more acceleration you get; the longer you apply the force, the bigger the change in momentum you can achieve.

Where swimming is concerned, the third law is perhaps the most important. It says that when you apply a force to an object, the object returns the favors and applies an equal force to you- in the opposite direction.

This law is often called action and reaction and it's the simplest way for a scientific non-swimmer to make sense of the water. You probably know already that if you kick backward against the wall of a swimming pool, you shoot forward through the water. The same applies to actual swimming strokes. Simply speaking, if you want to swim forward through water, you have to pull water backward with your hands. If you want your body to stay up, floating on the surface, you need to kick down with your legs.

If you are swimming along and you want to stop suddenly and stand up, you can pull your hands down in front of you (in a kind of circular motion- a bit like bowing down) and your legs will swing down behind you, so you land in an upright position on your feet.

Master these basic moves- Simple applications of newton's third law- and you will find you will be able to swim easily and stop confidently whenever you need to.

It doesn't matter whether the animal has eight legs, four legs, two, even if it swims with no legs.

BY-
ISHIKA KUMARI
B.SC PHYSICS HONOURS
IIIRD YEAR

EDITORIAL

WOMEN IN SCIENCE

Unleashing the Power of Her Mind

Women breaking barriers in Science

By Suruchi Singh

Hii there, do one thing :- Close your eyes and imagine a scientist. Who do you see? A male or a female? I bet 90% of you would've imagined a man as scientist. If you're in the other 10% then I must really congratulate you , very well done. But if you were in the 90% group then don't worry it's not your fault because the STEM field IS dominated by the male scientists. My aim through this article is to tell you about those powerful women whose minds made the world we see as of now. Just like black holes in the outer space, women might be minority in STEM but the impact they have is huge.

For example, here's a picture of "MARGARET HAMILTON"

WHAT'S IN?

TAKE A LOOK INSIDE

Women you know, and people you don't

ARE YOU READY TO LIST?

PROGRAMMER?

ASTRONOMER?

SCIENTIST?

TEACHER?

CHEMIST?

WRITER?

ENTERPRENUER?

She was an American computer scientist and software engineer. She handwrote the entire code that made the first human landing on the moon possible. In the picture above you can see her standing beside the code that she handwrote. She was the lead programmer for NASA's Apollo guidance programme. I bet you're impressed by her. Aren't you?

Another such example is Vera Rubin, who was an astronomer and pioneered work on galaxy rotation rates. Her work revolutionized our understanding of the universe. She discovered the discrepancy between the predicted and observed angular motion of galaxies by studying galactic rotation curves . This phenomenon became known as the galaxy rotation problem. Her work was the first direct evidence of the presence of dark matter. Yes, the very famous dark matter was discovered by her. Isn't it amazing to know?

Talking about women in Mathematics???

Allow me to introduce you to "KATHERINE JOHNSON". She was a mathematician whose calculations of orbital mechanics as a NASA employee were critical. She used to calculate flight paths of many spacecrafts. Her work was critical to the success of the first and subsequent U.S. crewed spaceflights. She was one of NASA's human computers. And then there are people who still believe that women are not good at math, how lame right?

WHAT ABOUT MIGHTY PHYSICS?

Women have also aced the physics -which is considered the toughest subject by many. One such example is "MARIA GOEPPERT MAYER". She was a German-American theoretical physicist. She was the second women to win a Nobel Prize in Physics. She proposed the nuclear shell model of the atomic nucleus. Her theory explained why some nuclei were more stable than other and why some elements were rich in isotopes.

CURIE OR CURIOUS?

How can we talk about women is STEM and not talk about "MARIE CURIE", one of the greatest physicist and chemist to ever exist. She was the first person to win two Nobel Prizes, in Physics and Chemistry. Her accomplishments include discovering radioactivity, discovering radioactive elements such as radium and polonium. She changed the way scientists understood the atom. Fun fact about her: her daughter also won a Nobel prize in chemistry for the breakthroughs she had made in the synthesis of new radioactive elements.

D.N.A

Now let us meet Rosalind Franklin. She was a chemist and Xray crystallographer. Rosalind was best known for her contributions to the discovery of the molecular structure of DNA which were a crucial part of the research that led to the discovery of the structure of DNA. Her work was also crucial in understanding of the molecular structure of RNA, viruses etc. Want to know an amazing fact about her? She has an asteroid named after her.

DID THEY AMAZE YOU?

I KNOW THEY DID!

I guess I've given you examples from every STEM field out there. Hence, I stop here. At last, I can only remember a quote : "Behind every successful man, there is a woman, but behind every successful woman is herself". One of us are going to become physicist, chemist, mathematician, biologist and engineers. So fellow ladies what are you waiting for? The future is ours to make, therefore work hard today so that the future of the country is bright tomorrow.

STEPHEN HAWKING'S THEORY ON ALIENS

Stephen Hawking's cautionary words about potential extraterrestrial threats indeed sparked widespread debate and intrigue, yet my perspective offers a unique angle to consider. When pondering the possibility of alien contact, it's essential to factor in the immense distances in our universe.

These are the possible factors:-

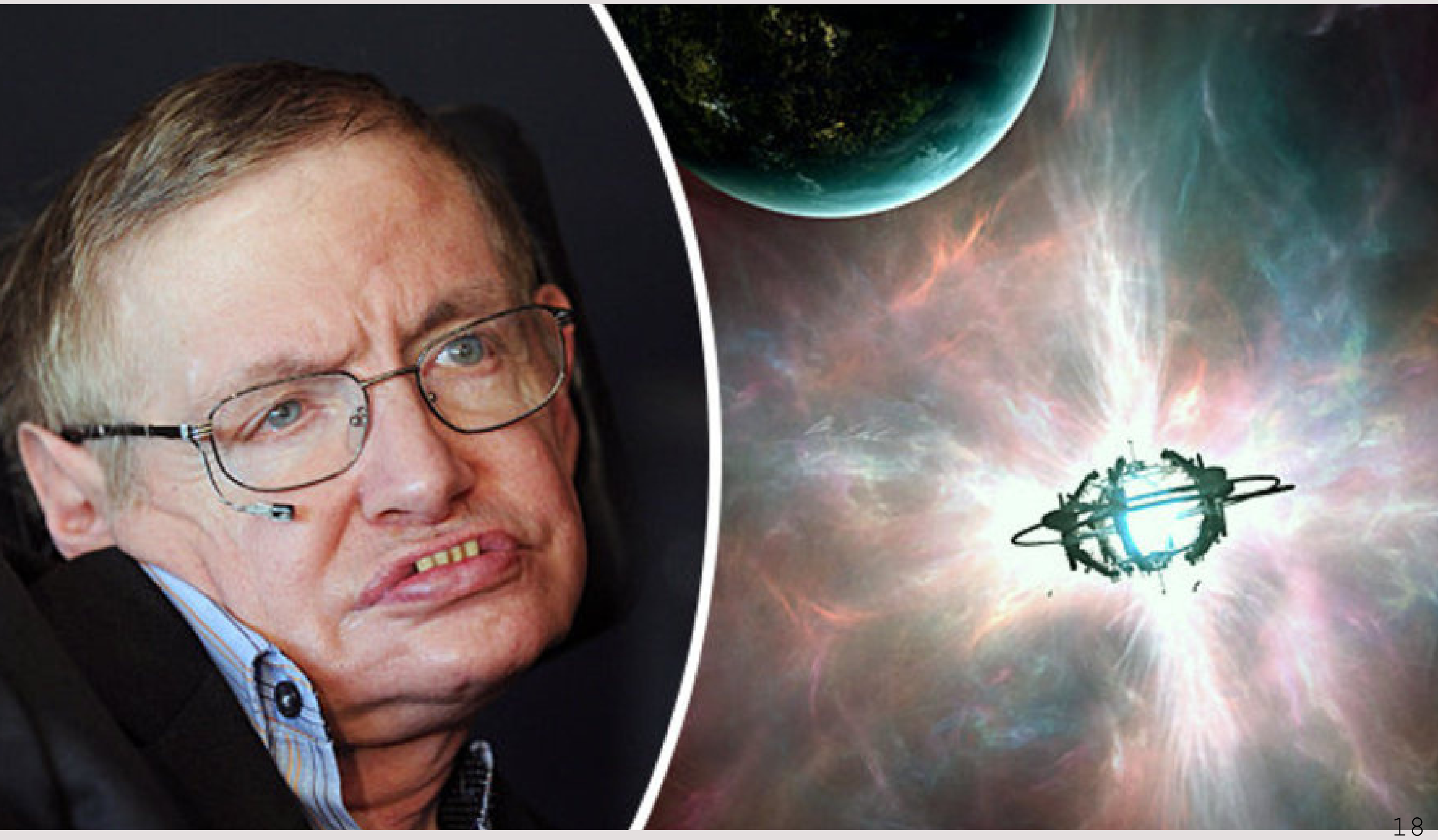
1. If aliens are going to traveling at a relatively modest speed, such as 100km/h-1000km/h, the vastness of space means that it will take them an enormous amount of time to cover interstellar distances, to reach out us. This reasoning aligns with the idea that there may not be any aliens within a relatively close 500 light-years proximity.

2. My notion about the behavior of aliens entering our universe is intriguing. If they are going to approach us at the speed of light,from the same universe, my understanding of the laws of physics suggests that they will undergo a transformation into photons, according to the laws of our universe.

3. This principle applies whether they originate from other another universe, as they enter into our universe, the laws of our physics they have to follow. These considerations lead to the conclusion that regardless of the speed or at the speed of light, at which aliens approach, they will either require an incredible amount of time to reach us or become photon.

In these contexts, my opinion is Stephen Hawking's theory on aliens (danger from aliens) might be wrong, suggesting that the practicalities of space and the laws of the universe could make close encounters with advanced extraterrestrial civilizations a considerably less imminent threat than previously imagined.Also this may violets the some laws of Physics.

-Mayank Jain



“If the universe is an artificial simulation then the mathematics is its code and a physicist is a programmer.”
- Shubham Sanap.

A Cosmic Eye in the Sky:
The James Webb Space Telescope

Humanity has often looked up to the cosmos and pondered our place in it. From early philosophers to contemporary scientists, there's a shared curiosity about understanding the universe. In the present day, our quest for understanding the cosmos is significantly aided by a remarkable instrument: the James Webb Space Telescope, which will be referred to as JWST from now on.

The JWST will study every phase of cosmic history, from within our solar system to the most distant observable galaxies in the early universe. Webb's infrared telescope will explore a wide range of science questions to help us understand the origin of the universe and our place in it.

According to NASA, JWST was created based on the results presented by the Hubble Space Telescope. The Hubble Space Telescope was launched in 1990, and it primarily studied the universe at optical and ultraviolet wavelengths with minor infrared capabilities. In Hubble's results, it was discovered that more distant objects are highly redshifted (stretching of light to longer wavelengths over time as the universe expands), and their light is pushed from the UV and optical into the near-infrared. Thus, observations of these distant objects require an infrared telescope, and this is where JWST comes into the picture.

Image of the pillars of creation
Left: By the Hubble Space Telescope
Right: By the James Webb Space Telescope

JWST's key areas of scientific interest are:

- Searching for the first galaxies that formed in the early universe
- Studying galaxies near and far to inform the evolution of galaxies
- Observing the life cycles of stars, from the first stellar nurseries to the formation of planetary systems
- Measuring the physical and chemical properties of planetary systems, including our solar system, and investigating the potential for life on planets that orbit other stars in addition to all this, JWST can forge additional questions that can be addressed in future missions and observatories.

Now the obvious question that emerges is: how are JWST's infrared capabilities important to astronomy? The answer is that infrared light allows us to see details in the universe and determine the composition of distant objects, from exoplanets to galaxies. With its longer wavelengths, infrared light can also penetrate dense star-forming clouds, whose dust blocks most of the light detectable by visible-light telescopes like Hubble. It also allows us to study some of the first galaxies to form after the Big Bang.

Webb will gaze into the time when the very first stars and galaxies formed, over 13.5 billion years ago. Ultraviolet and visible light emitted by the very first luminous objects has been stretched by the universe's continual expansion and arrives today as infrared light. Webb is designed to capture this infrared light with unprecedented resolution and sensitivity.

JWST's scientific instruments primarily have two functions:

- Imaging scientific targets
- Spectroscopy: breaking down light into separate wavelengths to determine the physical and chemical properties of various forms of cosmic matter

For this purpose, there are the following instruments and their wavelength ranges:

- NIRCam (Near-Infrared Camera): 0.6-5 microns
- NIRSpec (Near-Infrared Spectrograph): 0.6-5.3 microns
- MIRI (Mid-Infrared Instrument): 4.9–27.9 microns
- NIRISS (Near-Infrared Imager and Slitless Spectrograph): 0.6 – 5 microns

JWST was launched on December 25, 2021, from French Guiana aboard the Ariane 5 launch vehicle. The telescope orbits approximately one million miles from Earth, orbiting the second Sun-Earth Lagrange point (L2). Its mass is approximately 6200 kg. It covers wavelengths in the range of 0.6 to 28.5 microns in the infrared region and has an optical resolution of about 0.1 arc seconds. The mission duration of JWST is 5-10 years. The size of the primary mirror is over 6.5 m in diameter and consists of 18 hexagonal mirror segments. The mirror is made of Beryllium coated with a microscopically thin layer of gold and carried on a specially formulated graphite-epoxy composite structure. It operates at a temperature below 60 K. Further, the size of its sun-shield is about 21 m × 14 m, almost the size of a tennis court. The sunshield is made of five gossamer polymer membranes coated with aluminium and it operates in the temperature range of -235°C and 125°C. All of this was built over 40 million hours

The Webb represents a profound leap forward in our quest to understand the universe, building upon the legacy of the Hubble while extending the boundaries of what we can discover. Its advanced technology, unique capabilities, and focus on infrared observations will provide a fresh perspective on the cosmos. From peering into the universe's past to exploring exoplanets and addressing the mysteries of dark matter and dark energy, the JWST's mission is a journey into the unknown. As the Webb embarks on its mission, it symbolizes the collective curiosity and ambition of humanity and the hope that, with each new generation of space observatories, we come closer to unravelling the universe's most profound mysteries. The James Webb Space Telescope is more than just a telescope; it's a key to the universe's secrets, an instrument of discovery, and a testament to what can be achieved through international cooperation and the relentless pursuit of knowledge. Stay tuned for the wonders it will unveil, for the universe is about to reveal itself in ways we've never seen before.

JWST

Links:

https://webb.nasa.gov/content/webbLaunch/assets/documents/WebbFactSheet.pdf
https://webbtelescope.org/quick-facts https://hubblesite.org/quick-facts
https://www.jwst.nasa.gov/content/about/comparisonWebbVsHubble.html
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Chhavi Jhawar
BSc. Physics Hons

Celestial Choreography

A Dance of Stars in the Night Sky

In the stillness of a moonlit night, I turned my gaze to the heavens with nothing but a mobile phone in hand. What unfolded before me was a mesmerizing celestial ballet - star trails gracefully painting the canvas of the night sky. This photograph captures the essence of the universe's unending symphony, where stars, like dancers, leave their luminous mark as they pirouette across the cosmos.

Journey into the Science:
At first glance, the photograph might appear to be a work of art, but there's an underlying physics story that brings these stunning star trails to life. The arcs and streaks of light we see are the result of Earth's rotation on its axis. As our planet spins, stars appear to move across the sky, creating these intricate patterns.

1. *Stellar Orchestration:* Each trail represents a single star's journey across our field of view. The longer the exposure, the more extended and elegant their path becomes, reflecting their intricate orbital dances around the center of our galaxy.

2. Cosmic Synchrony: Not all stars move at the same speed across the sky. Some seem to glide lazily, while others streak by in a blur. This variability reveals the diverse orbital dynamics of stars in our Milky Way.

3. *Time Travel:* The longer the exposure, the more starlight is captured, often resulting in beautifully complex and intricate patterns. It's as if this photograph is a time-lapse video compressed into a single frame, offering us a glimpse of the universe's long-term rhythms.

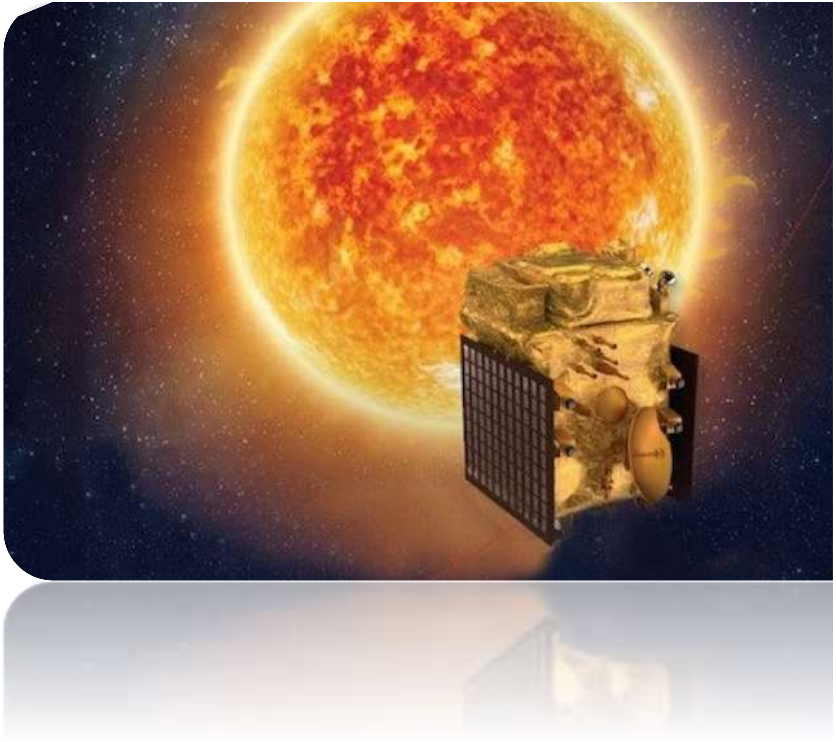
4. *Photographic Alchemy*: Achieving such striking star trails with a mobile phone requires patience, precision, and a bit of photographic magic. It's a testament to the convergence of technology and art in our pursuit of understanding the cosmos.

In this single image, we see not only the beauty of the night sky but also a snapshot of the ever-evolving universe. As we ponder these star trails, we are reminded of the intricate physics that governs our existence and the cosmic rhythms that have been playing out for billions of years.

So, the next time you gaze at the night sky, remember that you're witnessing a celestial dance, a symphony of stars, and the science of the universe in motion. It's a reminder that the cosmos is not just "out there"; it's also a part of us, an intricate and breathtaking part of the human experience.

~Munish

Venture to the Sun



1. WHY STUDY THE SUN?
2. WHAT EXACTLY IS ADITYA L1?
3. HOW WILL THIS MISSION BENEFIT INDIA?

"Somewhere something incredible is waiting to be known"

-Carl Sagan

ADITYA L1: VENTURE TO THE SUN

Following the achievement of Chandrayaan-3, ISRO has launched our Sun mission, Aditya-L1. What exactly is Aditya-L1? ISRO can't land on the sun the same way we landed on the moon. So how will this task be carried out? And does it make a difference? Let's dive into this topic in detail.

WHY STUDY THE SUN?

The sun is the nearest star to our planet Earth and the largest object in the solar system. The estimated age of the sun is 4.5 billion years. The sun is not only the prime source of energy on Earth but the solar system as a whole. Without solar energy life on Earth, as we know it, cannot exist. The gravity of the sun holds all the objects of the solar system together. The Sun moves around the Galactic Centre of the Milky Way, at a distance of 26,660 light-years. From Earth, it is on average 1 AU (1.496×108 km) or about 8 light-minutes far away.

At the central region of the sun, known as the 'core', the temperature can reach as high as 15 million degrees Celsius. The core is the only region on the Sun that produces an appreciable amount of thermal energy through nuclear fusion reaction. The visible surface of the Sun, the photosphere, is the layer below which the Sun becomes opaque to visible light. Photons produced in this layer escape the Sun through the transparent solar atmosphere above it and become solar radiation, sunlight.

The sun is a very dynamic star that extends much beyond what we see. It shows several eruptive phenomena and releases immense amounts of energy in the solar system. If such explosive solar phenomena are directed towards the Earth, it could cause various types of disturbances in the near-earth space environment. The various thermal and magnetic phenomena of the sun are of extreme nature. Thus, the sun also provides a good natural laboratory to understand those phenomena that cannot be directly studied in the lab.

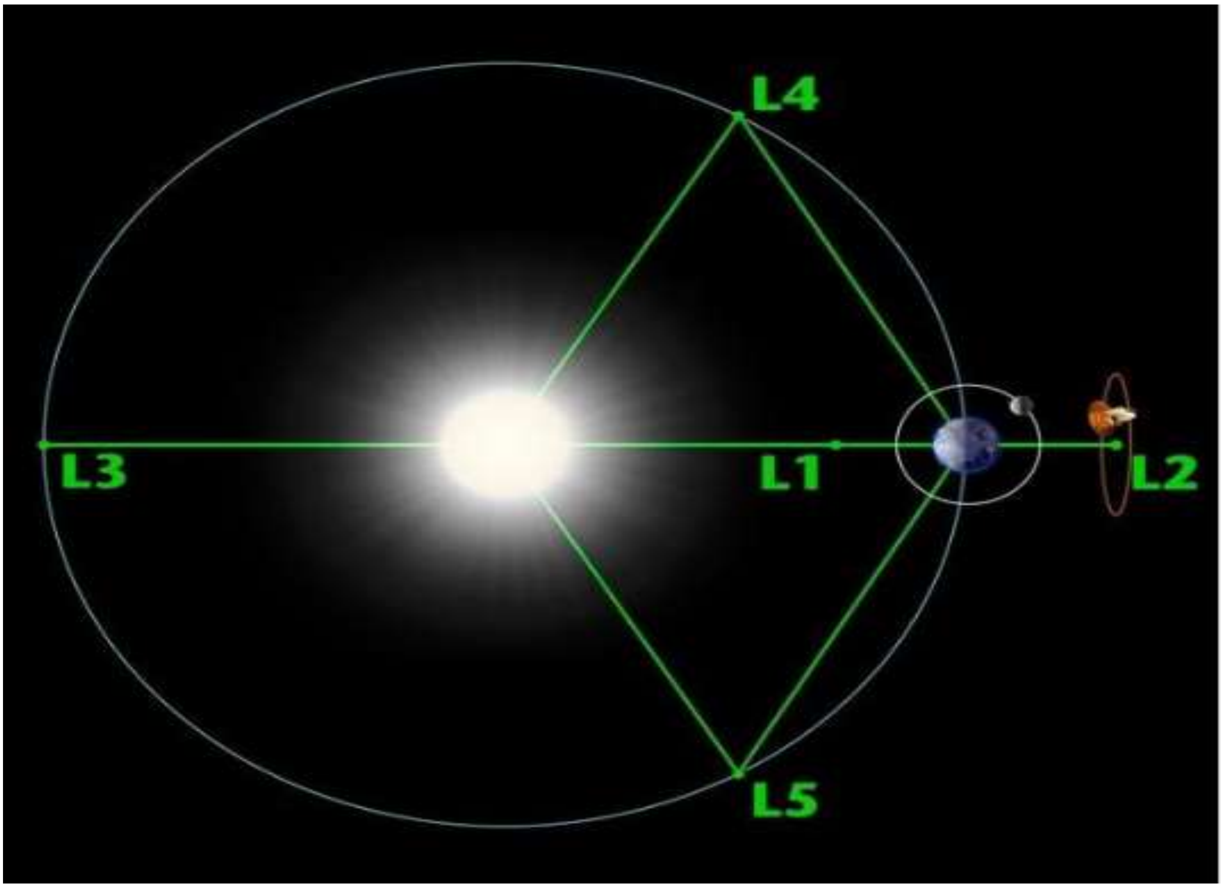
“In physics, you don't have to go around making trouble for yourself - nature does it for you.”

-Franck Wilhelm

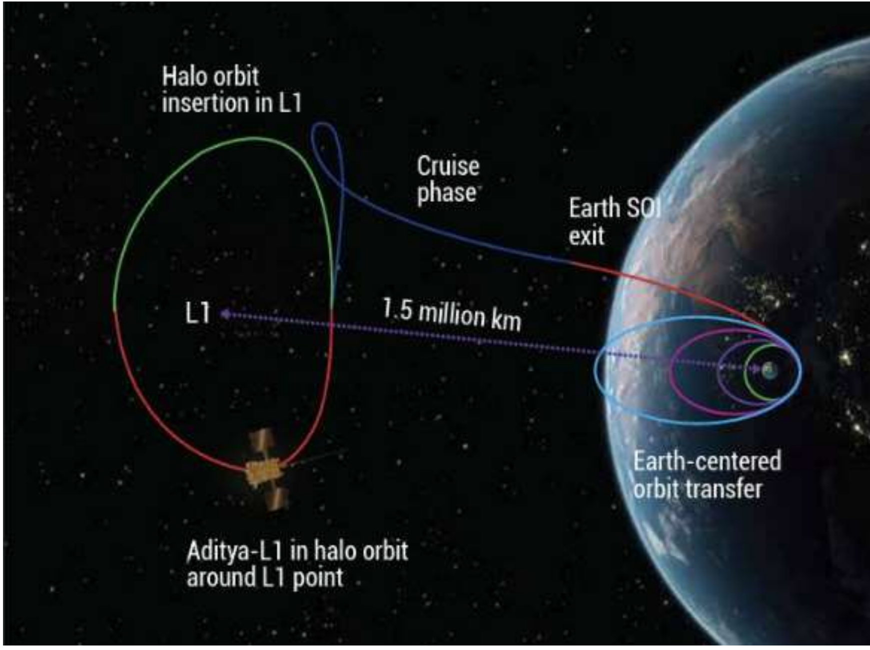
WHAT EXACTLY IS ADITYA L1?

Aditya L1 is the first space-based observatory class Indian solar mission to study the Sun. The spacecraft is planned to be placed in a halo orbit around the Lagrangian point 1 (L1) of the Sun-Earth system, which is about 1.5 million km from the Earth. We know “Aditya” is one of the names which are used to address Sun in Sanskrit. But what exactly do we understand by “L1”?

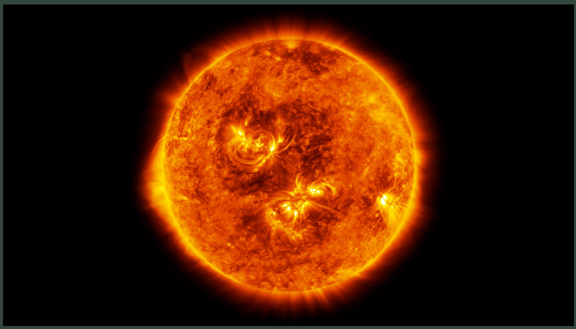
Newton's gravity must have bothered everyone in high school science class. Everyone will remember Newton's third law, even if they don’t recall anything else. “There is an equal and opposite reaction to every action.” This guideline is also followed in space. To put it simply, if the gravity of the sun affects the earth, then the gravity of the earth also influences the sun. The gravitational forces of the Earth and the sun engage in a tug of war. There is one location in space where both gravitational forces cancel each other out. There are total of five such points. L1, L2, L3, L4, and L5 are the letters.



TRAJECTORY TO L1 POINT



Initially, the spacecraft will be placed in a highly eccentric Low Earth orbit. The spacecraft will perform orbital maneuvers by using its LAM to reach Sun-Earth Lagrange point L1 (1.5 million kilometers from Earth, in a halo orbit). Subsequently, the orbit will be made more elliptical and later the spacecraft will be launched towards the Lagrange point (L1) by using onboard propulsion. As the spacecraft travels towards L1, it will exit the Earth's gravitational Sphere of Influence (SOI). After exit from SOI, the cruise phase will start and subsequently, the spacecraft will be injected into a large halo orbit around L1. The total travel time from launch to L1 would take about four months for Aditya-L1.



OBJECTIVES OF THIS MISSION

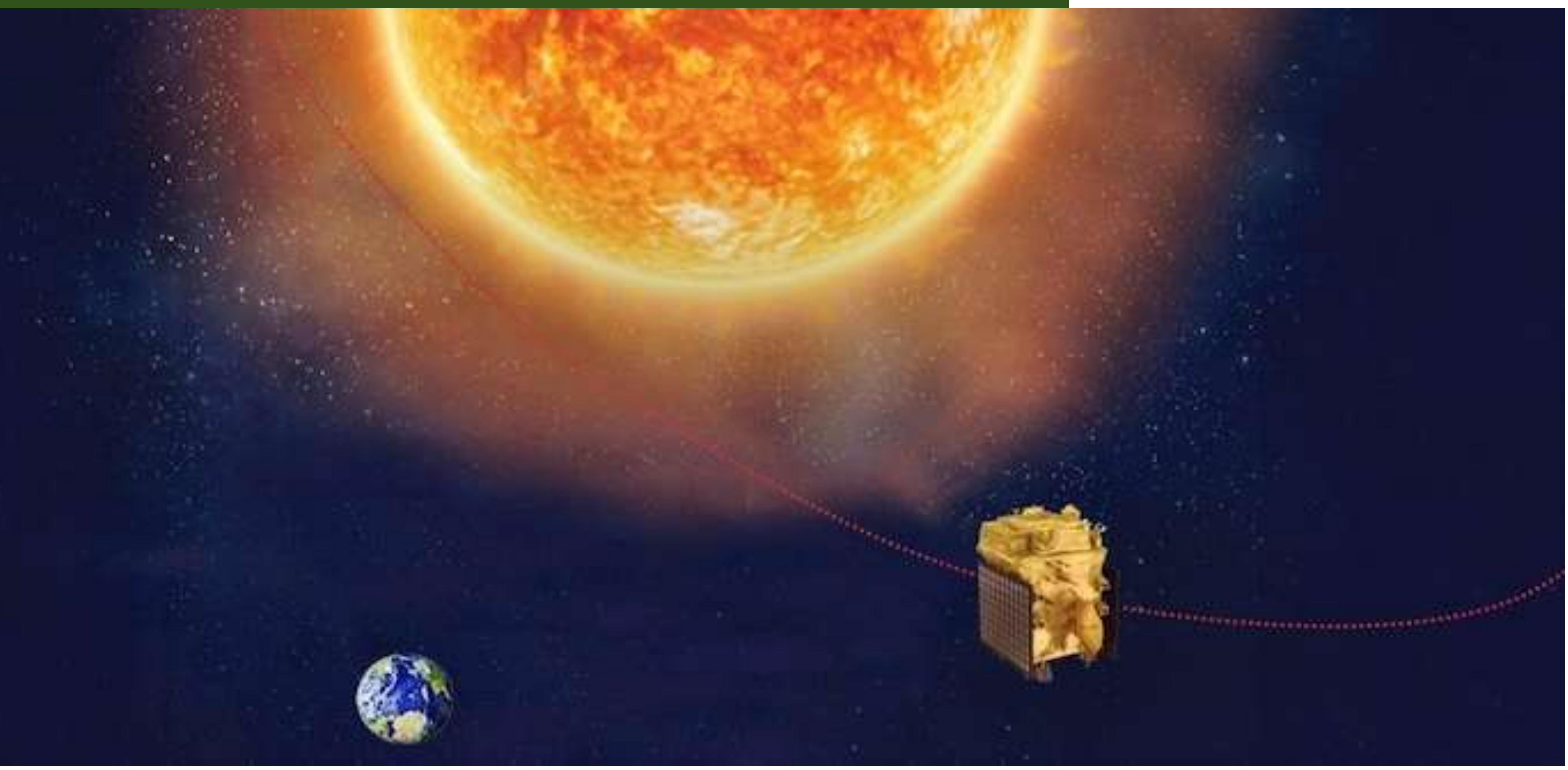
o Solar dynamics unveiled: Aditya L1's primary mission is to explore the upper reaches of the sun's atmosphere, including the chromosphere and corona. By studying these regions, the mission seeks to uncover the dynamics that govern the Sun's behavior.

o In-depth solar particle analysis: It will explore the core of the solar particles and plasma environments, offering crucial data on Sun-originating particle dynamics. This information is pivotal for unravelling the mysteries of the solar corona and its heating mechanism.

o Magnetic Marvels: ISRO will also study the magnetic field topology and measurements within the solar corona. This investigation is vital for comprehending the drivers of space weather, including the solar wind's origin, composition and dynamics.

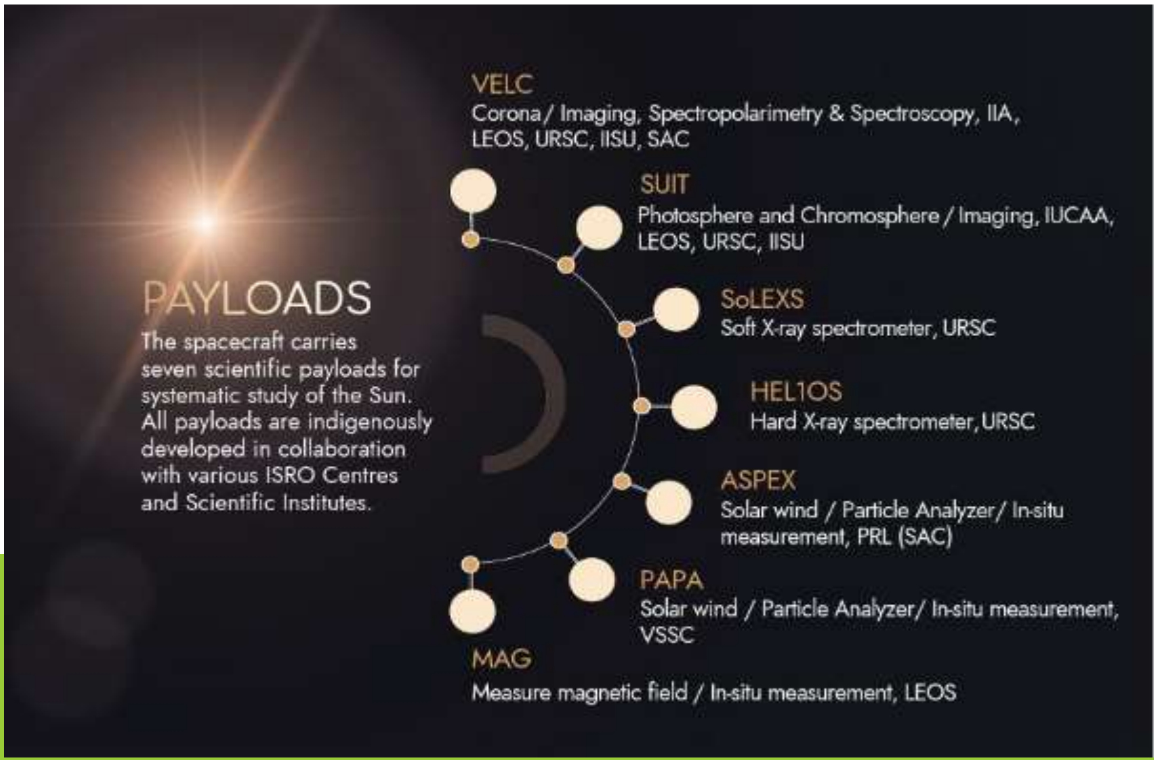
o Enhancing Space weather predictions: This mission's insight into the sun's behavior will shed light on critical solar phenomena like coronal heating, mass ejections, flares and space weather dynamics.

ADITYA L1



PAYLOADS

The spacecraft (weighing 1475 Kg) carries seven payloads to observe the photosphere, chromosphere, and the outermost layers of the Sun (the corona) using electromagnetic and particle detectors. Using the special vantage point of L1, four payloads (VELC, SUIT, SoLEXS, HEL1OS) directly view the Sun and the remaining three payloads (ASPEX, PAPA, MAG) carry out in-situ studies of particles and fields at the Lagrange point L1. The suit of Aditya L1 payloads is expected to provide the most crucial information to understand the problems of coronal heating, Coronal Mass Ejection, pre-flare and flare activities, and their characteristics, dynamics of space weather, study of the propagation of particles, and fields in the interplanetary medium etc.



HOW WILL THIS MISSION BENEFIT INDIA?

Aditya L1 being India's first ever space-based observatory class solar probe to unlock the mysteries of the Sun will be 1.5 kilometers away from Earth (4 times farther than the moon).

Although ISRO has carried out several space missions in the past, Aditya-L1 holds more importance because it is meant to study the base of our solar system, the Sun. For far too long, India has studied the Sun through advanced telescopes on the ground, while relying on data from solar missions of other nations, such as the United States, Japan, the United Kingdom, and Europe. With increasing demand to study space and, more importantly, the impact of the Sun on our planet's climate, it was never more urgent for ISRO to have its own large-scale observatory focused on the Sun than this time. Aditya-L1, thus, is an important mission for India.

CONCLUSION

Aditya-L1, mounted on PSLV-C57 and launched from Satish Dhawan Space Centre, Sriharikota, is unique in many aspects. The Aditya L1 mission is a complex and challenging task, but it has the potential to provide valuable insights into the sun and its impact on Earth. The mission is expected to have a life of around 4 to 5 years. However, one might ask: Is Aditya L1 a complete mission to study the sun? The answer is "NO", not only for this Indian mission but also for any other solar mission. The reason is that due to the limited mass, power, and volume of the spacecraft that carries the scientific payloads in space, only a limited set of instruments with limited capacity can be sent on board the spacecraft.

Launched on September 2, 2023 is currently on its way to the L1 point. For now, let's all join our hands and pray for the success of this mission!

DIPAKSHI SARMA
B.Sc. Physics (Hons)
IIND Year

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Explainer | How ISRO will study the Sun from space? (onmanorama.com)

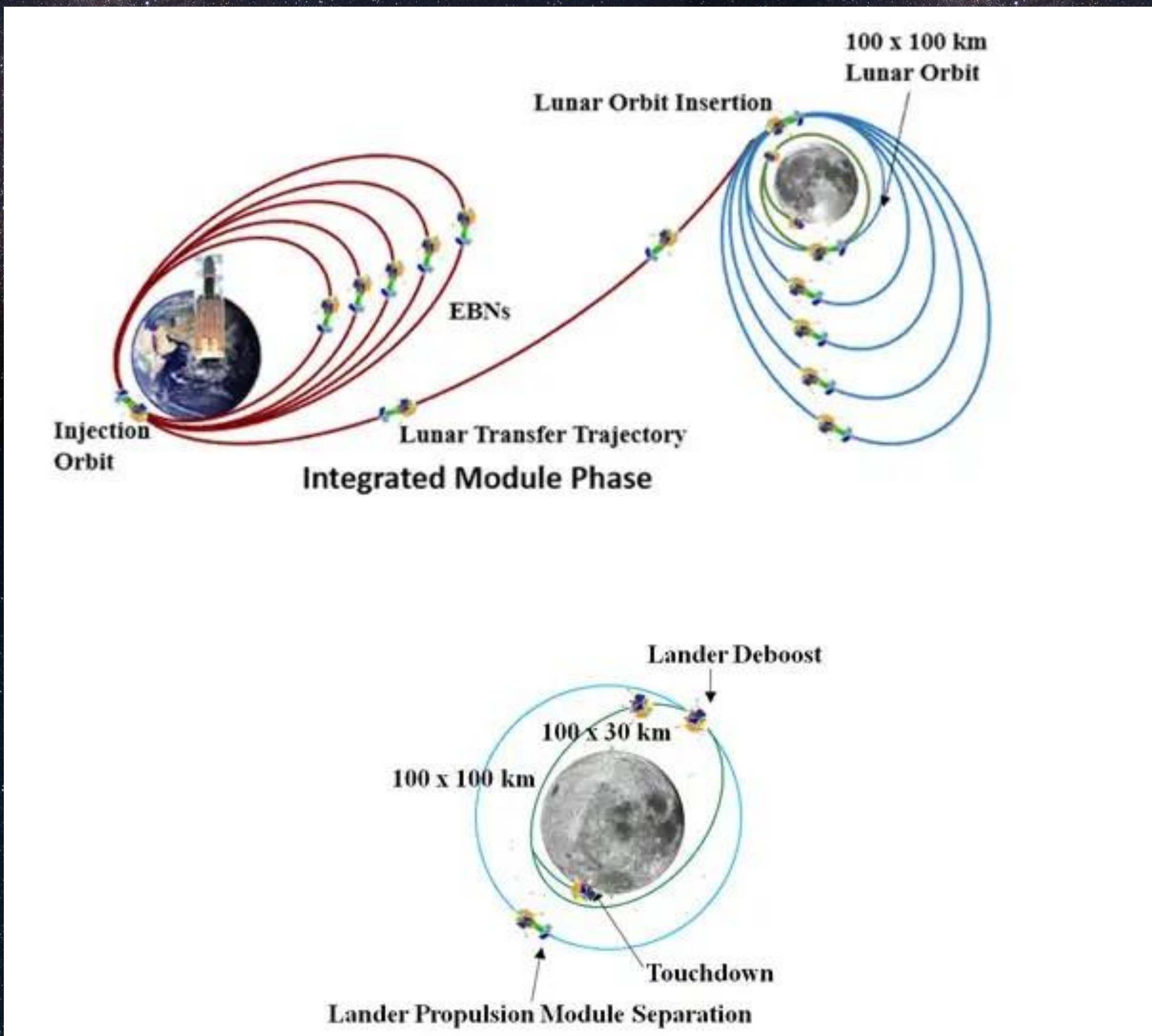
CHANDRAYAAN 3

The Next Chapter in India's Lunar Odyssey

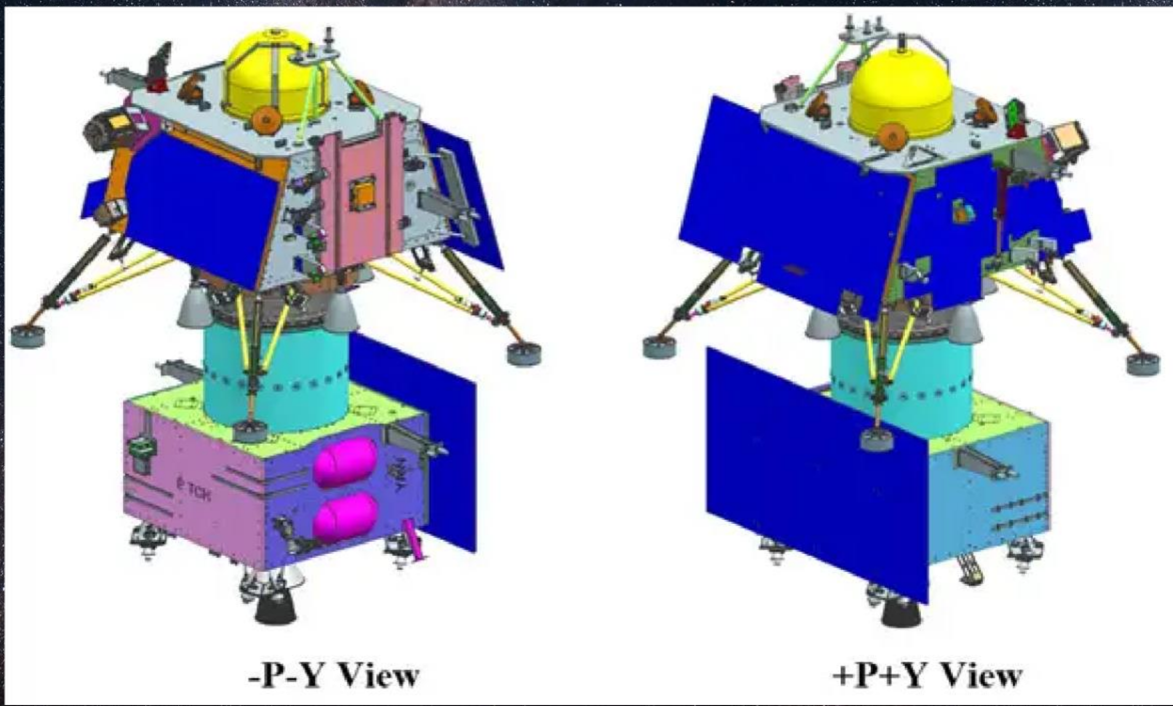
Chandrayaan 3: The Next Chapter in India's Lunar Odyssey

India's lunar research, notably through Chandrayaan-1 and Chandrayaan-2 missions, unveiled lunar water molecules and ice, reshaping lunar science. Chandrayaan-2's orbiter continues to gather vital data, while ISRO collaborates globally, positioning India as a significant contributor to lunar exploration and fostering future missions and international partnerships.

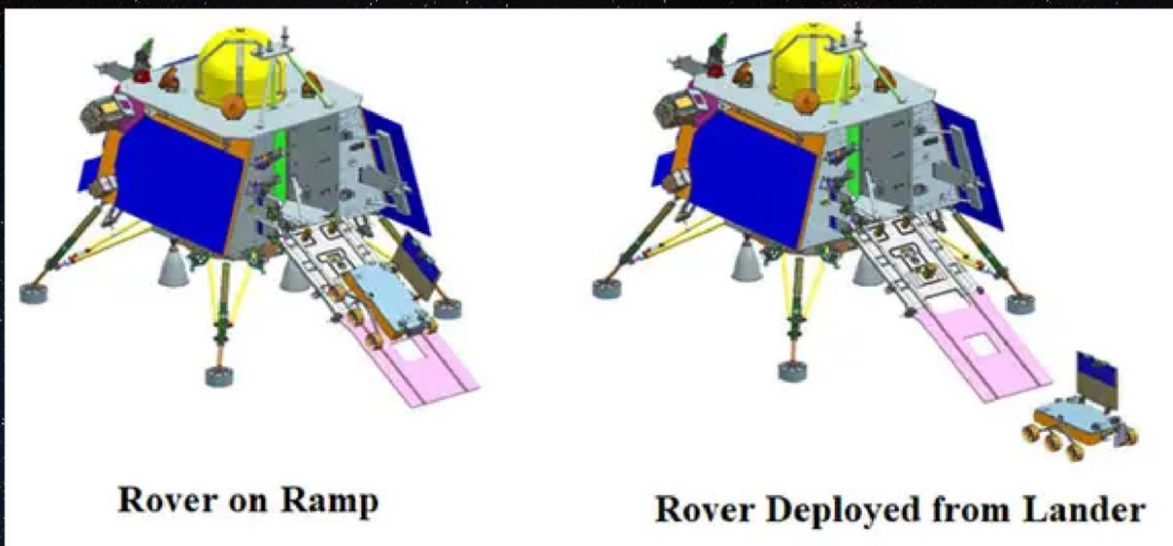
Chandrayaan - 3 mission is equipped with an enhanced navigation and backup system, addressing previous challenges, and advancing India's lunar aspirations. On July 14, 2023, **LVM3 M4 Vehicle successfully launched Chandrayaan -3 into orbit** from SDSC SHAR, Sriharikota. It will place the integrated module in an Elliptic Parking Orbit (EPO) 0f size ~170 x 36500 km.



Chandrayaan 3 consists of a combination of the **Lander module (LM)**, **Propulsion Module (PM)** and **a Rover** (which is accommodated inside the Lander). Where Propulsion module carries the Lander module from launch vehicle (LVM3) injection till final lunar 100 km circular polar orbit and separate the LM from PM, that deploys Rover upon successful soft landing at the specified location and then the Rover will carry out in-situ chemical analysis of the lunar surface during the course of its mobility.



Chandrayaan-3 Integrated Module



This mission targets to exhibit **safe and soft landing on the moon** and **execute in-situ scientific experiments**. It represents an improvement over its predecessors due to lessons learned. It aims to rectify the landing failure of

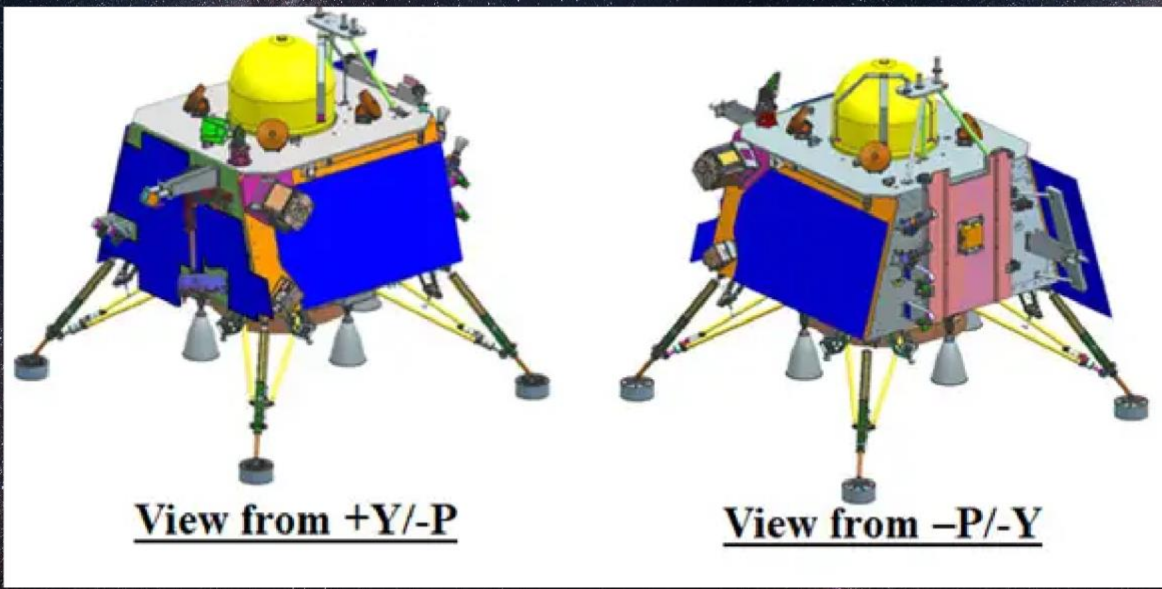
Chandrayaan-2, launched in July 2019 and with that **several advanced technologies are present in lander**:

1. Altimeters: Laser & RF based Altimeters
2. Velocimeters: Laser Doppler Velocimeter & Lander Horizontal Velocity Camera
3. Inertial Measurement: Laser Gyro based Inertial referencing and Accelerometer package
4. Propulsion System: 800N Throttleable Liquid Engines, 58N attitude thrusters & Throttleable Engine Control Electronics
5. Navigation, Guidance & Control (NGC): Powered Descent Trajectory design and associate software elements
6. Hazard Detection and Avoidance: Lander Hazard Detection & Avoidance Camera and Processing Algorithm
7. Landing Leg Mechanism.

Specification for Chandrayaan -3:

1. 1. Mission life (both lander and rover) is one lunar day, i.e. approx. 14 Earth days and 4 km x 2.4 km 69.367621 S, 32.348126 E indicates the area size and coordinates of the Landing Site.
2. 2. Propulsion module weighs 2148 kg and can generate 758W power and the Lander module (including Rover - 26 kg) weighs 1752 kg and generates 738W power and Rover generates 50W power.
3. 3. PM communicates with IDSN (Indian Deep Space Network - specialised ground station and tracking system used by ISRO to communicate with and track deep space missions), LM communicates with IDSN & Rover, Rover communicates with only Lander. Chandrayaan-2 Orbiter is also planned for a backup link.
4. **4. Specifications of LM** :
    a. **a. Lander sensors** : Laser Inertial Referencing and Accelerometer
    Package (LIRAP), Ka-Band Altimeter (KaRA), Lander Position Detection Camera (LPDC), LHDAC (Lander Hazard Detection & Avoidance Camera), Laser Altimeter (LASA), Laser Doppler Velocimeter (LDV), Lander Horizontal Velocity Camera (LHVC), Micro Star sensor, Inclinometer & Touchdown sensors
    b. **b. Lander Actuators** : Reaction wheels – 4 nos (10 Nms & 0.1 Nm)

- **c. Lander Propulsion System**: Bi-Propellant Propulsion System (MMH + MON3), 4 nos. of 800 N Throttleable engines & 8 nos. of 58 N; Throttleable Engine Control Electronics.
- **d. Lander Mechanisms**: Lander leg, Rover Ramp (Primary & Secondary), Rover, ILSA, Rambha & Chaste Payloads, Umbilical connector Protection Mechanism, X- Band Antenna
- **e. Lander Touchdown specifications**
  Vertical velocity: ≤ 2 m / sec, Horizontal velocity: ≤ 0.5 m / sec, Slope: ≤ 12 deg



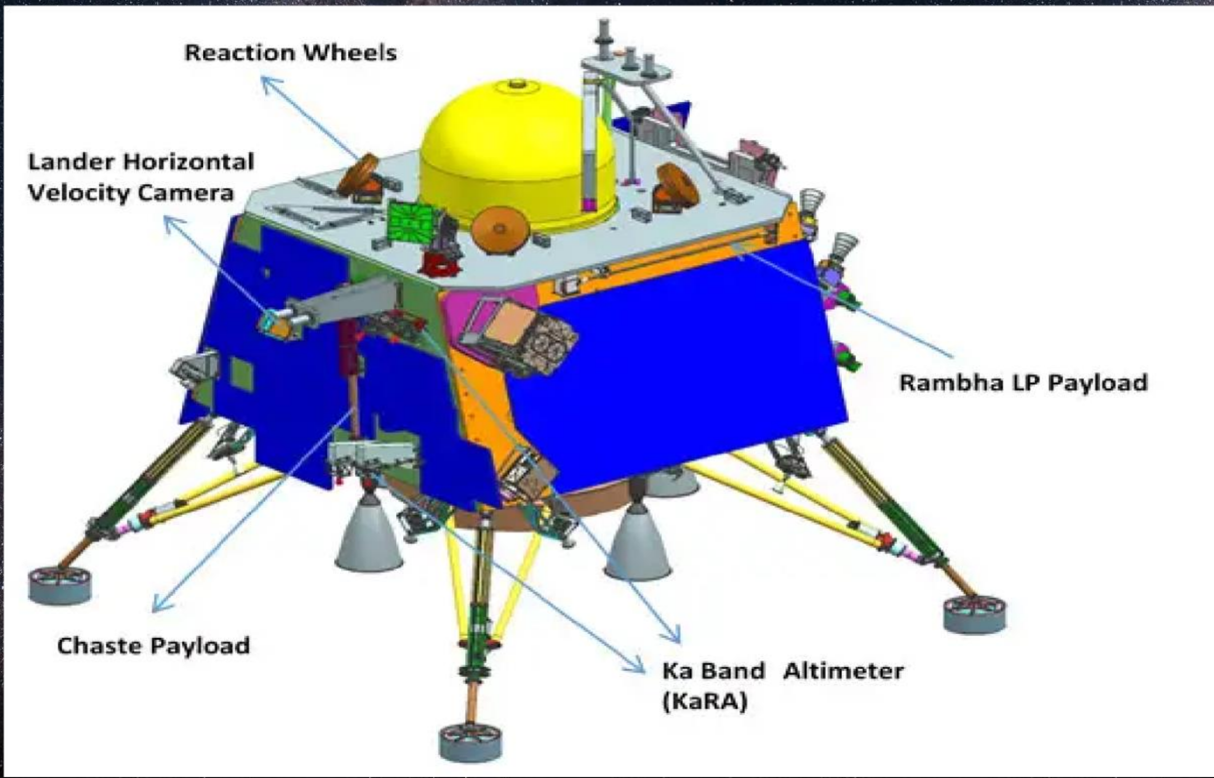
Lander Module View

5. The Lander and the Rover have scientific payloads to carry out experiments on the lunar surface :

- **a. Radio Anatomy of Moon Bound Hypersensitive ionosphere and Atmosphere** (RAMBHA) - Langmuir probe (LP) : To measure the near surface plasma (ions and electrons) density and its changes with time.
- **b. Chandra's Surface Thermo physical Experiment (ChaSTE)** : To carry out the measurements of thermal properties of the lunar surface near the polar region.
- **c. Instrument for Lunar Seismic Activity (ILSA)** : To measure seismicity around the landing site and delineate the structure of the lunar crust and mantle.
- **d. LASER Retroreflector Array (LRA)** : It is a passive experiment to understand the dynamics of the Moon system.

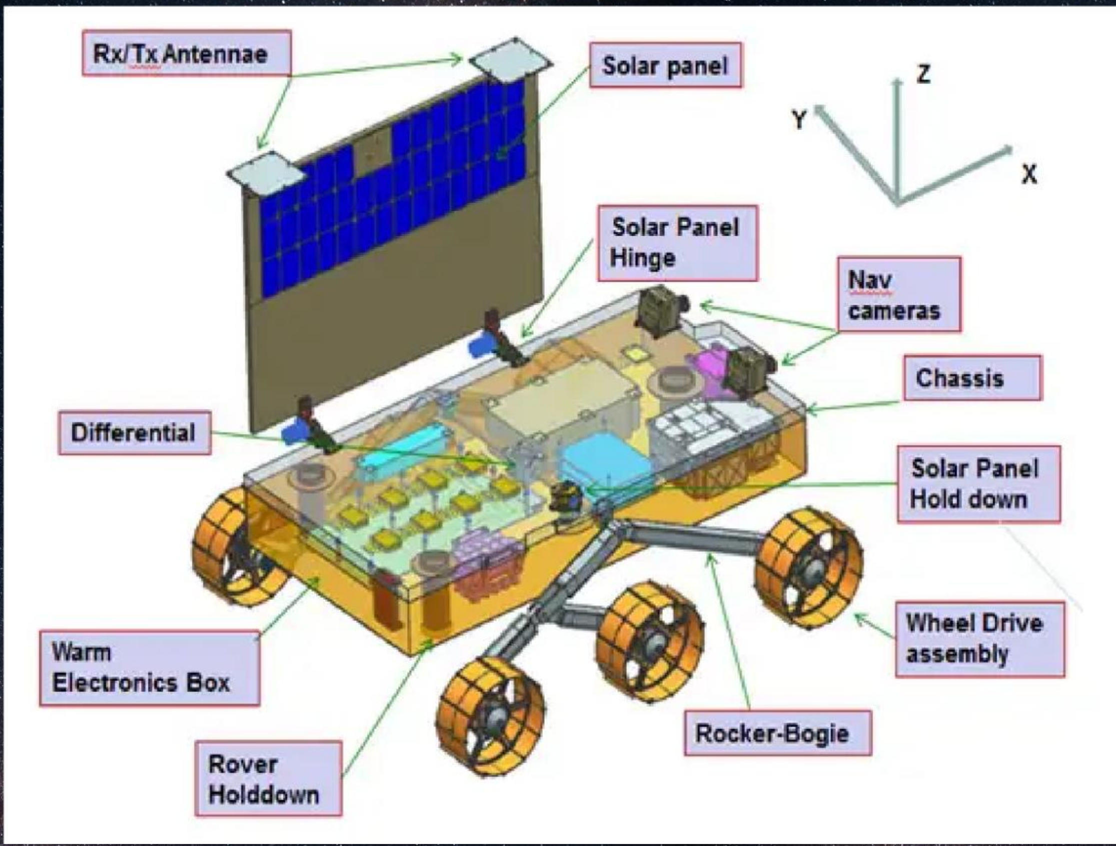
e. **e. LASER Induced Breakdown Spectroscopy (LIBS)** :Qualitative and quantitative elemental analysis & To derive the chemical Composition and infer mineralogical composition to further our understanding of Lunar-surface.

f. **f. Alpha Particle X-ray Spectrometer (APXS)** : To determine the elemental composition (Mg, Al, Si, K, Ca,Ti, Fe) of Lunar soil and rocks around the lunar landing site.

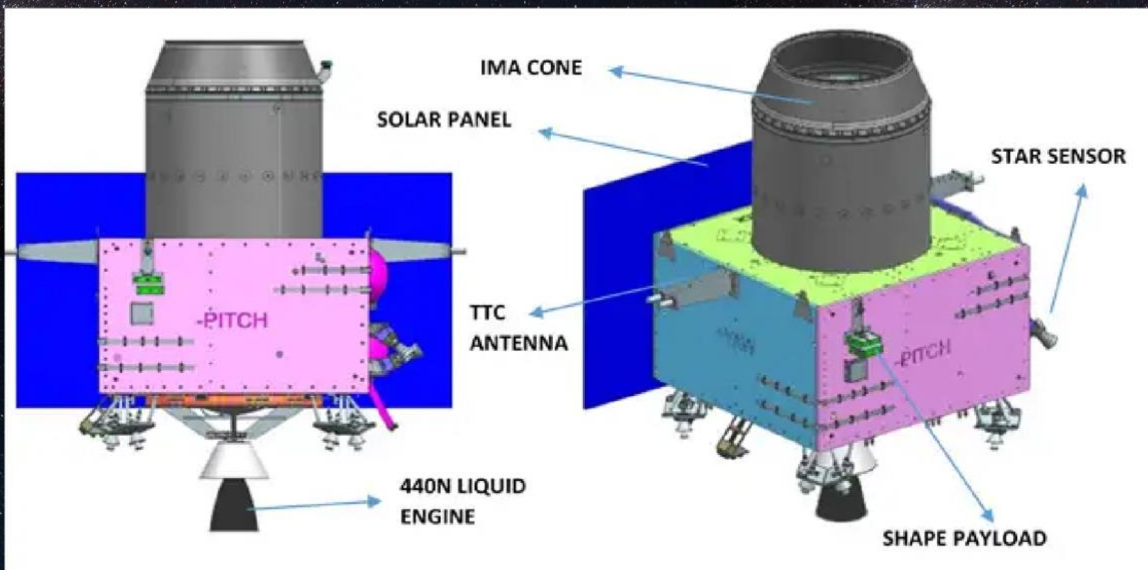


- **Lander Module**

6. The Propulsion Module also has one scientific payload as a value addition which will be operated post the separation : **Spectro-polarimetry of Habitable Planet Earth (SHAPE)**. Its purpose is for future discoveries of smaller planets in reflected light that would allow us to probe into a variety of Exo-planets which would qualify for habitability (or for presence of life).



Rover



Propulsion Module

Observations till now :

1. 1. Scientists from NRSC/ISRO estimate that about **2.06 tonnes of lunar epiregolith were ejected and displaced** over an area of 108.4 m² around the landing site resulting in a **reflectance anomaly** or '**ejecta halo**', which appears as an irregular bright patch surrounding the lander.

2. 2. ILSA's primary objective is to measure ground vibrations generated by natural quakes, impacts, and artificial events.an **event, seemingly natural, was recorded on August 26, 2023**, source of event under investigation.

3. 3. RAMBHA-LP on-board Chandrayaan-3 **measures near-surface plasma content** : Langmuir probe is a device used for characterising a plasma. The system can detect minute return currents, as low as pico-amperes, with a dwell time of 1 millisecond. Lunar plasma near the surface is sparse, with 5-30 million electrons per cubic metre during early lunar daytime. Probe continuously observes this, impacting **lunar surface charging in solar weather fluctuations.**

4. **4. APXS on-board Ch-3 rover detects the presence of minor elements and LIBS confirms the presence of Sulphur (S) on the lunar surface through unambiguous in-situ measurements.**

Reference:

1. 1. https://www.isro.gov.in/Chandrayaan3_Details.html
2. https://www.isro.gov.in/Ch3_ScienceResults.html#:~:text=Chandrayaan%2D3&text=Scientists%20from%20NRSC%2FISRO%20estimate,m%C2%B2%20around%20the%20landing%20site.&text=L
2.IBS%20confirms%20the%20presence%20of,through%20unambi guous%20in%2Dsitu%20measurements.

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Course - B.Sc. (H) Physics ; III year
Roll No. :- 21567019

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

Stephen Hawking

Voyage Through Quantum Mechanics

October 25, 2023

In encountering the existence of matter in the universe and unfolding the mysteries of Nature.

Belief in reality and understanding reality.

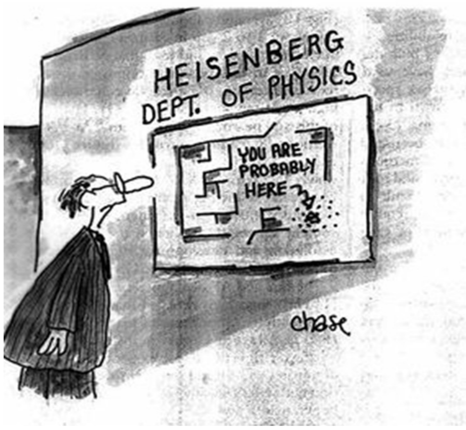
Reality often leads to disappointment - a statement that can push individuals to the brink of frustration. As Physicists, when tackling the challenges that arise, we typically adopt this perspective. It offers us a measure of comfort, shielding us from the human tendency to let ourselves down. Nevertheless, when we embark on the journey of perception, things become more intricate. In this realm, we are not as secure as we once thought, and our safety is far from guaranteed.

Three hundred years back, starting from 1687, a groundbreaking moment in history, a courageous individual stepped onto the world stage and granted humanity its inaugural glimpse of reality. This individual was no one other than **Sir Isaac Newton**, who undertook this tedious task with the help of his renowned work in his book "**Principia**", which introduced the fundamental concept of reality in the form of his three laws of motion, which applied to all, not just himself but everyone in the world.

The question that arises then is: What more do we require? We possess laws governing celestial motion, star formation, vehicle travel, and cost calculations. We understand speed for punctuality and weight limits. Yet, do we have it all? Are we overlooking an integral part of complete reality? Both you and I are composed of atoms. Within our minds, billions of atoms continually reconfigure as we speak, numbering orders of magnitude comparable to the age of our universe. As you read this article, you, the reader, encompass and harbor a universe within yourself.

However, the prevailing notion that the three laws of motion form the ultimate definition of reality may not be entirely accurate. Nature's behavior extends beyond these laws, encompassing the intricate movements of atoms that elude description through historical principles.
Therefore, there is no harm in concluding that there is something that we do not see as the physical reality, something that can be our true reality, something in the realm of “reality often disappoints.”

As **Richard P. Feynman** has said, “Things have common features, take the world from different points of view.”
For example, the main key elements in the universe are hydrogen, carbon, oxygen, and nitrogen. Every life here on earth, as far as we know, is composed of the same atoms. Therefore, the atoms and subatomic particles are the savior of life and we require some way to describe their behavior from nature’s standpoint completely independent of our perception.



Advent of quantum mechanics, quest to describe the existence of matter.

“Exploring the essence of existence of matter in the universe.”

“We have no right to assume that any physical law exists, or if they have existed up to now, that they will continue to exist similarly in the future.” ~ Max Planck, The universe in the light of modern physics.

The first significant breakthrough in the field, occurring roughly 215 years after the 1687 Classical mechanics era, was **Max Karl Ernst Ludwig Planck's** groundbreaking work in 1900. Planck questioned his concept of the continuous distribution of energy in matter, which had been widely accepted. He introduced a bold hypothesis on the quantization of light, laying the groundwork for "quantum conditions." These conditions were parameterized by the Planck constant, derived from the work of **Rayleigh** and **Wien** on blackbody radiation. **Albert Einstein** then made a pivotal prediction regarding the linear relationship between the kinetic energy of electrons and the wavelength of incident light. Later, it confirms the direct dependence of photoelectron energies on light frequency. **Niels Bohr's** contribution to constituting the atomic theory played a crucial role. It led to the idea that with each energy level jump, radiation is emitted as a single quantum with a defined frequency connected to its energy. This marked the second breakthrough when another visionary challenged established beliefs about the motion of electrons within atoms. Bohr's exploration along with **Hertz's** experiments inadvertently paved the way for the Uncertainty Principle, representing a limit to human understanding.

The grand introduction to “psi”, the complex description of simple reality.

“Only a few know how much one must know to know how little one knows.” ~ Werner Heisenberg.

For the first time in history, all physicists were able to relinquish the idea of knowing everything or attempt to know everything after discovering the uncertainty principle followed by Nature.

The non-commutative property of the **Hamiltonian's** mathematics proved to act as a savior for **Heisenberg** in his research with matrix mechanics, which revolved around commutative multiplication. Armed with this newfound insight, Heisenberg made remarkable progress toward attaining quantum mechanics as a general form of motion. Nevertheless, a comprehensive interpretation of “Quantum Mechanics” remained missing.

Erwin Schrödinger, a bright intellectual, worked independently during the same era and explored the quantum form using **Louis De Broglie’s** famous relation as his primary basis. Schrödinger generalized the theory to describe an electron's movement within the nucleus. A remarkable everyday occurrence of phenomenon is, the fluctuating electrons, resembling energy-laden clouds, encapsulate our existence. As a result, the intricate "psi" description did not appear in Heisenberg's original matrix formulation theory but emerged later in Schrödinger's quantum mechanics, aligning the two, giving the notion of behavior of these fundamental particles and their existence in the universe.

The delusional truth

"We understand reality when we surrender ourselves!"

Alright! In our historic journey to understand nature's mysteries, we've discovered that the fundamentals are both simple and complex. You might wonder about the uncertainty we're presenting. Answering to these two states simultaneously existing is that complexities in our understanding of reality don't arise from the world itself, but rather from how we observe and perceive it. As an example, we might state that the sky is a linear transformation of various fields present there. We see them because we're immersed in electromagnetic fields, but from nature's standpoint, "the sky is blue, and birds fly through it," as Heisenberg wisely noted.

So, the conclusive point we make is if we have to find answers that disclose nature's behavior then it does not depend on how much one knows via the math we follow, the laws or theories we develop but rather relies on how much we are willing to surrender ourselves to the grand universe. Letting uncontrolled nature guide us! And remember that nature will always behave against our intuitions not in an absolute sense, but in a way that at first glance we might tell ourselves, **"This is not Real!"**

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HARNESSING THE POWER OF PHYSICS: A PATH TO PREVENT CLIMATE CHANGE

"The climate emergency is a race we are losing, but it is a race we can win."

-Barack Obama

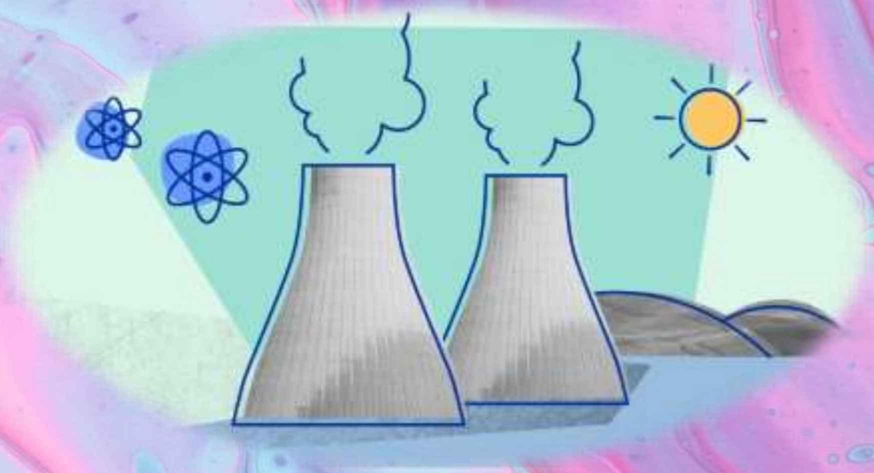
As our planet stands at the crossroads of history, the undeniable truth is that we are facing an existential threat like no other - climate change. The ominous signs of our planet's distress are all around us, from raging wildfires and ferocious hurricanes to melting glaciers and rising sea levels. The consequences of our actions, or inactions, are becoming increasingly clear, and the time to act is now. Climate change, driven primarily by human activities such as the burning of fossil fuels, deforestation, and industrial emissions, is reshaping our world at an alarming pace. The impacts are felt not only in remote corners of the globe but also in our own neighbourhoods. From prolonged droughts and devastating agricultural communities to coastal towns disappearing beneath the relentless tide, the evidence is undeniable: **we are in the midst of a climate crisis.** As concerns about climate change continue to grow, it is clear that we need to find ways to reduce our **carbon footprint** and lower our overall **greenhouse emissions**. One way we can do this is by using the **Fundamental Principles and Tools of Physics** needed to analyse and mitigate the effects of climate change and transition to a sustainable future.

There are several ways in which Physics can help prevent climate change. One of the ways is **the Development of Renewable Energy Sources**. By using solar, wind, hydro, geothermal, and nuclear energy we can develop clean energy without burdening limited natural resources like coal, wood, etc. For example, the use of solar panels, which are a sandwich of n-type silicon and p-type silicon, allows us to harness the power of the sun to generate electricity. India, in particular, is focusing heavily on solar energy production to satisfy its energy needs. We can also use **Green Hydrogen** as a substitute for fossil fuels which emits zero greenhouse gases in heavy industries and aviation. Green hydrogen is a clean source of energy produced through the electrolysis of water using renewable energy sources such as wind, solar and hydropower. This will help us in reducing our carbon footprint without affecting our development. **Green Ammonia** can also be produced with the help of green hydrogen is carbon-free, green ammonia has improved efficiency and reduced soil acidity.

Another way is **Optimizing Energy Use and Increasing the Energy Efficiency** of appliances through the application of principles like thermodynamics and electromagnetism, Scientists can develop efficient technologies for energy production, consumption and transportation. Advances in materials science have led to the creation of high-efficiency insulation, LED lighting, and energy-efficient appliances.

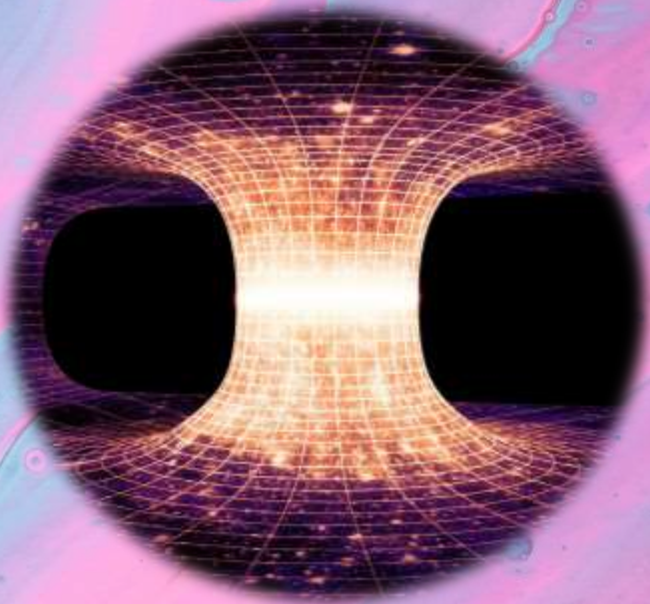
One of the emerging technologies to mitigate the emissions of carbon dioxide from entering the atmosphere and contributing to global warming and climate change is **Carbon Capture and Storage** as done by **Denmark** for the first time ever. It is a process to isolate carbon dioxide from other gases, compressing it and then injecting it at depths of one kilometre or more, where it remains stored for an extended period, sometimes lasting decades. Captured carbon dioxide from industries can be used to produce dry ice, it can also be combined with hydrogen to produce synthetic fuels such as synthetic natural gas, synthetic diesel, or even synthetic jet fuel. CCS can play a vital role in reducing emissions from sectors that are challenging to decarbonize fully.

Climate Physicists also use the technique of **Climate Modelling** to understand and predict climate behaviour on seasonal, annual, decadal and centennial time scales. In this Climate models are created which investigate the degree to which observed climate changes may be due to natural variability, human activity, or a combination of both. Their results and projections provide essential information to better inform decisions of national, regional, and local importance, such as water resource management, agriculture, transportation, and urban planning.



Harnessing nuclear energy is another way in which Physics contribute to a greener planet. The traditional way to harness nuclear energy is nuclear fission, where the nucleus of an atom splits, releasing a tremendous amount of energy. However recently, Scientists in the United Kingdom said they have achieved a new milestone in producing nuclear fusion energy, or imitating the way energy is produced in the Sun. Energy by nuclear fusion is one of mankind's long-standing quests as it promises to be low carbon, safer than how nuclear energy is now produced and, with an efficiency that can technically exceed 100%. There are several advantages of **Nuclear Fusion over Fission.** Nuclear Fusion produces four times more energy than nuclear fission, nuclear fusion reactors produce no high activity, and long-lived nuclear waste and if any disturbance occurs, the plasma cools within seconds and the reaction stops making it safer than fission.

Using **Quantum Physics to Mitigate Climate Change** is one of the most efficient ways to predict tsunamis, droughts, earthquakes and floods. A quantum communication technique can also measure minute vibrations in the ground, making it potentially useful for detecting earthquakes and landslides. The collection of data regarding climate change can be streamlined in a better way through Quantum Technology. Quantum technologies present the opportunity to tackle climate challenges in a new way by opening up possibilities in computing, imaging, sensing, meteorology, communications and more.



Quantum tech may be able to accelerate our efforts to mitigate the climate-harming effects of mission-critical processes by powering innovations across industries.

At last, one of the most common way through which we can mitigate climate change is The Development of Sustainable Forms of Transportation. Electric Vehicles, for example, produce fewer missions than traditional fossil-fuel powered vehicles and our understanding of Physics is helping us to design more efficient and effective electric propulsion systems. Another new innovation is Hydrogen-Fuelled Train under the National Hydrogen Energy Mission.

In conclusion, Harnessing the power of physics is not only a pathway to preventing climate change but a fundamental necessity. Physics provides us with the understanding, tools, and innovations required to address this global crisis. From unravelling the mysteries of the climate system to developing clean energy technologies, optimizing energy efficiency, and exploring advanced solutions like nuclear fusion and quantum computing, physics is at the forefront of our efforts to combat climate change. By understanding how energy is produced and used, we can identify opportunities to reduce our greenhouse gas emissions and lower our overall carbon footprint. This needs the collaboration of not only scientists but also government institutions to provide necessary funds for the research and development of innovative technologies and also sharing of technology between developed and developing countries. By the combined efforts of the whole world, we can surely combat climate change.

SALONI RANA

COMPUTER SCIENCE (HON.)

YEAR-III

Especial Edition

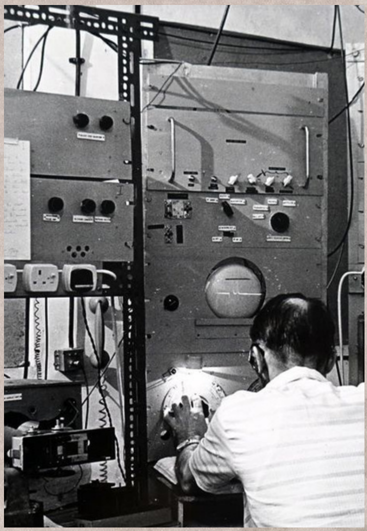
THE BIG BANG

A CATHOLIC PRIEST FIRST THOUGHT OF IT

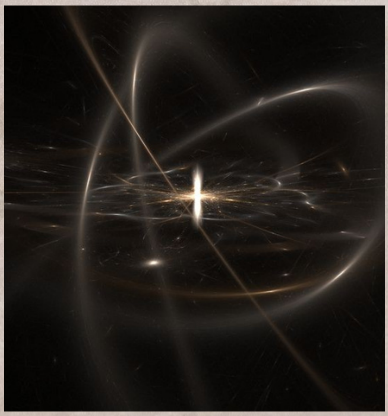
In 1915, Albert Einstein published his theory of general relativity, which originally stated that the universe would naturally be either expanding or contracting. But Einstein, along with the vast majority of astronomers and physicists at the time, believed that the universe was static, so he added some extra terms to the equations to balance everything out.

Years later, Edwin Hubble discovered that galaxies are, on average, receding away from us. While astronomers continued to debate the implications of that observation, Belgian physicist and Roman Catholic priest Georges Lemaître was the first to take both Einstein's and Hubble's results at face value, arguing that we live in an expanding universe that was once much smaller, hotter and denser than it is today. He dubbed this origin point the "primeval atom."

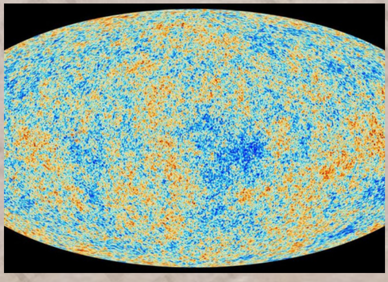
IT WAS VERIFIED ACCIDENTALLY



IT'S NOT A THEORY OF CREATION



WE CAN (ALMOST) SEE IT



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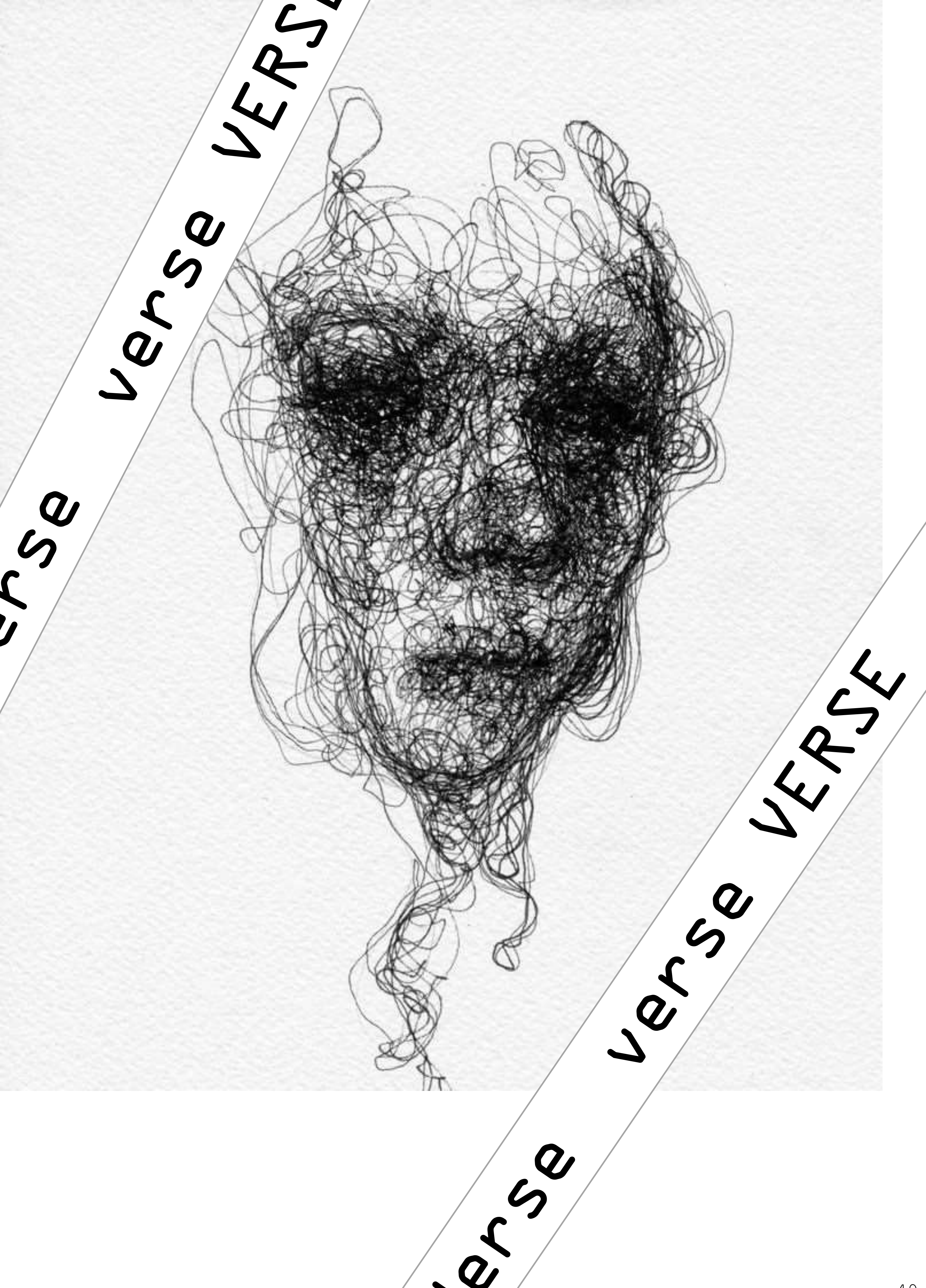
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ODE TO PHYSICS

Oh, physics, you dance of the cosmos,
Your laws so elegant and grand,
You guide the planets in their orbits,
And hold the atom in your hand.
From the tiniest quark to the vast expanse,
Your reach is infinite and deep,
You govern the motion of all things,
And the secrets of the universe you keep.
I marvel at your beauty and your power,
Your insights that amaze and thrill,
You inspire us to explore the unknown,
And to seek the truth with all our skills.
Oh, physics, you are the language of the universe,
Your equations sing with harmony,
You teach us that everything is connected,
And that we are part of something truly vast and free.
So let us raise a toast to physics,
To the minds that have unravelled its mysteries,
And to the future generations that will continue to explore its depths,
For in physics, we find the answers to life's greatest quests.

-Rituparna Gupta

"Protons give an atom its identity, electrons its personality."
- Bill Bryson.

String Theory

Tick-tock, tick-tock, tick-tock
It's 6:00 o'clock, mom!
Let's cut the cakes
Let's cut the cakes

We will, her mom replies
Wait for 10 more minutes, my dear Zeeva
Our guests haven't reached yet

Sure! Sure mom!
Daddy, until then, let's play a game! Suikawari.
Zeeva brings a watermelon from the refrigerator
Oh! Ho! Watermelon, it's so big in size and heavy too

Daddy! What is it made of? What's inside the watermelon?
Her daddy replies, if you want to look deep inside the watermelon,
you'll have to magnify it to the microscopic level, you'll find molecules
If you magnify it more, you'll find atoms
And if you look within an atom, you'll see subatomic particles like electrons, protons and neutrons
Now if you catch a subatomic particle and look within,
You will see tiny particles like quarks.

Zeeva asked, 'What is quarks? Daddy!'
Quantum mechanics proves that these are the smallest subatomic particles in the universe
String theory suggests that within these quarks, we'll find tiny one-dimensional strings
Vibrating in a certain pattern
Every particle is made up of these tiny strings of energy, her daddy replies.

Daddy, I understand a bit, please explain with an example
Her daddy said, 'Just like the string on a violin,
If you pluck it, it's vibrations create musical notes that we hear
These strings don't produce musical notes but matter itself,
So, quarks are nothing but a string vibrating in a particular pattern'

I got it! I got it!
Daddy, so if I take all of this back together, I'll have my watermelon?
'Yes, my dear Zeeva', replied the dad
The guests had arrived
The time had come, to cut the cakes

Zeeva blew the candles and made a wish
'May I become a scientist like Albert Einstein and contribute to physics as much as I can'

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MIDNIGHT STARGAZING

Since the beginning of time and till its end,
The light has been the only constant.
But before it was darkness,
And after that, it will be void too.
And even though abundant,
The universe is still barren too.
So, who are we, if not just ignorant
travellers
Fascinated by the doomed light?
But so we are,
Made up of the same void and star.
The same progenitor of light,
The forever doom of dark.
The rain at night still diffracts the moonlight.
The heart of the same glass should not be
painted black, right?
The rainbow at night is still one of the rarest
sights.
But still, in the closet, we let our truth hide,
And kill the light before its timely void.

-Privani
B.Sc (H) Physics

SONGS OF PHYSICS STUDENT'S LIFE

After studying science in class 10th, now you want to take science
Life ke sukhe chain to you:-
"haule haule saajna dhire dhire baalma , O ho ho hmm hmm ,"

But you to life:-
" mai chahe yeh karu, mai chahe woh karu, meri marzi"

And result, when you study physics for the first time in class 11th
" bas ek najar usko dekha dil mein usaki tasveer lagi kya naam tha uska rab jane"

And after some days, now you can understand this song easily:-
"give me some sunshine, give me some rain. give me another chance, I wanna grow up once again"

Class 11th to 12th journey :-
“O jab jaga, main bhaga, sab phatak sab signal main tod aaya, rab jane kab gujra Amritsar(11th & 12th) oh kab jane Lahore(boards) aaya”

When your friends opt for easy subjects and are enjoying their lives after 12th but you have to prepare for CUET then your mom to your friends:-
“ pappu can’t dance,haan pappu naach nahin saktaa”

In college when you are done with physics and you say bye to physics, then physics to you:-
“Never say good bye always say,” hum hain raahi pyar ke phir milenge chalte chalte”

And now due to your luck, you got physics as honours in college, you to your luck:-
“pal bhar ke liye koi hame pyar kar le jootha hi sahi”

Then your luck to you:-
“ye bandhan dilo ke bandhan, ye nate dilo ke nate, tay hote hai ambar pe, dharti pe jode jate”

When you start studying physics again, mann ki awazz:-
“chain gaya mera, yaar Canada, neendein London gyi”

But atleast college to mile gya ki khushi:-
“O mundeyan te kudiyan di gal ban gayi O ban gayi gal ban gayi’

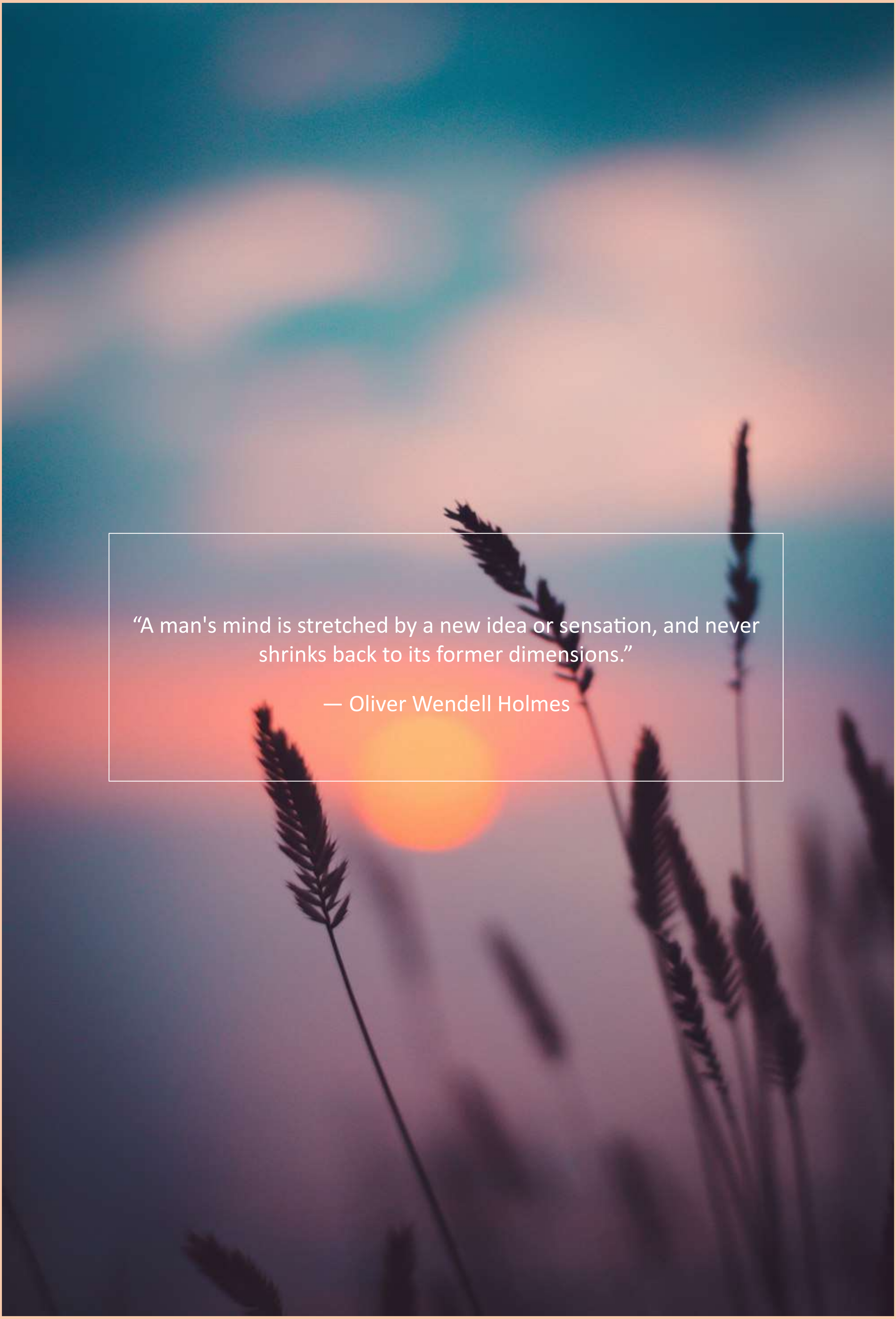
Starting months of college, you to life:-
“jiyo to iss pal aise jiyo, jaise ki aakhri ho”

And when it’s the day before your exam and your friends are helping you, you both :-
“ O jaao mujh ko sikhao naa tum aisi vaisi baate, tum dono ne milake jaan meri le li”

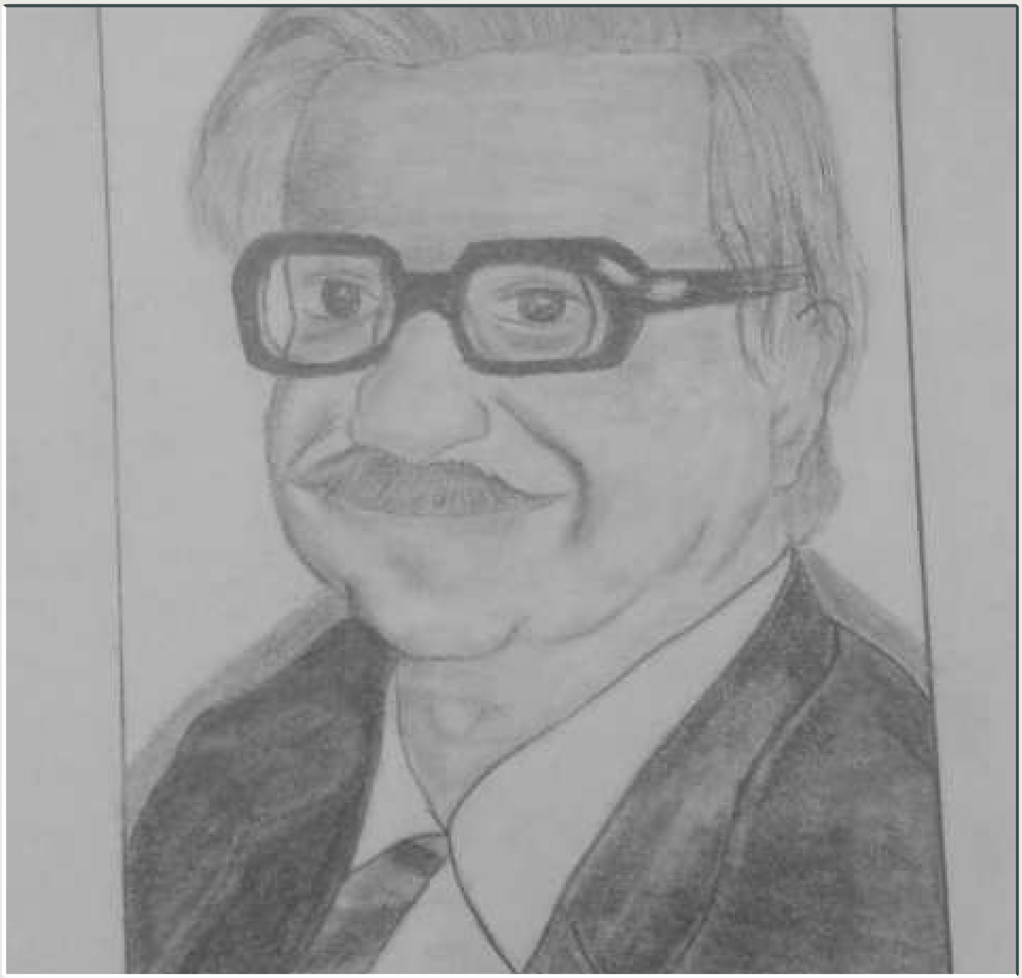
And suddenly you remember that the syllabus was easy but you didn’t study, then physics to you:-
“main dubh ke marjaunga jo jhutha dosh lagaya”

Abhi khatam nhi hua kyu ki
“hum hain raahi pyar ke phir milenge chalte chalte”

~ Ishu Bhadana


“A man's mind is stretched by a new idea or sensation, and never shrinks back to its former dimensions.”
— Oliver Wendell Holmes

ILLUSTRATIONS



Raja Ramanna

– Sketch By Neha Yadav, BSc.(H) Physics

Raja Ramanna (1925–2004) was an Indian nuclear scientist and the architect of India's first successful nuclear test, "Smiling Buddha," in 1974. As a key figure in India's atomic energy program, Ramanna's contributions extended to international collaborations and promoting peaceful applications of nuclear technology.

STEPHEN HAWKING

Sketch by Adarsh Kumar

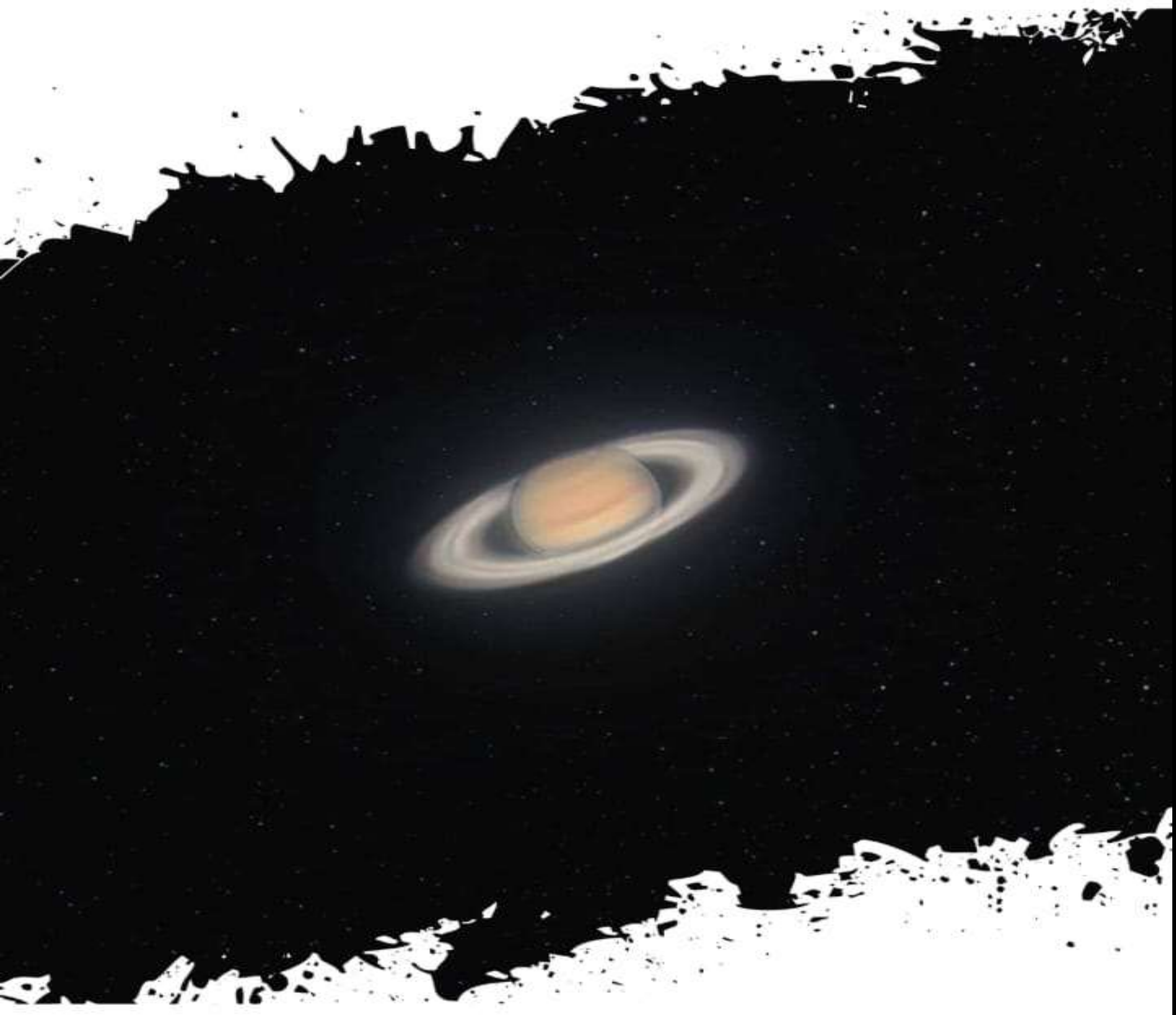
Stephen Hawking, a brilliant theoretical physicist (1942-2018), defied ALS to become an iconic scientist. Renowned for his work on black holes, Hawking authored "A Brief History of Time." His groundbreaking contributions reshaped cosmology, inspiring generations and demonstrating the power of intellect triumphing over physical adversity.

PURNIMA SINHA

SKETCH BY : **JAISMEE (B.SC. (H) PHYSICS -3RD YEAR)**

ABOUT Dr. PURNIMA SINHA :

- Dr. Purnima Sinha (12 October 1927 – 11 July 2015) was a pioneering Indian physicist, among the **first Bengali women to achieve a doctorate in physics**.
- She was an innovative physicist in the post-Independence 1950s, who **assembled an X-ray machine from World War II scraps** at Kolkata's Khaira laboratory, showcasing remarkable hands-on scientific prowess. She d**id tremendous work in the field of x-ray crystallography of clay minerals**
- After her PhD, she researched the 'Origin of Life' at Stanford University from 1963 to 1964, focusing on the interface between biology and physics. **Her work explored the relationship between clay structures and the bases found in the DNA double helix.**



"If you are not completely confused by quantum mechanics, you do not understand it."

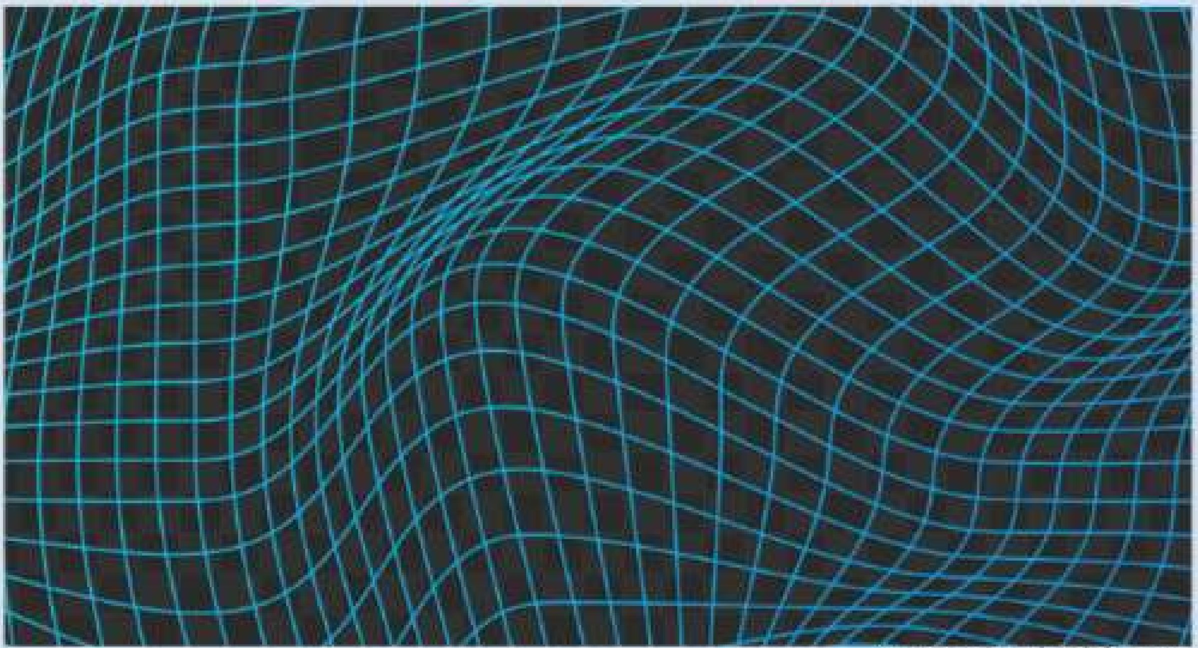
John Wheeler.

DR. ASIMA CHATTERJEE was the first woman to be awarded a Doctor of science by Indian University in 1944, by the University of Calcutta. She was also the first woman to be elected as the General President of Indian Science Congress., a premier institution that oversees scientic research. She was known for her work in the field of Organic Chemistry and phytomedicine, especially in the area of (vinca)alkaloids, terpenoids. and coumarins, and published a lot on medicinal plants of Indian Subcontinent.

RESEARCH ARTICLES

ELECTRONS LEAD THEIR LATTICE BY THE NOSE

Experiments with an unconventional superconductor show that a change in the properties of the material's electrons can, unexpectedly, cause the material to become dramatically less stiff.



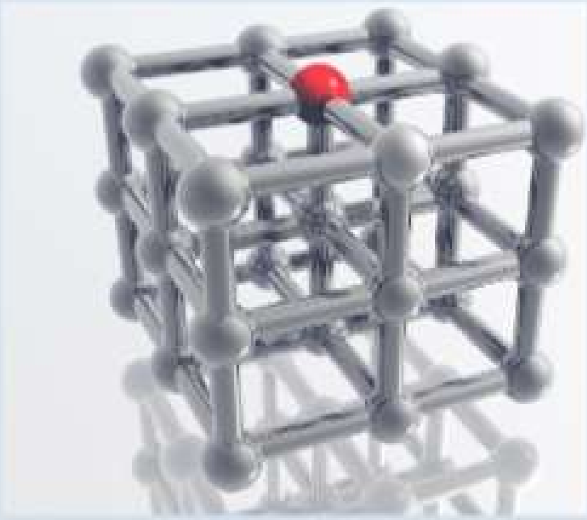
Aaozoar/stock.adobe.com

A material's lattice backbone can become soft because of something its electrons do, according to new experimental results.

Electrons flowing through a crystal lattice don't usually get to call the shots: their behavior is generally set by the lattice structure. But certain materials exhibit an electron–lattice coupling that allows the conduction electrons to influence the lattice behavior. This electron version of "wagging the dog" is predicted to be quite weak, making it a surprise that experiments with an unconventional superconductor now uncover a large electron-driven softening of the material's lattice. The finding could provide new insights into the mechanisms underlying unconventional superconductivity.

The lattice in a crystalline material is a periodic framework of atoms held together by electrostatic bonds. That framework dictates the properties of electrons moving through the material. For example, if the lattice is altered by applying mechanical strain or by adding dopant atoms, the electron momenta will correspondingly change, which can affect the material's electronic band structure.

This subordinate status of the conduction electrons makes sense given their relatively small numbers, explains Hilary Noad from the Max Planck Institute for Chemical Physics of Solids in Germany. She notes that conduction electrons are outnumbered by valence electrons—those that stay fixed to the atoms and create the bonds that hold the lattice together. The valence electrons are the ones expected to control the elasticity, or softness, of a material, says Anna Böhmer, a solid-state experimentalist from Ruhr University Bochum in Germany who was not involved in the study. "Intuitively, the conduction electrons should have only a minor effect on lattice properties," she adds.

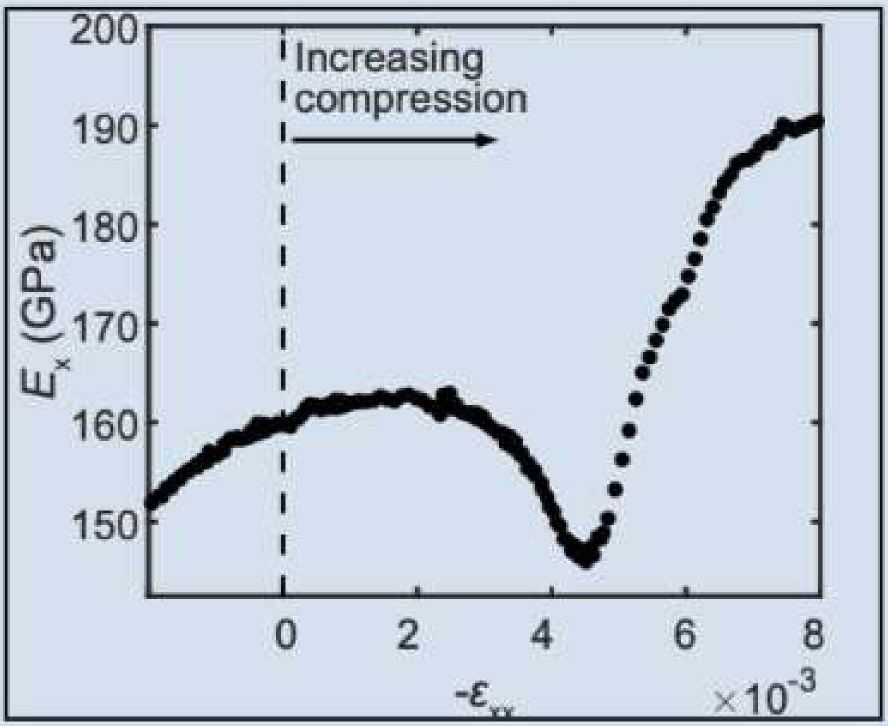


Despite that general intuition, physicists have identified scenarios in which conduction electrons could have the upper hand. One of the first to suggest this possibility was Soviet physicist Ilya Lifshitz [2]. In 1960, he calculated that electrons could induce a softening of 0.01% of a conductor's lattice structure if the energy landscape of the electrons suddenly changed. Such an electronic transition (now called a Lifshitz transition) occurs when the boundary between occupied and unoccupied electron states takes a different form. "Lifshitz included the prediction in a footnote because he expected the effect to be quite small," Noad says. Now she and her colleagues have found a case that upsets that expectation.

The team performed experiments on the unconventional superconductor strontium ruthenate (Sr2RuO4). The material has a two-dimensional electronic structure in which electrons predominantly flow along flat planes within a crystal framework. The team placed a Sr2RuO4 crystal in a custom-built device that compressed it along a single axis, causing an observable shortening (strain) of the material. The device was simultaneously used to measure the stress in the material —its resistance to compression. And from those measurements, the team derived the elastic modulus, which quantifies the material's stiffness.

The researchers observed that the stiffness initially increased with increasing strain, before taking a brief nosedive and then rising again. The abrupt stiffness dip occurred at a known Lifshitz transition in Sr2RuO4, suggesting that the electrons were responsible for the softening. To prove this electron dominance, the researchers explored the temperature dependence of the softening, which indicated that the softening was tied to a large increase in entropy in Sr2RuO4.

That entropy jump could come from lattice excitations, but previous work showed that a lattice source was unlikely at the low temperatures (around 4 K) of the experiments. The team's model instead indicates that the entropy jump is tied to a sudden spike at the Lifshitz transition in the density of electron states. "The basic picture I have is that suddenly the electrons can just do so much more, and that freedom makes the lattice softer," Noad says.



The elastic modulus (Ex), which represents a material's resistance to elastic deformation, vs strain (εεxx) in compressed strontium ruthenate [1]. The large dip corresponds to a giant softening of the lattice at the Lifshitz transition. Note that the strain is negative, indicating a reduction in length of the material along a particular direction.

The team estimated the lattice softening to be about 10%, roughly 1000 times larger than the softening Lifshitz predicted. "The lattice softening across the Lifshitz transition is remarkably large," says condensed-matter theorist Rafael Fernandes from the University of Minnesota. He compares it to another softening that is associated with electronic nematics, an effect in which electron interactions induce a change in the rotational symmetry of a material, as happens, for example, in iron-based superconductors. Fernandes' initial expectation was that the Lifshitz-related softening would be much smaller than the electronic-nematic softening, but they are roughly equal.

Fernandes says that Noad and colleagues give sound arguments for why the softening is so large—that Sr2RuO4 has unique properties (a two-dimensional character and a transition between correlated d orbitals) that lead to a stronger lattice sensitivity than seen for other conductors. "I think this work convincingly shows yet another case in which the lattice and the electronic system are not mere spectators of each other, but intertwined degrees of freedom," Fernandes says.

With the lattice softening explained, Noad says that the top of her to-do list is now to investigate possible connections between this newly observed behavior and the superconducting properties of Sr2RuO4. She says that, intriguingly, the lattice softening occurs at a pressure where the superconducting transition temperature of Sr2RuO4 peaks. That could indicate that the unconventional superconductivity in Sr2RuO4 comes from some coupling between the electron and lattice systems, Noad says. Böhmer agrees that Sr2RuO4 is a remarkable material that may have more surprises. "The interrelation of electron and lattice properties is a really exciting topic at the forefront of current research in quantum materials," she says.

–Michael Schirber

Michael Schirber is a Corresponding Editor for Physics Magazine based in Lyon, France.

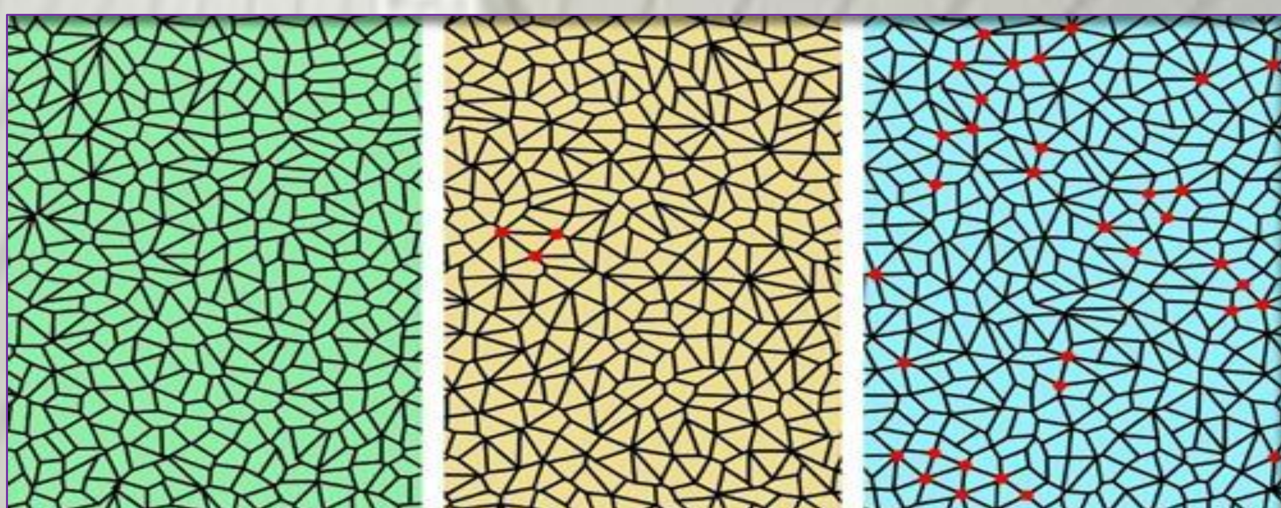
References:

- H. M. L. Noad et al., "Giant lattice softening at a Lifshitz transition in Sr2RuO4," • Science 382, 447 (2023).
- I. M. Lifshitz, "Anomalies of electron characteristics of a metal in the high pressure region," Sov. Phys. JETP 11, 1130 (1960).

Tension Remodeling Resolves Tissue Architecture Question

November 27, 2023• *Physics* 16, s169

A dynamical tension model captures how cells swap places with their neighbors in epithelial tissues, explaining observed phase transitions and cellular architectures.



F. Pérez-Verdugo and S. Banerjee

Epithelial tissues line the surfaces of every organ in our bodies. In the earliest stages of organ development and in wound healing, the cells that make up these simple sheets constantly rearrange themselves, exchanging positions like molecules in a liquid. But this fluidization is often hindered by the formation of multicell clusters, whose origins remain unclear. Using a dynamical structural model, Fernanda Pérez-Verdugo and Shiladitya Banerjee of Carnegie Mellon University in Pennsylvania now identify the mechanical prerequisites that lead to the formation and dissolution of these stabilized clusters . They show how dynamic feedback between tension and strain controls the tissue's material properties.

Existing models of tissue fluidity treat epithelial tissues as foam-like, polygonal networks of cells whose edges join at triple points. However, these models fail to explain the mechanisms underpinning cell neighbor exchanges. In particular, they oversimplify such exchanges by treating them as an instantaneous process, thereby avoiding the impact of exchanges that stall midprocess. One resulting discrepancy with experimental results is the absence of stable "rosette" structures that are observed in developing tissues where four or more cells meet.

To reproduce stalled exchanges in their model, Pérez-Verdugo and Banerjee made the tension across cell boundaries strain dependent. Specifically, cell junctions remodel themselves so that when the tissue undergoes local extension, tension is minimized, and when it undergoes contraction, tension is increased. They found that this strain–tension feedback allows the spontaneous assembly of stable, flow-suppressing cellular rosettes that dissolve when the tension remodeling is inhibited. The researchers say that the patterns that emerge in their model mirror cellular structures observed in living tissues, suggesting that this remodeling process is responsible for regulating tissue morphology.

–Rachel Berkowitz

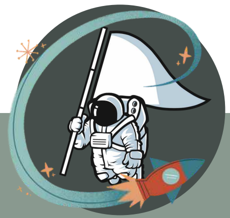
Rachel Berkowitz is a Corresponding Editor for *Physics Magazine* based in Vancouver, Canada.

References

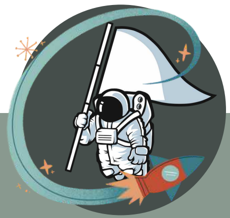
1. **F. Pérez-Verdugo and S. Banerjee, "Tension remodeling regulates topological transitions in epithelial tissues," PRX Life 1, 023006 (2023).**

REFRESH THYSELF

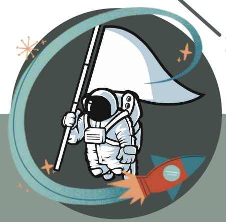
Strange and Intresting FACTS about The SOLAR SYSTEM



- Light gets much slower in water.
- The universe is growing every second.
- Water can boil and freeze at the same time.
- Hard steel tends to be more elastic than rubber.



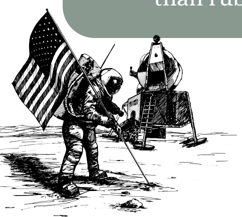
- Saturn might float on water as ice does.
- Space is not entirely a vacuum.
- All of humanity could fit in a sugar cube.
- Black holes can stop time.



- Sound waves could heat up a cold soup.
- Heat gets generated from sound waves
- A year on Venus is shorter than a day there.

The sun makes up 99.8% of the solar system's mass.

The International Space Station (ISS) is the size of a football field.



There are probably more than 1,000,000,000,000,000,000,000,000 (1 septillion) stars in the universe.
The Apollo astronauts' footprints on the moon could last up to 100 million years.

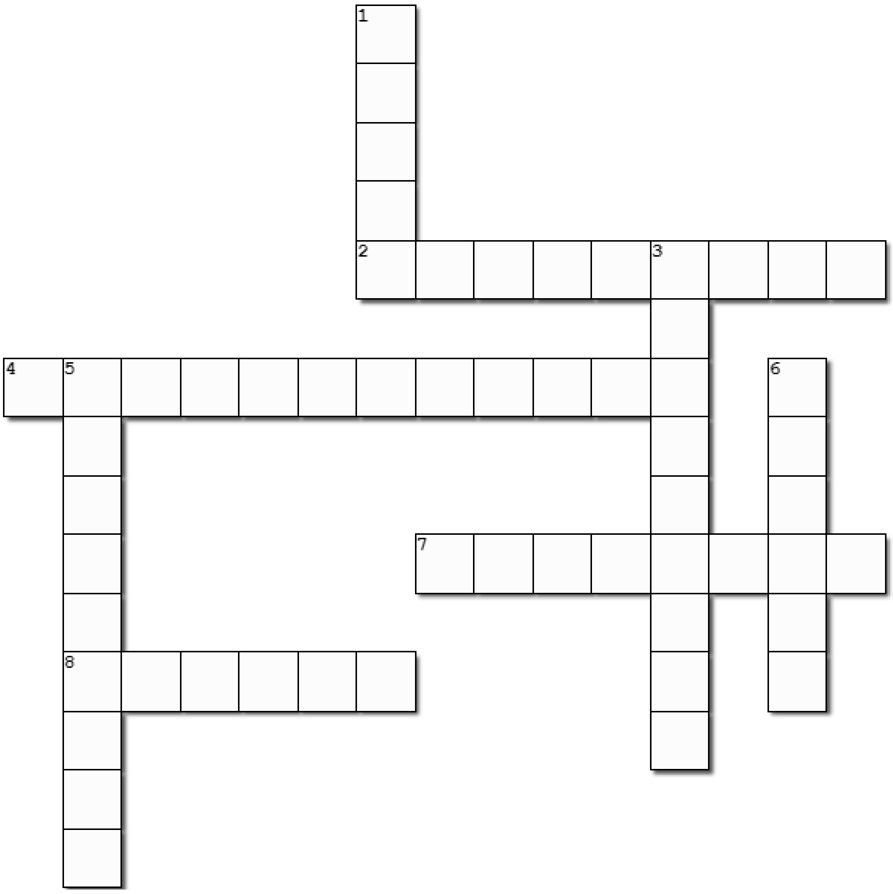
It turns out that roughly 68% of the universe is dark energy. Dark matter makes up about 27%. The rest - everything on Earth, everything ever observed with all of our instruments, all normal matter - adds up to less than 5% of the universe.

Content Reference
https://www.businessinsider.com/things-never-knew-space-facts-2018-4?IR=T#nasa-has-recorded-eerie-space-sounds-1

Content Reference
https://science.nasa.gov/astrophysics/focus-areas/what-is-dark-energy/

Content Reference
https://www.boredpanda.com/fun-facts-of-physics/

Complete the crossword puzzle below



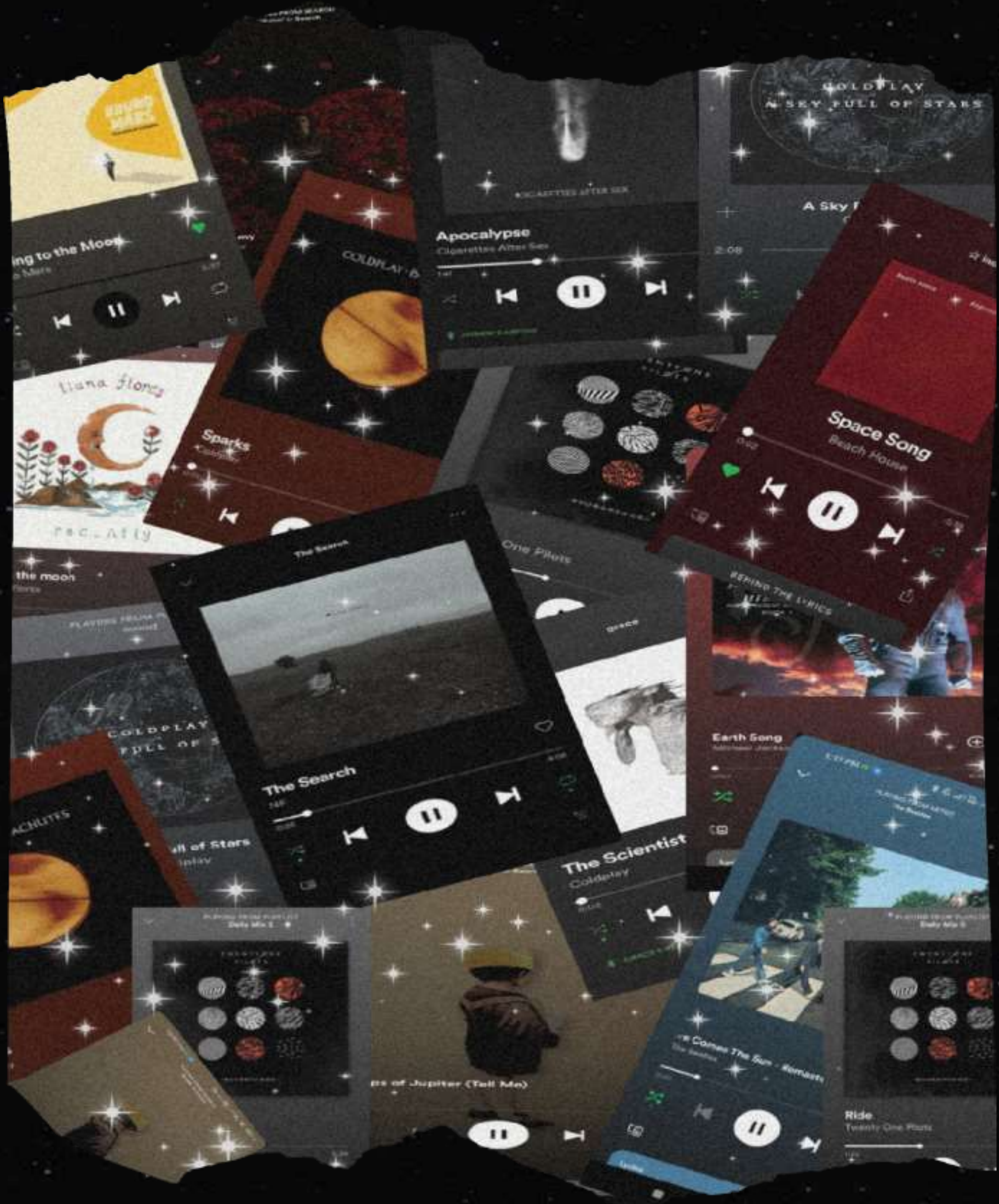
Across

2. A device used to magnify and observe distant objects in the sky
4. Branch of astronomy that deals with the physical and chemical properties of celestial bodies
7. The apparent shift or change in the position of an object when viewed from different perspectives.
8. A cloud of gas and dust in space, often where stars are born

Down

1. A celestial body made of ice and dust that has a tail
3. Study of the origin, evolution, and eventual fate of the universe
5. A powerful and luminous explosion of a star
6. A vast system of stars, gas, dust, and dark matter bound together by gravity

Answers :
1.Comet, 2. Telescope, 3. Cosmology , 4. Astrophysics, 5. Supernova, 6. Galaxy, 7. Parallax, 8. Nebula.



Songs recommendations