

EPISTEMIE

TO KNOW, TO BE ACQUAINTED WITH

1st Edition

28/2/2021

It contains more than
SCIENCE.....

**Wonder what's
fun in physics?**

We refer you to
'ROFL'

**Want to get inspired
from real life
GENIUSES?**

Join us at
'You are Born
to Blossom'

Bored at home?

please help
yourself with
our
'Let's Play'

BETHUNE COLLEGE

DEPARTMENT OF PHYSICS

CHIEF EDITOR

1. *Dr. Gautam Goswami*
2. *Dr. Santa Bandopadhyay (Rajguru)*

STUDENTS' TEAM

1. *Titir Chatterjee (Head)*
2. *Shamayita Dutta (Asst. Head)*
3. *Trishita Chatterjee (Asst. Head)*
4. *Manisha Ghosh*
5. *Anushka Konar*
6. *Srijita Hazra*
7. *Samarpita Chatterjee*
8. *Animita Chakrabarti*
9. *Sayantani Bhandari*

COVER PAGE DESIGNER

1. *Shamayita Dutta*
2. *Titir Chatterjee*
3. *Animita Chakrabarti*

*Dedicated to the the
sacred memory of*

Late Prof. Nandini Kaha

**Formerly Proffesor and Head,
Physics Department**

Bethune College, Kolkata



*The loss is immeasurable,
but so is the love left behind.....*

Editorial Note

A very difficult task is to move a static car. The long pandemic session during the last almost one year tried to suppress every Endeavour keeping the lives behind the bars. But History tells if enthusiasm is properly nourished the buds come out with colour. The students of Physics of Bethune College have shown that they are capable to crack the most difficult obstacle; they can move the static car. They have also proved that the online life cannot suppress their efforts to blossom in their own colour. The e-magazine “EPISTEME” has proved the truth that the hungry minds cannot be restricted by the imposed rules and surrounding constraints.

The three years' UG students have done a collective venture and planned in their own ways and have presented their creative minds. Being the students of Physics, most of the topics in this e-magazine have been presented here addressing the different aspects of Physics from different angles starting from the amazing glow of fireflies and going beyond the mystery of Time to Black hole. The articles have covered the scientific outlook starting from the ancient era to the modern age and are sorted in clusters in different sections accordingly.

The editorial works have been done keeping in mind that young students within their limitations have collected most of the information related to the articles through internet searching. The corresponding links are provided against each article as reference in the Bibliography.

To break the monotony, the subsequent articles are interrupted by light moments with cartoons, jokes and crosswords. They have made our Physics family nostalgic in the section “Second Home”. The classrooms, the laboratories are eagerly waiting for their friendly users.

Its worth mentioning that within the limitations and under the constraints during the last one year, the efforts of the students, their skill to choose the topics, presentation are commendable and we expect to see better version in near future.

Lastly we believe that the students are successful to give the right judgment to the title “EPISTEME”.

INDEX

① A New Beginning

About Our Department ----- 1-2

(Dr. Santa Bandopadhyay (Rajguru), Assistant Professor, Physics Department , Bethune College)

From Students' Desk ----- 3

② The Journey to the Past

The Cosmos Under the Sea

(Manisha Ghosh, Animita Chakrabarti) ----- 4-7

③ Into the Unknown

As Time Goes by...

(Titir Chatterjee, Shamayita Dutta) ----- 12-17

④ The Glorious Dark

The Fermi Paradox and its Possible Solutions

(Adrija Sarangi, Moumita Chatterjee) ----- 8-11

Ring Dynamics

(Turni Biswas , Sara Akhter) ----- 20-21

Black hole: The Hungry Predator of Universe and an Impulse

(Sayantani Bhandari, Srijita Hazra, Debarati Mukhopadhyay) ----- 36-41

Anti Gravity, A Bizarre Concept

(Sahana Chanda) ----- 62-65

Cosmic Ripples : A new era of astronomy begins

(Saptashi Chatterjee, Madhuparna Das, Sangita Paul) ----- 79-83

⑤ The Secrets of Energy

Nuclear Fusion and Plasma

(Anushka Konar, Manisha Chowdhury, Trishita Chatterjee) ----- 42-51

⑥ Behind the Curtain

Anti bubble

(Samarpita Chatterjee) ----- 22-23

Magnus Effect

(Mehuli Maity) ----- 59-61

Boom!

(Priyadarshini Saha) ----- 66-69

Synchornization of Fireflies

(Aindrila Paul Chowdhury)

----- 72-75

⑦ You Are Born to Blossom

Nikola Tesla

(Kuheli Sinha)

----- 52-53

The Boy Who Fixes Radios By thinking

(Sairindhree Saha)

----- 24-28

A biography of Shankar Abaji Bhisey-

(Anuskha Barua , Trisha Pal)

----- 76-78

⑧ Rolling on the Floor Laughing

Fun time Alert

(Olivia Majumder, Soumita Paul)

The Stellar Scuffle

(Samarpita Chatterjee, Sahana Chanda,

Srishti Sikdar, Ritoma Chakraborty, Debdita Ghosh)

----- 54-58



9 Second Home

Photo Gallery ----- 29-35

10 Let's Play

Word Search

(Mehuli Maity) ----- 18-19

Crossword

(Alolika Roy, Srijita Hazra) ----- 70-71

❖ Answer of Wordsearch ----- 84

❖ Answer of Crossword ----- 85

❖ Bibliography ----- 86-90

ABOUT OUR DEPARTMENT

Dr. Santa Bandyopadhyay Rajguru

Department of Physics, Bethune College

Bethune College, Kolkata, has the distinction of being the first women's college in Asia which was established in the year 1879. The illustrious past presents its success in the hallmark of women's education, societal struggle, women emancipation, and finally their empowerment. The legacy of Kadambini Ganguly, Chandramukhi Basu, Pritilata Waddedar and other luminaries in the league, inspired the students and learners to fight against all odds for social empowerment and justice through individual enlightenment.

The journey of the Undergraduate Physics began in the year 1960 at Bethune College with the introduction of B.Sc. Physics Pass course under the University of Calcutta. Thereafter, in 1967, to widen the academic scope and need of the students, the B.Sc. Honours Course in Physics was introduced. This was possible under the magnanimous leadership of Prof. Chameli Basu, Head of the Department, supported ably by her notable colleagues namely Dr. Annapurna Sarker, Smt. Pratibha Dasgupta, Smt. Seema Sengupta, Smt. Srirupa Bhagat, Smt. Nandini Raha and other officials. The Physics Honors journey initiated with twelve (12) students, which now stands around one hundred and eight (108). Since then the associates of the department, including students, ventured here to learn, explore, research, work, teach and grow in the pursuit of truth, knowledge, and a better world. This vibrant community pursued diversity, built inclusion, and created more equitable opportunities for learning, which could connect the learners from many diverse backgrounds, with opportunities in the department now and into the future. The department nurtured to produce brilliant graduates, majority of whom pursued higher education, innovations in science, teaching, and learning with the aim of broader national and global concerns. They are spread across length and breadth of the world and shined gloriously in universities and institutes of repute, both in India and abroad, making a positive difference in communities. Such is the environment of studies and the general ambiance in the department.

Over the years, the department assembled well-equipped laboratories for both Honours and Generic Elective courses, computer laboratory connected with Internet facility, class room with LCD projector, a rich reservoir of Seminar Library in addition to College Library, a book bank donated by Alumnae for needy students and similar endeavors in its continuous path of improvement.

Other than academics, various scientific co-curricular activities and outreach programmes are organized in the form of Seminars and Workshops that are routinely conducted in order to trigger and shape informed young minds. There are several Prizes institutionalized for appreciation of meritorious and performing students to encourage further advancement and development of specialized field of their choice.

Recently, Golden Jubilee was celebrated for completion of 50 years of Physics Honours teaching of the department and a commemorative volume published bearing the name "Bahe Nirantara", compiling resource articles from the past and present students as well as past and present teachers.

Now, with the sudden strike of COVID'19 pandemic, capable of triggering loneliness, when feelings of social isolation are on the rise, it has become all the more important for the young minds to engage in online learning activities to keep anxiety at bay. During this unprecedented time, students might feel disconnected from important social groups or communities. This is the time when colleges and departments can perform important function of intervention, where teachers can ensure that students stay connected that brings in an era of mentorship.

The e-magazine entitled "EPISTIME" produced by our students during this tiring times is a perfect tribute to the Department and of our illustrious college, which is an outcome of their individual efforts and collective brilliance. This e-magazine deserves heartfelt appreciation of all concerned for the mental strength and courage showed by the students in bringing life into this magazine in this uncertain time. The coordination involved to bring out this magazine is worth appreciating and speaks volume about the sense of community life in shared prosperity, which was possible by digital infrastructure. The topics selected by the students are so interesting and contemporary that it has the capacity to capture the evolving scientific minds and their imaginations. The choice of articles and reference made only goes to show how much our students is attached to the major discoveries and inventions in scientific frontiers of the world, which is nothing short of our venerable traditions and continuing strengths into a leading department of the future.

FROM STUDENTS' DESK

This lockdown has tested us immensely, turning our lives dull and tiresome, but some people surely managed to find colour in our monochromatic life. Some of us read a lot, some of us learnt new skills, some of us took the time reflect upon themselves but most importantly everyone took the time to do what they love.

Our beloved professor Dr. Santa Bandopadhyay (Rajguru), randomly planted this idea of an online magazine in our heads and or sheer love of physics drove us towards its completion. Learning about the wonders of physics has always been exciting for us lot and we were glad to have gotten a chance to utilise our creativity in such mundane times. The participation among the students of our department took us by surprise because previously, no such initiative had been taken for an online magazine and the eagerness among students helped us overcome our initial nervousness and lack of sureness about the magazine. We would be nowhere without the help of our professors Dr.Kamal Kanti Som and Dr. Gautam Goswami. The process of search for topics, proof reading and editing to make the magazine look presentable would not have been easy without everyone's support and encouragement especially our beloved professors.

Hence we have compiled pieces of ourselves to present to you this magazine and we wholeheartedly hope you enjoy reading it as much as we did in the making.

MANISHA GHOSH

ON BEHALF OF ALL STUDENTS

OF

PHYSICS DEPARTMENT , BETHUNE COLLEGE

BONTONTV

THE COSMOS UNDER THE SEA

Manisha Ghosh

Animita Chakrabarti

Semester 3, Physics Department

Fascinated by the possible scientific advancements in the future? How about the ones from the past left forgotten in the deep chasms of time? Imagine having a time machine, go on, press the button to travel back a few years, how about a few centuries. Let's stop at 70 BC. There is a shipwreck, quite natural however this one holds timeless evidence of the scientific manoeuvre possessed by our ancestors. This magnificent device is now named as "The Antikythera Mechanism". The Antikythera mechanism is the only known physical survivor of a long tradition of mechanical astronomical displays. The widespread existence of such devices can be inferred from references in Greco-Roman literature, particularly in the descriptions left by Marcus Tullius Cicero (1st century BCE), that stretch from Archimedes (3rd century BCE) to a poetic reference in the late 4th or early 5th century CE. Sounds theoretical? Well not really, this actually is the first analogue computer of human existence.



The Antikythera Mechanism

Discovery: At first glance, the piece of the brass found near the wreck looks like something you might find in a junkyard or hanging on the wall of a maritime-themed dive bar. What remains of the mechanism is a set of rusted brass gears sandwiched into a rotting wooden box.

But if you look into the machine, you see evidence of at least two dozen gears, laid neatly on top of one another, calibrated with the precision of a master-crafted Swiss watch. This was a level of technology that archaeologists would usually date to the 16th century, not well before the first.

The Greek Antikythera island housed the Antikythera shipwreck for over two centuries until it was discovered by Captain Dimitrios Kontos along with a crew of sponge divers in 1900-01. The Hellenistic Astronomical machine with bronze wheels was identified on May 17, 1902, by archaeologist Valerios Stais in the Museum of Archaeology in Athens. Though initially perceived as an astronomical clock by the discoverer, the mechanism was considered prochronistic.

This magnificent device was neglected until British science historian Derek J. De Solla Price restarted it in 1951. In 1971, accompanied by Greek nuclear physicist Charalampos Karakalos, a series of X-ray and Gamma imaging was performed, resulting in an extensive 70 page paper in 1974. The most recent scientific data gathering was undertaken in 2005 by the ANTIKYTHERA MECHANISM RESEARCH PROJECT (AMRP).

Till date, two non-destructive investigatory techniques were used: *Polynomial Texture*

Mapping (PTM) to enhance surface details of the fragments and *Microfocus X-ray Computed Tomography* (X-ray CT) to examine the interiors of the fragments at high resolution.



Both sides of Fragments A, B and C of the Antikythera Mechanism. 2005 Antikythera Mechanism Research

Origin: The device uses Hipparchus' theory for the motion of the Moon, therefore indicating the possibility of his hands behind the construction of this astronomical clock. Accompanied by other Rhodian artefacts, some theory suggests this was constructed in an academy found by Posidonius.

2008: continued research showed that the concept may have originated in Corinth, since the calendar was identified as Metonic Spiral, this device is also arguably associated with the school of Archimedes. The device was supposedly from Syracuse, a colony of Corinth however this was later rejected.

2014, Carman and Evans: They believed this device was more similar to the Babylonian arithmetic style of prediction than the traditional Greek Trigonometric Style.

2017, Paul Iverson: He showed that the prototype was indeed from Rhodes, however, this particular model was modified for a client of Epirus in Northwest Greece.

The advanced stage of corrosion has made it impossible to perform an accurate compositional analysis, however, this device arguably contains 95% copper and 5% tin. The

proper instructions of which are encoded in Koine Greek.

Despite extensive researches conducted on this priceless artefact, the actual time of creation still raises disagreements among scientists. The quality and complexity of the structure indicates precursors in the Hellenistic period. Some of the popular origin periods are:

- ❖ 200 BC (Carmen and Evans, 2014)
- ❖ 140 – 120 BC (Other Artefacts indicate this era)
- ❖ Late Second Century (Device is based on theories of astronomy used in this period in Greece)
- ❖ 87 BC (Price in his paper of 1974)
- ❖ 76 BC – 67 BC (Jacques Cousteau)
- ❖ A generation prior to the shipwreck (70 BC) (Paul Iversen in 2017)

Description of the Mechanism: The Antikythera mechanism had the first known set of scientific dials or scales, and its importance was recognized when radiographic images showed that the remaining fragments contained 30 gear wheels. No other geared mechanism of such complexity is known from the ancient world or indeed until medieval cathedral clocks were built a millennium later.

The Antikythera mechanism was fabricated out of a bronze sheet, and originally it would have been in a case about the size of a shoebox. The doors of the case and the faces of the mechanism are covered with Greek inscriptions, enough of which survive to indicate clearly much of the device's astronomical, or calendrical, purpose. It is believed that a hand-turned shaft (now lost) was connected by a crown gear to the main gear wheel, which drove the further gear trains, with each revolution of the main gear wheel corresponding to one solar year. *On the front of the mechanism is a large dial with pointers for showing the position of the Sun and the Moon in the zodiac and a half-silvered ball for displaying lunar phases.* The drive train for the lunar position is extremely sophisticated,

involving epicyclic gearing and a slot-and-pin mechanism to mimic subtle variations (known as the “first anomaly”) in the Moon’s motion across the sky described in the Hipparchus and Ptolemaic system.

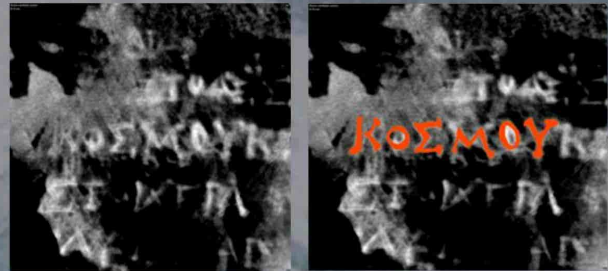
Two large dials are on the back of the mechanism. The large upper dial has a five-turn spiral slot with a moving pointer to show the 235 lunations, or synodic months, in the Metonic cycle. This cycle is almost exactly 19 years long and is useful in regulating calendars. The large lower dial has a four-turn spiral with symbols to show months in which there was a likelihood of a solar or lunar eclipse, based on the 18.2-year Saros eclipse cycle. These astronomical cycles would have been known to the Greeks from Babylonian sources. The inscriptions imply that there may originally have been a display of planetary positions, most likely on the front face, but nearly all the relevant parts are missing.

The Antikythera Mechanism Research Project, under the aegis of Greece’s Hellenic Ministry of Culture, supports an international collaborative effort by academic researchers to study the Antikythera mechanism.

Courtesy of “The Cosmos in the Antikythera Mechanism” by Tony Ferret and Alexander Jones: Out of the 82 fragments 7 large ones are listed as A – G and the smaller ones as 1 – 75. Fragment A is by far the largest and alone contains twenty seven of the thirty gears. There is a single additional gear in each of the fragments B, C and D. Despite two thousand years underwater, many of the surfaces of the fragments are rich in detail, showing mechanical features as well as inscriptions, which cover some of the surfaces. The remains of about a dozen gears are visible on the surface and the rest have been identified through X-ray studies.

The Cosmos Held Within: Improved readings of an inscription that was on the Mechanism's back cover and that described its external features and displays leave little room

for doubt that the front display incorporated revolving pointers bearing little spheres to represent all five planets known in antiquity making their apparent motions around the Earth. Each sphere is said to move through a “circle” belonging to the planet. This is strong evidence that the inscription “cosmos” on the front display refers to the entire front dial, portraying in cross-section the Aristotelian conception of the universe as a system of nested geocentric spherical shells.



The inscription “ΚΟΣΜΟΥ” (Cosmos). ©2005 Antikythera Mechanism Research Project.

Uses: Researchers are still not sure who, exactly, used it. Did scientists build it to aid their calculations? Or was it a type of a teaching tool, to show students the math that held the cosmos together? Was it unique? Or are there more similar devices yet to be discovered? Still, some of the undisputable uses are:

- ❖ The front plate, divided into three sections contained a central dial system, which displayed outputs from the Mechanism on a Zodiac Dial, marked with 360° scale divisions and a Calendar Dial, marked with 365 days. The Calendar Dial was designed to be movable, so that the Mechanism could accommodate the fact that four Egyptian calendar years fall short of four 365.25 day solar years by one day.
- ❖ A subsidiary four-year dial on the back showed when the various Panhellenic games should take place, including the ancient Olympic Games.

The exact purpose of the Antikythera mechanism remains speculative, however. Nor is it known if the bronze-gear technology and the advanced mechanical design skills involved in its construction were exploited for other applications within the Greco-Roman world.

Its assembly remains another mystery. How the ancient Greeks accomplished this feat is unknown to this day.

Whatever it was used for and however it was built, we know this: Its discovery changed our understanding of human history, and reminds us that flashes of genius are possible in every human age.

Existence of Similar Models: "Nothing like this instrument is preserved elsewhere. Nothing comparable to it is known from any ancient scientific text or literary allusion," Price wrote in 1959. "It is a bit frightening, to know that just before the fall of their great civilization the ancient Greeks had come so close to our age, not only in their thought, but also in their scientific technology."

However, as released in the exhibition: Voyage – Greek shipbuilding and seafaring from antiquity to modern times (2017) There has been a new and interactive model constructed by Dr. Markos Skoulatos. The model is gold plated and the inscriptions are sophisticatedly handcrafted. The base is of Pentelic Marble, the marble that adorns the Parthenon and other structures of Athens. Inside the model "hides" a contemporary microcomputer that moves the gears of the mechanism.



The new Antikythera model released in Voyage (2017)

THE FERMI PARADOX AND ITS POSSIBLE SOLUTIONS

Adrija Sarangi

Semester I

Moumita Chatterjee

Physics Department

Our curiosity in the extra-terrestrial has remained consistent since the times of Greeks and Romans. The Greeks apparently believed that there were living creatures on the moon! As our ideas and perceptions regarding the universe increased, we realized that may be not only the moon or the Solar system, but there are nearly 60 billion other earth-like planets in the Milky Way Galaxy that might be capable of supporting intelligent life. In an attempt to figure out the probabilities involved in existence of alien life; an equation was developed by Frank Drake in 1961. It goes like this:

$$N = R_* f_p n_e f_i f_c L$$

Where the variables represent:

- N is the number of technologically advanced civilizations in the Milky Way galaxy;
- R_* is the rate of formation of stars in the galaxy;
- f_p is the fraction of those stars with planetary systems;
- n_e is the number of planets, per solar system, with an environment suitable for organic life;
- f_i is the fraction of those suitable planets whereon organic life actually appears;
- f_c is the fraction of those planets whereon intelligent life actually appears;
- f_c is the fraction of civilizations that reach the technological level whereby detectable signals may be dispatched;
- L is the length of time that those civilizations dispatch their signals.

The fundamental problem is that the last four terms are completely unknown, rendering statistical estimates impossible.

The universe has been existing for billions of years now, with our Galaxy being 13.51 billion years old. Earth is a comparatively younger planet than many others in the solar system. Henceforth compared to our planet, the other much older planets capable to support intelligent life must have advanced space travel to a greater extent leading to gradual colonization of galaxies. But there had been no such proof, found till date that could support existence of alien life on any other parts of our galaxy or the universe.

There are 400 billion stars in our galaxy, and astronomers estimate that each has 1.6 planets on an average (probability of how many planets each of stars can hold), bringing the total number of planets to a range of

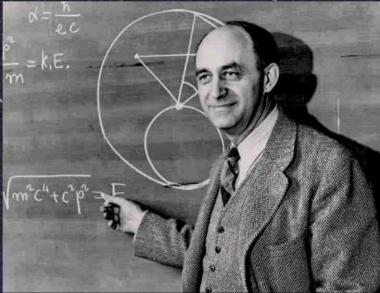
640 (400 × 1.6) billions. 1.6 is just an average calculation. Out of 400 billion stars in the galaxy, some stars may hold planets and some may not or some may be in the process of forming planets. Though the number of potentially habitable world differ based on various parameters, calculations show the Milky Way alone may have 60 billion habitable planets. Based on these numbers alone, our state of loneliness seems rather improbable.

Herein lies the paradox: isn't there any intelligent life in existence yet, which is civilized enough to establish contact with other developing intelligent



creatures? If they have unlocked modes of communication and interstellar travel, then, “where are they?” If the universe is supposed to be teeming with life, then why haven’t we ever got any proof of alien habitats?

The above question pretty much describes the



Fermi Paradox. As the story goes, Italian physicist Enrico Fermi, most famous for creating the first

nuclear reactor, came up with the theory with a casual lunch time remark in 1950.

Fermi thought that any civilization with a modest amount of rocket technology and an immodest amount of imperial incentive could rapidly colonize the entire Galaxy. While interstellar distances are vast, perhaps too vast to be conquered by living creatures with finite lifetimes, it should be possible for an advanced civilization to construct self-reproducing autonomous robots to colonize the galaxy.

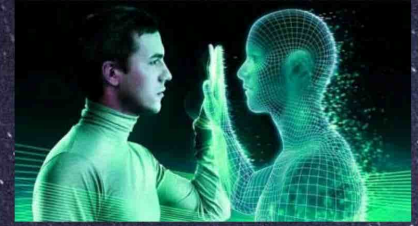
So, what Fermi immediately realized was that the aliens have had more than enough time to pepper the Galaxy with their presence. But looking around, he didn’t see any clear indication that they are out and about. This prompted Fermi to ask the question, “Where is everybody?”

Our relentless quest for the intelligent life out in space has yet, practically, borne no fruit. Though theoretically, we have reached out for a few possible solutions that seem to apparently satisfy the questions put forward by the Fermi Paradox. Essentially, according to the Drake Equation, there must be approximately 600 billion habitable planets in the observable universe, which may support intelligent life.

But why didn’t we find traces of any life, in spite of our tireless search and modern technologies?

Some of the possible answers lie herein:

1.The Simulation theory: The Simulation theory, being the most popular and thought-provoking theory, seems to well explain our state of loneliness in this vast universe.



The theory throws

light on the possibility that the universe we are living in, is a complete illusion, in other words, most likely, a computer simulation, created by our alien overlords. This theory is put on a strong base by the fact that we live in an accelerated universe, which stops us from making out our final destination. Also, this theory points out that we can never get the perception of time, with respect to our alien overlords (since we are just a line of code executed by the computer!),

we may be in the simulation for a fraction of second, or may be



trapped here for billions of years, which we’ll never get to know. Also, the rules governing the universe are made by our simulator, and we are all created from variations of certain discrete physical quantities, just like images in a computer are created by discrete quantities, pixels. We are merely objects in a computer simulation, that is being run, in order to serve a specific purpose.

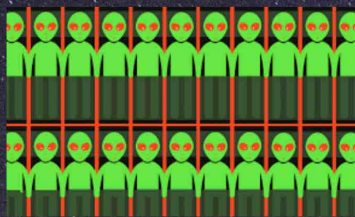
2.The Dark Forest Hypothesis: The Dark Forest Hypothesis, stresses on the probability that intelligent civilizations in space,



deliberately do not broadcast their existence, so as to hide their presence

from the rest of the universe. They may use this as a self-protective measure, to prevent attacks from more advanced civilizations. If we haven't found any signals, and provided the extra-terrestrials exist, it means they have very good reasons not to send out those signals. Since we are releasing signals in space for over a century now, there is a high probability that "everyone is listening, and no one is talking".

3. We are the Aliens: This theory highlights the probability that extra-terrestrials may take the advantage of relative motions of stars, and travels to



the destination only when it is relatively closer, just as we send spacecrafts to Mars, when it is nearer to Earth. So, it is highly probable that they visited us, say 10 million years ago, and seeing all the earmarks of a habitable world, sowed the seeds of life, with their own genetic material, and allowed us to flourish. Next, to travel to Earth again, they need to wait for that previous favorable condition (nearest distance, movement of stars etc.), as a result, would not visit us for a long time. We in a sense, are merely their experiment.

We don't know where to search: Our search for intelligent life is largely confined to planets with an environment favorable for life. What if,



we are searching altogether, in a wrong place? This suggests that truly

intelligent species do not always necessarily need a rocky planet, in order to thrive. It may happen that their

energy demands, have either, driven them to lurk on the galactic edge, or, they may have found ways to wind up spacetime, and thus probably, made their way through a supermassive black hole, so as to hide forever from the galactic neighbours and prevent attacks as well.

Life is Extremely Rare and Space is

too vast: Perhaps, in search of extra-terrestrial intelligence, the simplest solution is the correct one. We haven't encountered any signs of life yet, either because it is not there, or because it is exceeding ly rare.



Although Drake Equation points out a large probability, it may happen that intelligent life forms are not that frequent, as expected.

Another possibility indicates that space, simply put, is extremely vast, and radio bubbles take too long to reach out other intelligent life forms. Also, since we haven't encountered any significant radio bubbles yet, it indicates the fact that life forms are rare, and signals take too long.

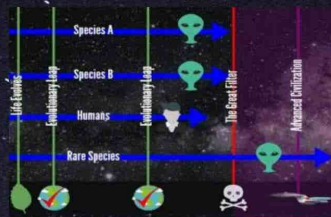
They use Tech to spy: No matter how technologically advanced a species might be, space exploration will always remain a long,

fraught and hostile work. Therefore, it may possibly happen that



extra-terrestrial civilizations send advanced technologies, or self-replicating nanobots, instead of life-driven crafts, like the Von Neuman probes, for space exploration and to do the work for them.

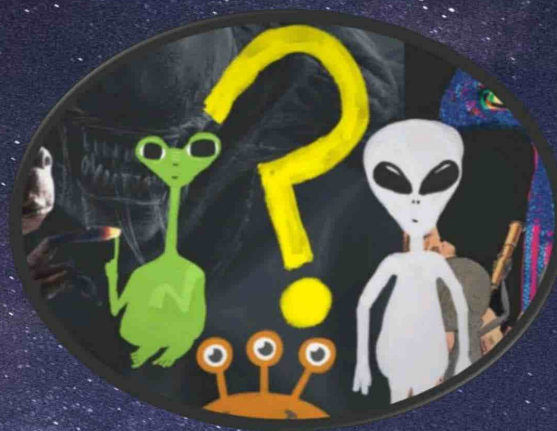
The Great Filter: Simply stated, the Great Filter suggests that interstellar



life forms must clear a series of hurdles in order to survive through the ever-changing

cosmos. The premise of Great Filter is that there is at least one hurdle that no species could complete and move on to the next. Even if so, probability suggests that there must be a few interplanetary species, colonizing galaxies by now. But such traces are yet to be found.

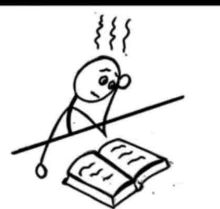
Above, just suggests, a few solutions to the Fermi Paradox, out of which none is established to be true. Astronomers see no evidence of any civilizations, out there in space. So, are we alone in this vast cosmos? The affirmative answer to this question is too scary and improbable to be true. Again, when we look to the stars, the silence is deafening. Thus, Fermi Paradox, certainly leaves us with a deep humbling. We end herein, with a stimulus to continue to search for the truth.



FUNTIME ALERT

Physics major in New Year's Eve:

11:59 pm



12:00 am



12:01 am



AS TIME GOES BY...

Shamayita Dutta

Titir Chatterjee

Semester 3, Physics Department .

“कालःपचतिभूतानि, कालःसंहरतेप्रजाः ।

कालःसुप्तेषुजागर्ति, कालोहिदुरतिक्रमः ॥”

***“Time devours all things, Time kills all that are born.
Time is awake while all else sleeps, Time is
insurmountable.”***

- Vidura in Mahabharata



Ever since humans first noticed the regular movement of the Sun and the stars, we have wondered about the passage of time. People wanted to know “what is time”! What is now? What is past and what is future? Where we are from and where we are going. The Buddhists thought time was cyclic; the Christians believed it was pre-ordained. In Hindu mythology time is described as almighty and endless. According to Oxford Dictionary- “Time is the indefinite continued progress of existence and events in the past, present and future regarded as a whole.” In layman’s language Time is one of the seven fundamental physical quantities in both the International System of Units (SI) and International System of Quantities. It is not something we can see, touch, or taste, but we can measure its passage.

Even today in the 21st century, physicists are in search of an answer for this question.

Generally, we think time is linear. Around 13.799 billion years ago time started with Big Bang. So, if we plot time graphically on X axis, the Big Bang will be represented as the origin of the graph. Here a question arises. Can we plot time on negative X axis also? Was there any time before Big Bang? Philosophically yes, but mathematically or scientifically the answer is NO. The answer was first given by St. Augustine, he said –“time is a property of the universe that God created, and that time did not exist before the beginning of the universe”. However while answering the question what is time, St. Augustine, the famous theologian, and philosopher, sarcastically admits (that he’s in a) “sorry state, for I do not even know what I do not know!”

About 2500 years ago, Aristotle, was the first philosopher who has ever stated an explicit and concise definition of Time. Aristotle defines time as a kind of number. More precisely, time is "a number of change with respect to the before and after". The Aristotle's definition indicates that time has a counting and numerical aspect. He regarded Time and Change as closely related and interpreted time in regard to changes and variation not vice versa. Time is not a kind of motion rather it is based on motion.

After Aristotle, Walter Charleton, a scientist, came forward with a conception of time in his book "*Physiologia Epicuro-Gassendo-Charltoniana*". According to him - time and space are real entities even though they fit neither of the traditional categories of substance or accident, also time "flow[s] on eternally in the same calm and equal tenor," while the motion of all bodies are subject to "acceleration, retardation, or suspension".

However those attempts to define time were not much scientific, till Newton came. Sir Isaac Newton believed in the fact of ABSOLUTE TIME. Absolute, true, and mathematical time, from its own nature, passes equably without relation to anything external, and thus without reference to any change or way of measuring of time. According to Newton, two observers can unambiguously measure the time interval between two events and it would be the *same* for everybody. If a pulse of light is sent from one body to another body, different observers would agree on the time that the journey took but would not agree on how far the light travelled. That means the speed of light will be different for each observer. He believed time is different from space. This is apparently true and holds for things like cars, earth, moon etc. But don't hold for things moving at the velocity of light. Newton did not regard space and time

as genuine substances (as are, paradigmatically, bodies and minds), but rather as real entities with their own manner of existence as necessitated by God's existence (more specifically, his omnipresence and eternity). Newton's views on space, time, and motion dominated physics from the 17th Century until the advent of the theory of relativity in the 20th Century.

In 1887 and 1905, physics again surprised us. With the help of Michelson-Morley experiment and Lorentz Experiment it was proved that the velocity of light is constant. This contradicts the theory of Sir Isaac Newton.

In 1905 Albert Einstein, an unknown clerk in Swiss patent office put an end to that theory of absolute time and merges space with time. Keeping the fact that velocity of light is constant, Einstein gave his famous equation of relativity:

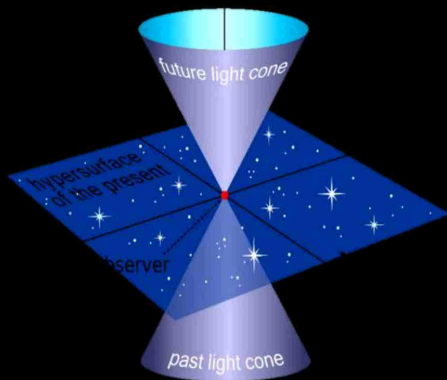
$$E = mc^2$$

Where *m* is the mass of a body, *E* is the energy emitted by the body; *c* is the velocity of light. It proves mathematically that no mass can move faster than light. This equation revolutionized the idea of space and time. It says if a pulse of light is sent from one place by one observer to a different observer at another place, they *must* agree on how fast light travels but they must not agree over the time it has taken which contradicts Newton's idea.

An observer could use radar and say where and when an event is taking place by sending a pulse of light. Part of the pulse will be reflected back to the observer from the event and the observer can measure the time at which he received the echo. Using these process observers at different points in space or having relative velocity will assign different time.

So this theory forces us to change our conventional idea over space and time and we must accept that space and time is combined with each other forming space-time. If an event is happening in space one must use four coordinates to define this. Those coordinates

can be arbitrarily chosen, as there is no such difference between space and time.



Taking the velocity of light constant we can form a cone by the path of light travelled. It can be formed by a three dimensional space time model, in which two coordinates

are of space and one dimension is of time. If we consider light from a present event making a three dimensional cone then we can call the cone as future time cone. In the similar way we can make a past time cone. The tip of both will be attached at the present or 'P'. So, the absolute future of the event 'P' lies in the future cone of 'P'. Events outside the future light cone will not affect 'P'. Similarly the absolute past of the event 'P' lies in the past cone. Events outside the past cone cannot affect 'P'. For example if the Sun ceases to shine at this moment it would take 8 minutes to affect Earth because light takes eight minutes to travel from Sun to Earth. Only then earth would enter to the future light cone of sun. This theory depicts that light travels in a straight path and so time. Time cone for an event will be the same everywhere in space.

However if we take gravitational force in account the theory slightly changes. According to general relativity space seems to be curved around a massive mass. It means light can no longer travel in a straight path and it should be bent by the curve. For example the time cone of the Sun will slightly bend inwards near the sun for the massive mass of the Sun. This means if light from a star happened to pass near the sun it would be deflected by a small angle. Apart from that time would also run slower near a massive body like earth. Here comes the conception of time dilation.

Time dilation can easily be explained by taking the example of the famous movie "*Interstellar*". The movie starts with two characters Cooper and Doctor Brand, who stayed in the Miller's planet which is near the black hole, Gargantua for hours. However, after returning to Earth, they discovered that several years had elapsed on Earth and Cooper's daughter, Murphy had been 84 years old while her father doesn't look a day older than 35, although his biological age was 124 years. This is the most appropriate example of time dilation that comes handy. Time dilation is a difference in the elapsed time as measured by two clocks due to a relative velocity between them or to a difference in gravitational potential between their locations.

If there are twin brother A and B, A lives in higher altitude of earth and B is in lower altitude, the age of them will be different because of time dilation. This is known as famous Twin Paradox. As B is closer to the earth, time will run slower for him than for A, who being farther from the mass of earth will have time running faster for him. So if two systems stays at different distances from a gravitational mass time will be different for them (that is why when a spaceship nears a black hole of extreme mass, observers see time slowing to a crawl for them)

There is another reason for time dilation also. Let us take two systems. One system moves at relativistic speeds and the other system remains stationary. If one observer A is in an inertial frame of reference with a clock while the other observer B is in a moving system with a clock. A will find out that the clock with B is ticking slower than his clock. This case is sometimes called special relativistic time dilation. The faster the relative velocity, the greater the time dilation between one another, with the rate of time reaching zero as one approaches the speed of light.

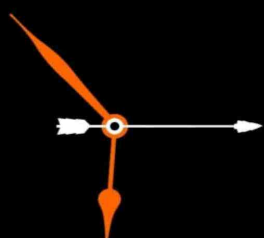
There is another question that arises while talking about time. We know, if a person is going towards east, he can change his direction and go towards west also. But can time move backwards? With special dimensions, the 3-Dimensional world that we live in, it is very

easy to go back and forth between places because these things are absolutely fixed in space. If I went to market to buy some groceries and I forgot soap, I could easily go back and buy soap. However, the time that it took to do that is unable to be retrieved. It is lost forever into the past. An object placed in 3-Dimensional space will stay there almost forever if no factors are available to disturb that. If I place a book on the table, it will just stay there but that book still falls victim to time. We can suppose time is like an arrow. It moves in one direction forward. Scientists and researchers called this the arrow of time.

In this context we can recall these lines...

*“The Moving Finger writes; and, having writ,
Moves on: nor all thy Piety nor Wit,
Shall lure it back to cancel half a Line,
Nor all thy Tears wash out a Word of it.”*

— Omar Khayyám



Those eternal lines by Omar Khayyam portray that time only moves forward, which in terms of physics we call as “THE ARROW OF TIME”. The phrase “the arrow of time”

was coined in 1927 by Sir Arthur Eddington and popularized in his book published in 1928, *The Nature of the Physical World*. Basically, the arrow of time is the idea that time flows in only one direction. In the time-like direction, however, there cannot be complete symmetry. In layman’s language this phenomenon means - eggs may break, but they never spontaneously reform, milk can only spill but can never be unspilled, a work can be done but never can be undone.

When it comes to explaining the arrow of time we may take help of the second law of thermodynamics. Because there are no laws of physics that suggest that the past is different from the future. The only reason we differentiate between past and present is only

because of entropy, because the universe had a beginning.

The second law of thermodynamics gives us the idea of ENTROPY. This law states that, as one goes forward in time, the net **entropy** (degree of disorder) of any isolated or closed system will always increase. The universe appears to have started extremely small, conceivably it all started in a single point. That point must have been highly ordered, having total entropy very small or possibly zero. This is a reasonable boundary condition at the origin of time. Ever since the Big-Bang, all the matter in the universe has been expanding away from each other making the universe a higher entropy system. Because of entropy and because of the arrow of time, we have galaxies, stars, planets and even life. And since then time is moving only in forward direction as entropy is increasing. It’s the reason why life today is the way that it is. Each previous day had entropy lower than the present before. So with the help of entropy we can easily differentiate between past and future.

We can explain arrow of time by psychological arrow of time also. We appear to have an innate sense that our perception runs from the known past to the unknown future. We anticipate the unknown, and automatically move forward towards it, and, while we are able to remember the past, we do not normally waste time in trying to change the already known and fixed past. This also indicates the forward direction of time. However **Stephen Hawking** has argued that even the psychological arrow of time is ultimately dependent on the thermodynamic arrow.

Not only this but several of the other arrows of time like Cosmological Arrow of Time, Radiative Arrow of Time, Quantum Arrow of Time, Causal Arrow of Time ultimately come back to the asymmetry of thermodynamics.

TIME TRAVEL:-

Time and again we have seen that various people all around the entertainment industry have tried to approach the idea of time travel. We have witnessed multiple instances where time travel has been the central focus of the story, such as the NASA pilot Joseph Cooper racing against time to save the human race and his daughter by transporting the population to a new home via a wormhole in the movie "Interstellar". Then again the German show "Dark" has brought out the various mishaps, complications and all the things that can go wrong with Time Travel. The most famous of all, "Avenger Endgame": where the Avengers travel to the past to save earth from the mega villain Thanos.

Time Travel builds up a major premise for superhero movies and comic books and theorizes various Super abilities of superheroes such as "The Flash" and "Quicksilver". We have also seen Hermione from the "Harry Potter" series use a Time Turner to travel back and forth in time to attend all her classes. Time travel is such a fascinating concept that it has been introduced to the younger generation of viewers by Doraemon and other cartoon characters.

One of the scientific theories for traveling into the distant future is to use the time-dilation effect of Special Relativity, which states that a moving clock appears to tick more slowly the closer it approaches the speed of light. Time dilation may be regarded in a limited sense as "time travel into the future": a person may use this mechanism so that a small amount of proper time passes for them, while a large amount of proper time passes elsewhere. Einstein's equations clearly prove that at a speed equivalent to the speed of light, time becomes slower for the person who acquires this speed. It means that person enters the future of other persons which are not moving at that speed.

The method of using gravity to travel in time is also inspired by Einstein. According to his theory of general relativity, the stronger the

gravity you feel, the slower time moves. So, we need a strong gravity like black hole to travel to the far future, but it's risky

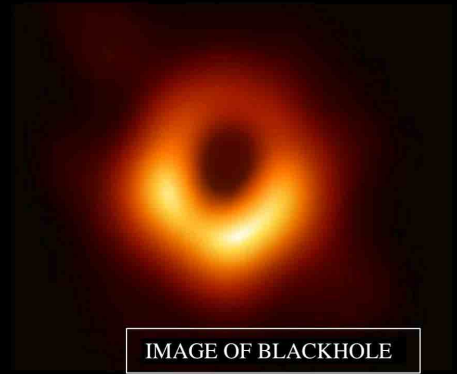
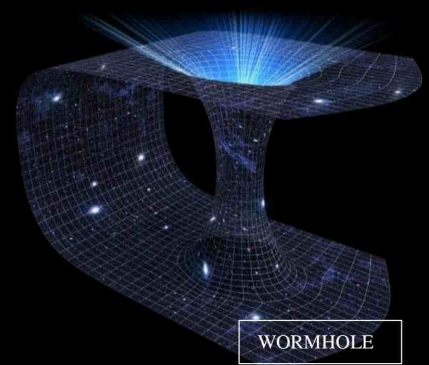


IMAGE OF BLACKHOLE

as once we cross the boundary, we can never escape. General relativity also allows for the possibility for shortcuts through space-time, known as wormholes, which might be able to bridge distances of a billion light years or more, or different points in time. A wormhole connects two points in space via a sort of tunnel through a higher dimension. An object entering one end of a wormhole would emerge almost instantly on the other end, even if the openings were

separated by trillions of miles.

However, wormholes for travel would likely need to be artificially constructed, because



WORMHOLE

there is no solid evidence that they exist naturally. This is just possible theoretically.

Another idea, put forward by the American physicist Ron Mallett, is to use a rotating cylinder of light to twist space-time. Anything dropped inside the swirling cylinder could theoretically be dragged around in space and in time, in a similar way to how a bubble runs around on top of your coffee after swirling it with a spoon. According to Mallett, the right geometry could lead to time travel into either the past or the future.

Since publishing his theory in 2000, his ideas have not grabbed the rest of the physics community however, with others arguing that one of the assumptions of his basic model is

plagued by a singularity, which is physics-speak for “it’s impossible”.

However, in spite of these theories time travel has not been yet achieved by humans, but with the advancement of science and technology we can hope that someday in the future, time travel will be practically possible.

Time is, beyond a mysterious self-similar backdrop upon which we lead our lives. It is intricately woven across the scales of observation - from the quantum level to the phenomenological time of cultural revolutions. Why is time so important? Stephen Hawking answered, “Because it governs our life and the universe”. We know, on a deeply practical level, that each moment in time carries the potential for great integrity within our lives. Time is an integral part of the Universe. It is something which prevents everything from happening at once. We can define it but we don't really understand it entirely. Aristotle, said that time is the “most unknown of all unknown things”. Even today his saying is perfectly true. Time still remains a mystery, an unsolved problem. As physicists says: *Time is the fundamental basis of the illusory.*



WORDSEARCH

MEHULI MAITY

SEMESTER 3,

PHYSICS DEPARTMENT

S	P	I	R	A	L	G	A	L	A	X	Y	E	C	F	J
C	O	U	E	N	T	R	O	P	Y	K	N	V	X	O	N
A	L	R	D	I	A	M	A	G	N	E	T	I	S	M	Y
P	O	V	G	A	N	Y	M	E	D	E	O	P	A	C	O
I	N	Q	I	T	C	E	F	F	E	N	A	M	E	E	Z
L	I	Z	A	C	O	N	D	U	C	T	O	R	C	J	K
L	U	E	N	E	R	G	Y	W	D	N	E	V	T	I	P
A	M	O	T	N	O	Z	I	R	O	H	T	N	E	V	E
R	F	O	R	C	E	S	C	O	O	P	B	X	V	L	O
Y	A	C	T	I	O	N	H	W	R	E	U	Y	T	T	P

HINTS

- The type of galaxy our Milky way is _____.
- The largest moon of our solar system is _____.
- Sun will become a _____ once all hydrogen is exhausted in the core.
- _____ just increasing from the beginning of the universe and will get as high as it is ever going to get.
- First radioactive element discovered was _____.
- There is no electric field inside a _____.
- _____ is the most fundamental behaviour of all matter, although usually very weak

- The surface defining the boundary where the escape velocity is more than the speed of light is called _____.
- The effect of splitting of a spectral line into several components in the presence of static magnetic field is known as _____.
- Upward movement of water molecules from plant roots to the leaves through xylem, is an example of _____.
- Time and _____ cannot be measured simultaneously and precisely.
- There are four basic _____ in nature.

[FRIENDLY TIP: TURN YOUR HEAD IN ALL DIRECTIONS]

ANSWER IN THE LAST PAGE

BONTON TV

RING DYNAMICS

TURNI BISWAS

SARA AKHTER

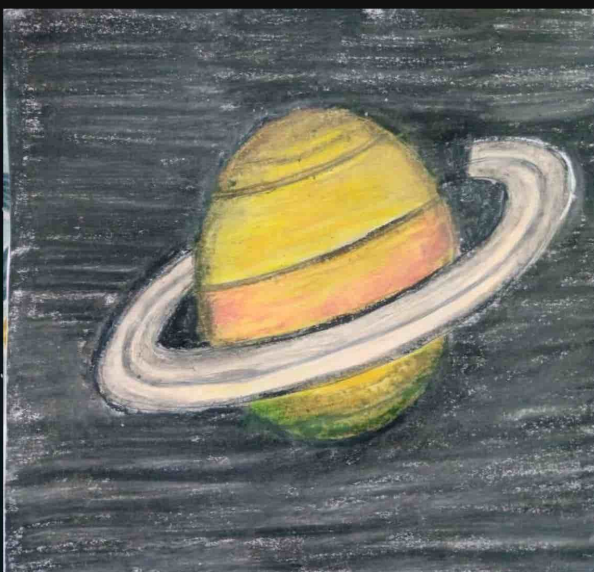
Semester 1

Physics Department

A ring system is a disc or ring orbiting an astronomical object that is composed of solid material such as dust and moonlets, and is a common component of satellite systems around giant planets. A ring system around a planet is also known as a planetary ring system. In our solar system there are three planets that contain rings. The most famous planetary rings in the Solar System are those around Saturn, and in around Jupiter, Uranus, and Neptune. Recent evidence suggests that ring systems may also be found around other types of astronomical objects, including minor planets, moons, and brown dwarfs, and as well, the interplanetary spaces between planets such as Venus and Mercury. However we are more interested in Saturn, Jupiter, Uranus, and Neptune.

So, let us discuss about some basic information of the ring dynamics.

Saturn's rings are the most extensive ring



PLANET SATURN

system of any planet in the Solar System, and

thus have been known to exist for quite some time. Galileo Galilei first observed them in 1610, but they were not accurately described as a disk around Saturn until Christiaan Huygens did so in 1655. Saturn's rings are as thin as a sheet of tissue paper spread across a football field. The dense main rings extend from 7,000 km to 80,000 km away from Saturn's equator, whose radius is 60,300 km. With an estimated local thickness of as little as 10 m and as much as 1 km. The rings are composed of 99.9% pure water ice with a smattering of impurities that may include tholins or silicates. But the question is how do they stay thin? The particles experience partially inelastic collisions, which damp out their vertical motions. These collisions keep the rings thin, and also moving in circular orbits. The velocity dispersion of Saturn's rings is probably 0.1 cm/s or less. (one ten millionth of their orbital velocity.) No other planet in our solar system has rings as splendid as Saturn's.

Let's come to Jupiter now. Jupiter's intricate, swirling ring system is formed by dust kicked up as interplanetary meteoroids smash into the giant planet's four small inner moons. In late 1970's, NASA's two Voyager space craft first revealed the structures of Jupiter's rings, a flattened main ring, inner cloud like halo rings and a faint outer gossamer ring. Because of its transparency, it consists of two rings, composed of microscopic debris from two small moons, Amalthea and Thebe. Unlike Saturn's rings there are no signs of ice in Jupiter's rings.

Now let us talk about Uranus's Ring Dynamics;

Pressure from the solar radiation, and drag from the charged particles around Uranus, can cause the ring particles spiral into the planet. The rings of Uranus are thought to be very young. They probably came from a few shepherded moons that were shattered by Uranus's gravity and turned into rings around the planet.

The planet Neptune has five complete rings (According to Voyager 2). The outer ring is known as Adam's Ring which according to the scientists have originated from Galatea, (Neptune's moon).

However, the universe is very large and full of mysteries. Many concepts and theories related to ring dynamics are yet to be discovered.

John B.S. Haldane truly said, "The universe is not only queerer than we suppose, it is queerer than we can suppose."



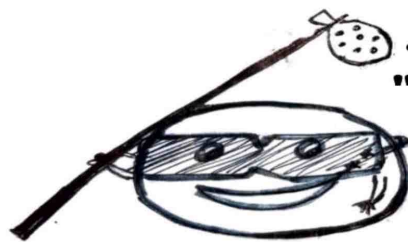
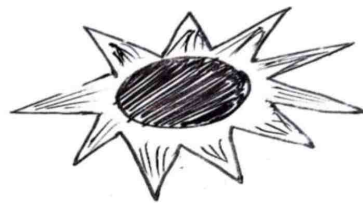
PLANET JUPITER



PLANET NEPTUNE

FUNTIME ALERT

A photon checks into a hotel and is asked if he wants some help regarding his luggage



• **Photon:**

"*NO, I'M TRAVELLING LIGHT ***"



ANTI BUBBLE

Samarpita Chatterjee

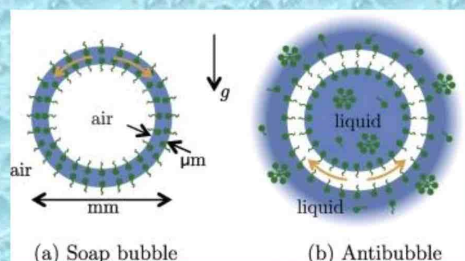
Semester 3

Physics Department

When we were children, our favourite fun time was playing with bubbles. Yes, that bubbles, that soap bubbles. Whenever I went to the fair, I always indulged my father to buy it for me, or sometimes I was able to make it my own at home. Not only in childhood, bubbles make all ages of people quite surprised and delighted. But now! Just think! Can you imagine? We are using bubbles for safely delivering cancer drugs to the human cell!

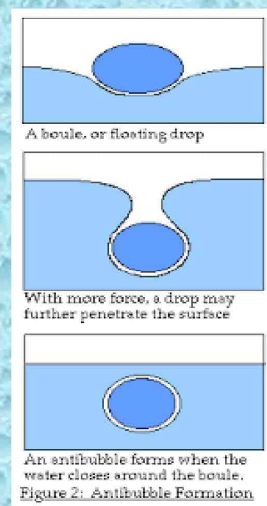
These bubbles are different to those one with which we are habituated to play. These consist of a volume of liquid surrounded by a membrane of gas, giving rise to the name '**ANTI BUBBLE**'. Simply, anti bubble is just the opposite of our natural air bubble and like air bubble, it is also a very common object around us. We can easily observe it just by giving a closer and minute look to the tap water in time of filling a bucket. Anti bubbles can either skim across the surface of a liquid such as water, in which case they are also called '**WATER GLOBULES**' or they can be completely submerged into the liquid.

Basically, in ordinary circumstances, anti bubbles are short lived (life time depends upon the liquid, ranging between few seconds).



Anti bubbles are held in place by **surface tension** of liquid. So, we can use mixture of liquids or some kind of soapy substances instead of

using a single pure liquid to increase the surface tension. Even we can perform **vibration** within the liquid which cause water droplets to continuously bounce and levitate over the liquid surface. There are many cool and amazing video stuffs regarding anti bubble's stability, formation, life time, collapse etc. in the internet world. Just search it and enjoy!!!!



But why are anti bubbles important? Practically, investigating of the physics of anti bubble could lead to a better understanding of physics of fluids and build a better model for **visualization of quantum superposition**. Yves Couder and Emmanuel Fort have recently discovered that droplets walking on a vibrating fluid bath exhibit features previously thought to be peculiar to the quantum realm, including single-particle diffraction, tunneling, quantized orbits and orbital level splitting.



Recent research has been directed towards elucidating the subtle pilot-wave dynamics of these walking droplets, and rationalizing their quantum-like behavior.

Moreover, anti bubbles have a potential role in ultrasonic imaging, **ultrasound guided drug delivery**, hydrocarbon leakage detection. In traditional cancer drug delivery through pills

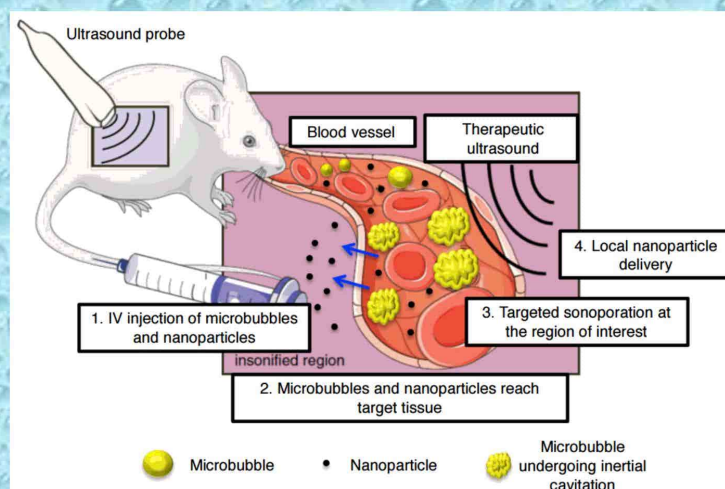
or injection sends the active agent through the bloodstream, meaning that a high percentage of cells around the whole body are exposed to the drug. By encapsulating cancer drugs within gas micro bubbles and liquid nano droplets, Eleanor has created a targeted delivery mechanism which releases sufficiently high concentrations of the drugs only when they reach the part of the body where they are needed.

The micro bubbles are loaded with magnetic nano particles which means an externally applied magnetic field can be used to guide the bubbles to the target site, where they are then activated using ultrasound to burst the bubble and release the drug. The advantages of using ultrasound is that it can be easily focused for accurate targeting, even deep within the body. It's safe and non-invasive, cheap, and it provides an accurate way to

monitor the treatment. In addition, exposure to ultrasound is known to promote drug uptake in cells. This drug delivery method has the potential to avoid the widespread destruction of healthy cells that is presently unavoidable with chemotherapy, which would revolutionize the future treatment of cancer sufferers.

Furthermore, if antibubbles can be stabilized they can be used to form a long lasting froth — antifoam. Possible uses for antifoam are as a lubricant or as a filter for air or other gases. Antibubbles themselves could be used for chemical processes such as removing pollutants from a smokestack.

Yep! Physics is all around us. We are living within the grand laboratory of nature. Every single natural and simple phenomenon teaches us amazing things. We need to just to learn from it !!!!



THE BOY WHO FIXES RADIOS BY THINKING

Sairindhree Saha

Semester 1

Physics Department

“There are two types of genius. Ordinary geniuses do great things, but they leave you room to believe that you could do the same if only you worked hard enough. Then there are magicians, and you can have no idea how they do it. Feynman was a magician.” Hans Bethe.

Feynman – perhaps one of the most curious characters in the history of science – a combustible mixture of high intelligence, unexhaustive inquisitiveness, eternal scepticism and unapologetic unconventionality – is the only man in history to solve the mystery of liquid helium and to expertly crack the uncrackable safes guarding the atomic bomb’s most critical secrets. He



has traded ideas with Einstein and Bohr; discussed gambling odds with Nick the Greek and accompanied a ballet on the Bongo drums!

Much is known and discussed about this genius scientist who

remade quantum electrodynamics and altered the way science understands, the nature of waves and particles and the atypical teacher Feynman is, who shows and teaches you the beauty of theoretical reasoning in Physics in the most exceptional ways possible. It’s a delight to read his words, be it his seminal

works in physics or the personal accounts of his colourful life. This piece tells, for the most part, a few interesting stories in the life of the prodigious Feynman before he became one of the ‘Top Ten’ physicists in the world.

Richard P. Feynman was born on May 11, 1918 in a small town called Far Rockaway. Feynman was a very curious little kid with an unquenchable thirst for knowledge, especially for science. At the age of eleven or twelve, he had already set up a laboratory in his house. He used to do all sorts of little experiments using self-built fuses, circuits, lamp banks etc. His father had a large contribution in his love for observing natural phenomena and discovering the principles working behind them. From his father, he learned how to translate- words into thoughts into images that he could physically work with – indeed a priceless exercise that would pay off for the rest of his life. Feynman recalls a beautiful lesson learned from his father: “He had already taught me: ‘See that bird?’ he says. ‘It’s a Spencer’s Warbler’. ‘Well, in Italian, it’s a *Chutto Lapittida*. In Portuguese, it’s a *Bom da Peida*. In Chinese, it’s a *Chung-long-tah*, and in Japanese, it’s a *Katano Takeda*. You can know the name of that bird in all the languages of the world, but when you’re finished, you’ll know absolutely nothing whatever about the bird. You’ll only know about humans in different places, and what they call the bird. So, let’s look at the bird and see what it’s *doing*- that’s what counts.’ (I learned very early the difference between knowing the name of something and knowing

something)” And for this eagerness towards learning, Feynman was unsurprisingly advanced in his academics as well. He started learning Algebra, Trigonometry, even Calculus on his own with the help of books from his local library. Feynman recalls how in high school all the seniors in his school would come to him with various different problems from their advanced mathematics classes that they were having problems in solving. And being the stubborn boy he was, he wouldn’t stop until he solved the problem, no matter how hard it might seem. So, on the first try it would take him fifteen-twenty minutes to solve it, but during the day, when other seniors would come to him with the same problems, he would do it for them in a flash. “So, for one guy, it took me twenty minutes, while there were five guys who thought I was a super-genius!” Demands from seniors to discuss and help solve their advanced problems went on for Feynman even in his MIT years.

However, he learned everything on his own, so his process of learning and teaching were different from the conventional way. He invented different symbols for mathematical expressions. Feynman writes, “When I was doing all this trigonometry, I didn’t like the symbols for Sine, Cosine, Tangent, and so on. To me, ‘sin f’ looked like ‘s’ times ‘i’ times ‘n’ times ‘f’! So, I invented another symbol, like a square root sign, that was a sigma with a long arm sticking out of it, and I put the f underneath.” Not only for the sine function, but he also invented symbols for tangent, $\log(x)$, dy/dx , etc. As a teacher, Feynman has also always encouraged his students to invent their own symbols for better understanding as he always believed that learning is an individual experience and that students should always have the autonomy of inventing their own unique way of understanding as that alone can provide the confidence of original thought and execution.

Feynman, since he was a school freshman, was keen to know about Radios and their mechanisms. Whenever in the neighbourhood someone’s radio got broken, Feynman was called to fix it. So, he’d climb on tops of roofs to fix antennas and all other kinds of stuff. Feynman recalls one particular job he got at his mother’s friend’s house, and it took him the whole afternoon to find out a not-so-apparent burnt-out resistor in the system. He tells, “I finally fixed it because I had, and still have, persistence.” He treated each repairing work as a puzzle. Feynman said “Once I get on a puzzle, I can’t get off.... because I want to beat this damn thing, as long as I’ve gone this far. I can’t just leave it after I’ve found out so much about it. I have to keep going to find out ultimately what is the matter with it in the end.... That’s a puzzle drive. It’s what accounts for my wanting to decipher Mayan hieroglyphics, for trying to open safes.”

One thing Feynman has always emphasized is the ability to visualize what you read and to apply your passive understanding to physical and practical scenarios. He often liked to play little tricks on his classmates at MIT. One day in a mechanical drawing class one student picked up a French curve (a scale-like thing to draw smooth curves) and asked if there were any special formulas for the curves in it. Amused by this, Feynman told them that the curves were very special curves and they indeed had a special character. He then picked his own curve and begun to turn



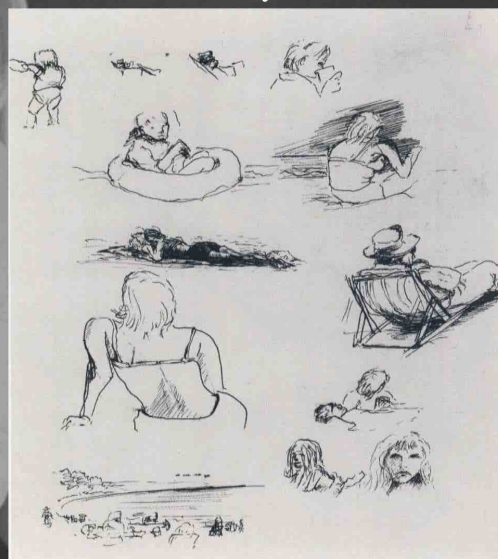
it slowly and said that the French curves are made so that, no matter how you turn it, at the lowest point on each curve, the tangent is horizontal. Then all the students in the class were holding their French curves at different angles testing this 'new knowledge'. In Feynman's words, "They were all excited by this 'discovery'—even though they had already gone through a certain amount of calculus and had already 'learned' that the derivative (tangent) of the minimum(lowest point) of any curve is zero (horizontal). They didn't put two and two together. They didn't even know what they 'knew'."

Feynman took interest in various other fields than Physics throughout his life. He was also an artist. He was very good at drawing sketches or making cartoons. In the dining area of Princeton University, where he was completing his graduate degree, students would sit with their specific groups. Feynman used to sit with the physicists usually, but after a bit, he thought, 'it would be nice to see what the rest of the world was doing'. So, he would sit for a week or two in each of the other groups.

So, one day when he sat with the Philosophers, they were very seriously discussing a book called *Process and Reality* by Whitehead. And he didn't quite understand what they were talking about. Finally, the philosophers invited him to their seminar. They had a seminar that had been meeting once a week to discuss a new chapter out of *Process and Reality*—some guy would give a report on it and then there would be a discussion following. Feynman went to the seminar promising himself to keep his mouth shut (which was so very rare of this man as we all know), reminding himself that he didn't know anything about the subject and was going there just to watch. But it would've been a miracle in itself if Feynman left the seminar without stirring up some argument! So, at the beginning of the seminar, a student

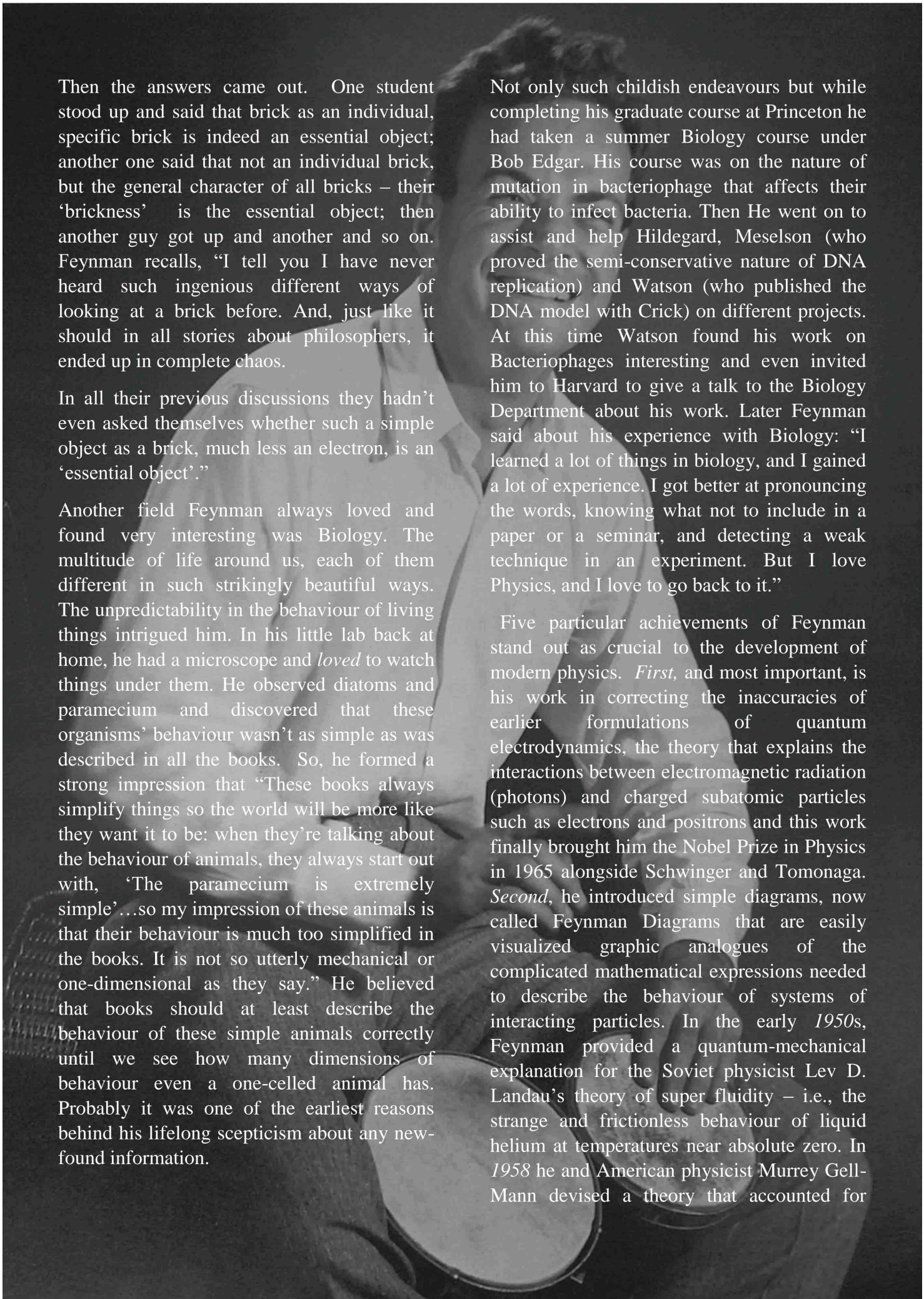
gave a report on the chapter which was to be studied that week, in which Whitehead kept using the term "essential object" in a particular technical way that presumably the author himself had defined.

After some discussion as to what 'essential object' meant, the professor leading the seminar asked, "*Mr. Feynman, would you say an electron is an 'essential object'?*" To that Feynman confessed that as he had not read the book, he had not the slightest idea of what that meant; but he could try to answer the professor's question if he'd first answer a question from him first, so that



DRAWINGS BY FEYNMAN

he could gain a better understanding of an 'essential object'. Feynman asked the class, "Is a brick an essential object?". What he had intended to do was "to find out whether they thought theoretical constructs were essential objects. The electron is a *theory* that we use; it is so useful in understanding the way nature works that we can almost call it real. I wanted to make the idea of a theory clear by analogy. In the case of the brick, my next question was going to be, 'what about the *inside* of a brick?' — and I would then point out that no one has ever seen the inside of a brick. Every time you break the brick, you only see the surface. The brick has an inside is a simple theory that helps us understand things better. The theory of electron is analogous."



Then the answers came out. One student stood up and said that brick as an individual, specific brick is indeed an essential object; another one said that not an individual brick, but the general character of all bricks – their ‘brickness’ is the essential object; then another guy got up and another and so on. Feynman recalls, “I tell you I have never heard such ingenious different ways of looking at a brick before. And, just like it should in all stories about philosophers, it ended up in complete chaos.

In all their previous discussions they hadn’t even asked themselves whether such a simple object as a brick, much less an electron, is an ‘essential object’.”

Another field Feynman always loved and found very interesting was Biology. The multitude of life around us, each of them different in such strikingly beautiful ways. The unpredictability in the behaviour of living things intrigued him. In his little lab back at home, he had a microscope and *loved* to watch things under them. He observed diatoms and paramecium and discovered that these organisms’ behaviour wasn’t as simple as was described in all the books. So, he formed a strong impression that “These books always simplify things so the world will be more like they want it to be: when they’re talking about the behaviour of animals, they always start out with, ‘The paramecium is extremely simple’...so my impression of these animals is that their behaviour is much too simplified in the books. It is not so utterly mechanical or one-dimensional as they say.” He believed that books should at least describe the behaviour of these simple animals correctly until we see how many dimensions of behaviour even a one-celled animal has. Probably it was one of the earliest reasons behind his lifelong scepticism about any new-found information.

Not only such childish endeavours but while completing his graduate course at Princeton he had taken a summer Biology course under Bob Edgar. His course was on the nature of mutation in bacteriophage that affects their ability to infect bacteria. Then He went on to assist and help Hildegard, Meselson (who proved the semi-conservative nature of DNA replication) and Watson (who published the DNA model with Crick) on different projects. At this time Watson found his work on Bacteriophages interesting and even invited him to Harvard to give a talk to the Biology Department about his work. Later Feynman said about his experience with Biology: “I learned a lot of things in biology, and I gained a lot of experience. I got better at pronouncing the words, knowing what not to include in a paper or a seminar, and detecting a weak technique in an experiment. But I love Physics, and I love to go back to it.”

Five particular achievements of Feynman stand out as crucial to the development of modern physics. *First*, and most important, is his work in correcting the inaccuracies of earlier formulations of quantum electrodynamics, the theory that explains the interactions between electromagnetic radiation (photons) and charged subatomic particles such as electrons and positrons and this work finally brought him the Nobel Prize in Physics in 1965 alongside Schwinger and Tomonaga. *Second*, he introduced simple diagrams, now called Feynman Diagrams that are easily visualized graphic analogues of the complicated mathematical expressions needed to describe the behaviour of systems of interacting particles. In the early 1950s, Feynman provided a quantum-mechanical explanation for the Soviet physicist Lev D. Landau’s theory of super fluidity – i.e., the strange and frictionless behaviour of liquid helium at temperatures near absolute zero. In 1958 he and American physicist Murrey Gell-Mann devised a theory that accounted for

most of the phenomena associated with the weak force, which is the force at work in radioactive decay. And finally, in 1968, while theory of 'Partons'- a hypothetical hard particle inside the nucleus of the atom, that helped lead to the modern understanding of quarks.

This relentless mind came to a final stop on the 15th of February, 1988. Feynman's stature among physicists transcended the sum of even all his contributions to the field. His bold

experimenting at the Stanford Linear Accelerator on the scattering of high-energy electrons by protons, Feynman invented a personality, unencumbered by false dignity or notions of excessive self-importance, seemed to announce: 'Here's an extra-ordinary mind.' Feynman – a curious mind from the beginning till the very end, is an iconoclast whose fervor, the capability of questioning the authority, and finding the most unique ways of solving problems, and scientific integrity has and will lead the path of many more scientific minds.

Wrapping this up in the legend's own words: "A poet once said, 'The whole universe is in a glass of wine.' We will probably never know in what sense he meant it, for poets do not write to be understood. But it is true that if we look at a glass of wine closely enough, we see the entire universe. There are the things of physics: the twisting liquid which evaporates depending on the wind and weather, the reflections in the glass, and our imagination adds the atoms. The glass is a distillation of the earth's rocks, and in its composition we see the secrets of the universe's age and the evolution of stars. What strange array of chemicals are in the wine? How did they come to be? There are the ferments, the enzymes, the substrates, and the products. There in wine is found the great generalization: all life is fermentation. Nobody can discover the chemistry of wine without discovering, as did Louis Pasteur, the cause of much disease. How vivid is the claret, pressing its existence into the consciousness that watches it! If our small minds, for some convenience, divide this glass of wine, this universe, into parts—physics, biology, geology, astronomy, psychology, and so on – remember that nature does not know it! So, let us all put it all back together, not forgetting ultimately what it is for. Let it give us one more final pleasure: drink it and forget it all!"

FUNTIME ALERT

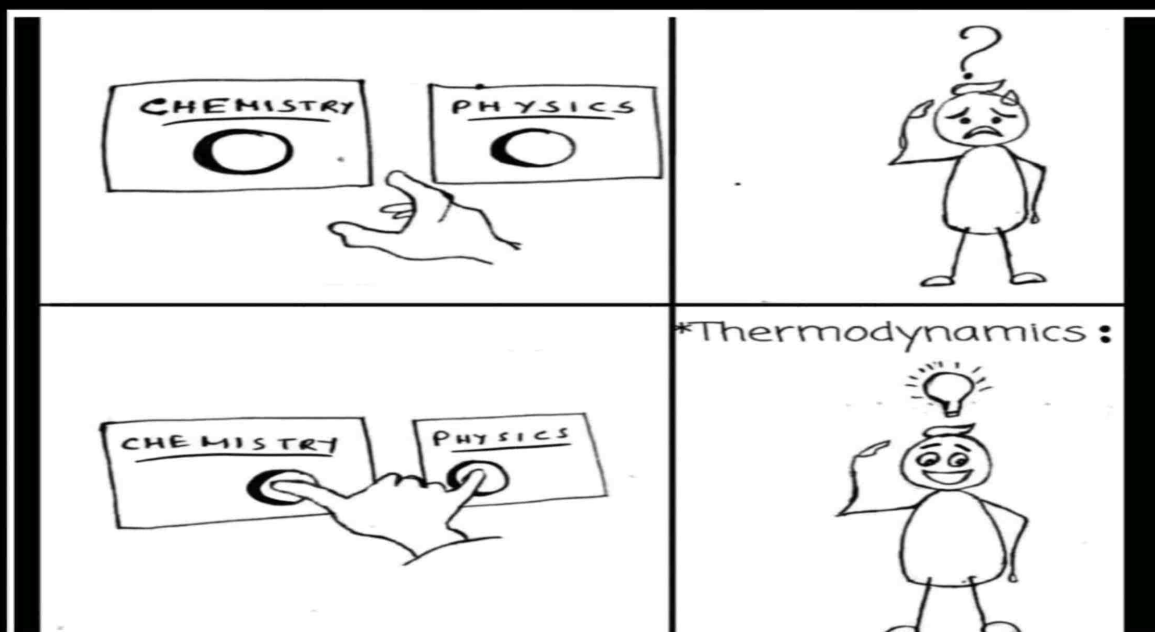
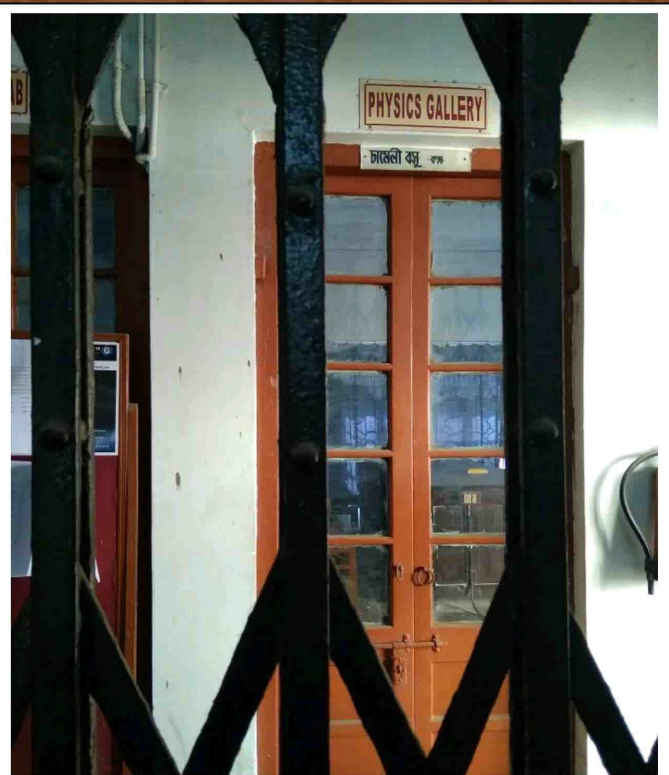
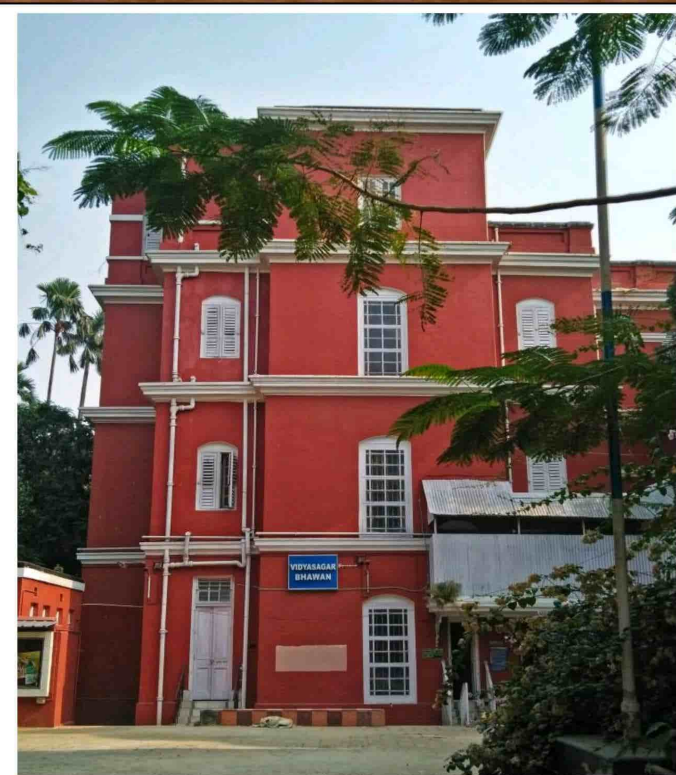
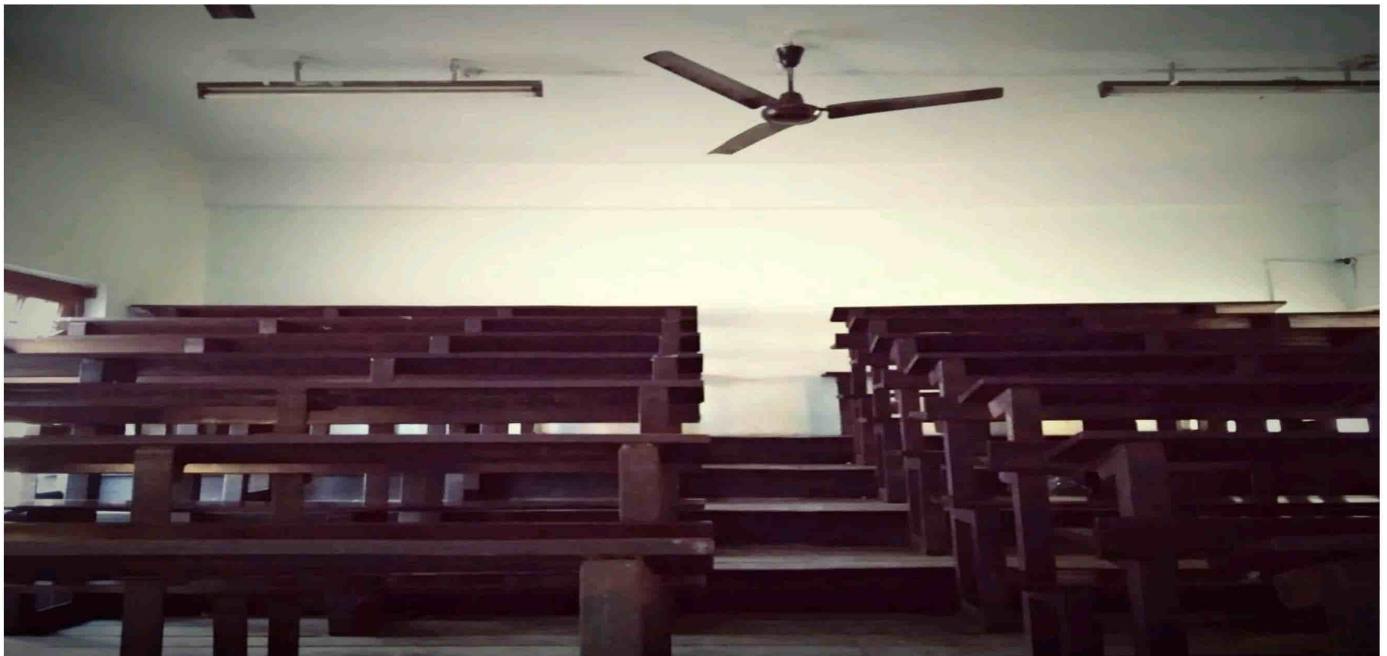
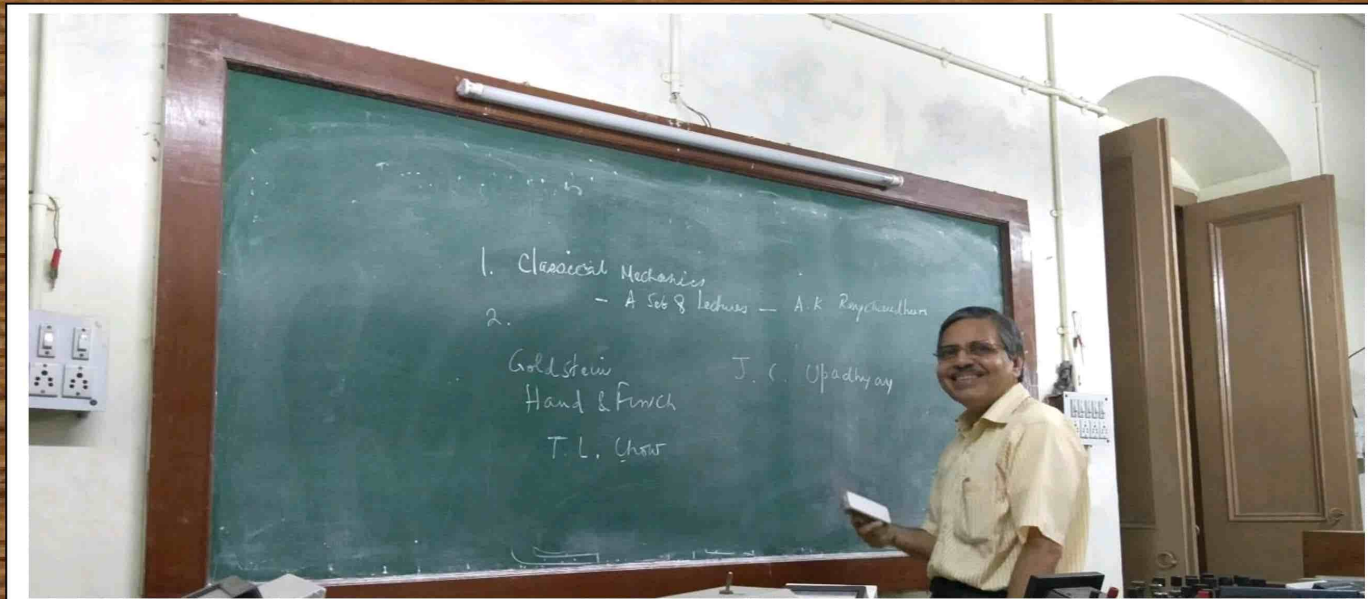
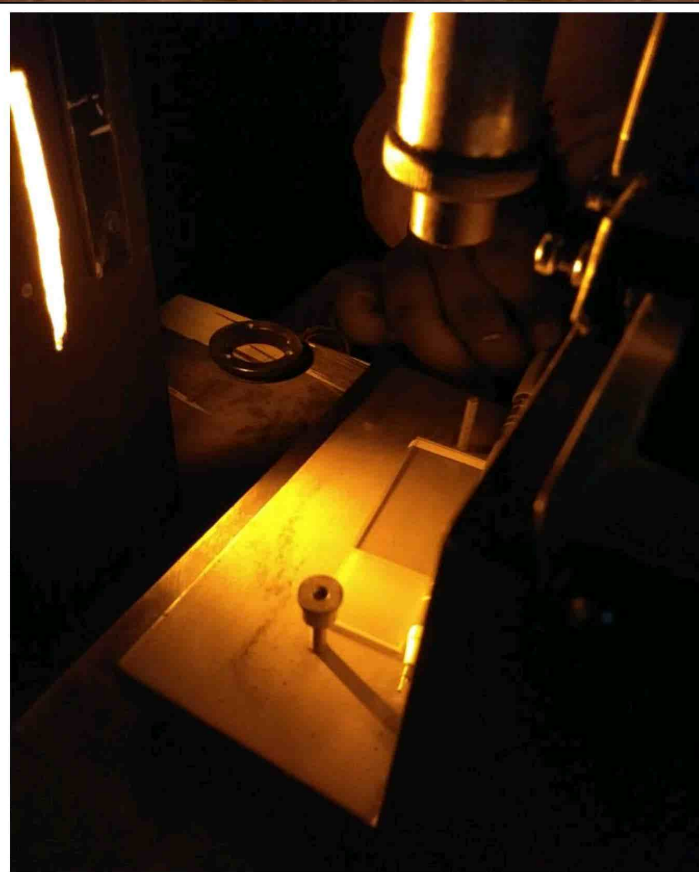


PHOTO GALLERY



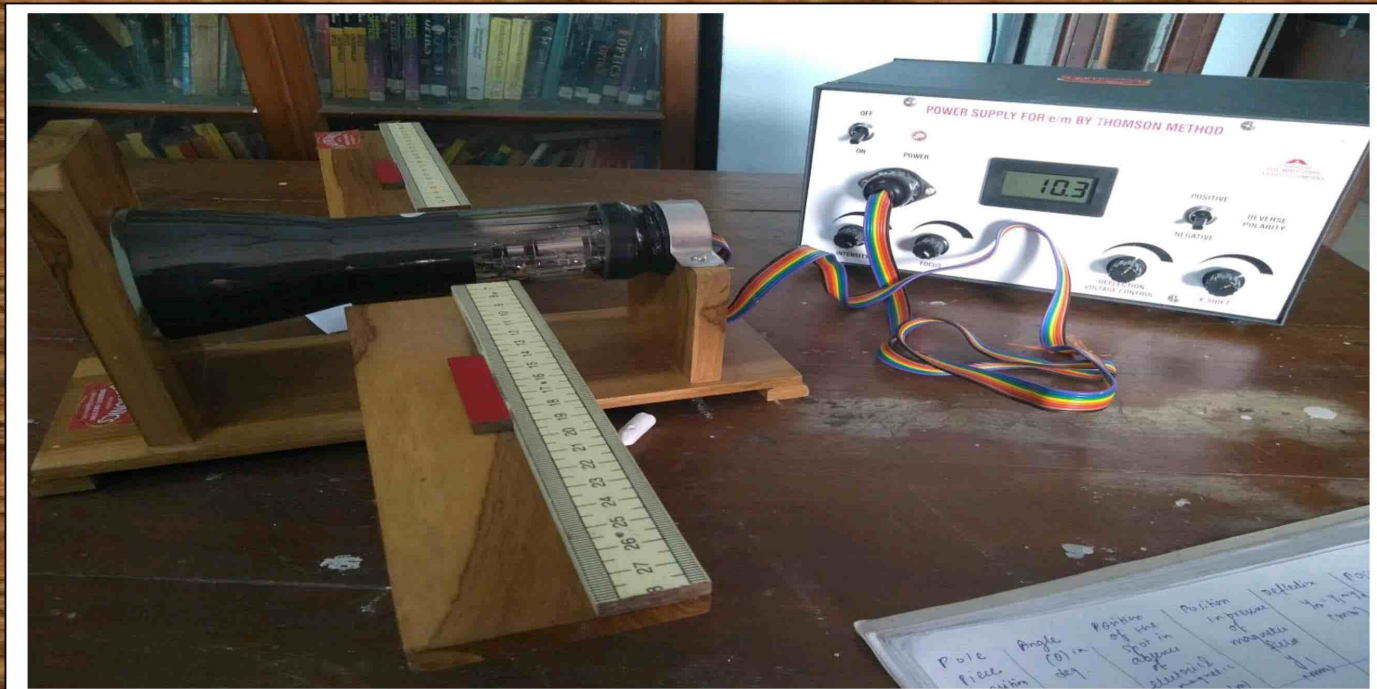












PICTURE COURTESY
TRISHITA CHATTERJEE, PRIYADARSHINI SAHA
COMPILED BY
TITIR CHATTERJEE

BLACKHOLE: THE HUNGRY PREDATOR OF UNIVERSE AND AN IMPULSE

Sayantani Bhandari

Srijita Hazra

Debarati Mukhopadhyay

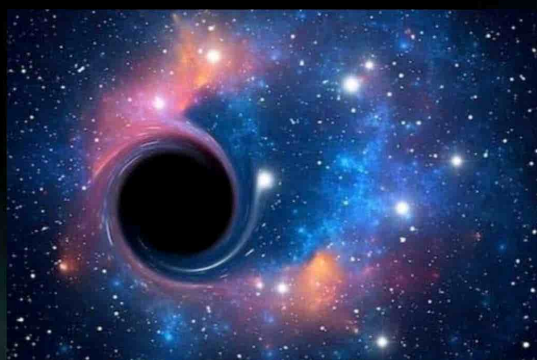
Semester-3

Physics Department

*কালো? তা সে যতই কালো হোক,
দেখেছি তার কালো হরিণ-চোখ ।।*

-- Rabindranath Tagore

Like Tagore, we can also say that Black doesn't always mean melancholy, abomination or something negative. Black also has an incomparable fascination, an unavoidable attraction. In universe one of the best examples of the "Beauty of black" is **Blackhole**. Humans have a never-ending curiosity about this fascinating and one of the most mysterious things of our universe. We can't control our imagination and fabulous ideas about another universe while thinking about it. But what exactly is a blackhole? How does it form? When did the idea of blackhole come into our minds? What is so interesting or amazing about it? Why it is so special? Do blackholes exist in universe? There are so many queries that come in our mind when we 1st learn the word blackhole. Well, here we try to understand some of these questions.



It was coined in 1969 by an American scientist Jhon Wheeler that if light is both wave and particle then it must have affected by gravity. But to overcome its huge velocity we indeed need an extreme gravitational field. On such assumption Jhon Michell in 1783 pinned that if a massive star could have such a

strong gravitational field that even light could not escape: any light emitted from the surface of the star would be dragged back by the star's gravitational attraction before it could get very far. Although we would not able to see them because the light from them would not reach us, we would still feel their gravitational field. such objects are what we now call **blackholes**, because that is what they are: black voids in space. But to understand how these stars transform into blackholes we first need to understand the life cycle of a star.

A star is formed when a large amount of gas

Paradoxically, if a star starts off more fuels, sooner it runs out and more hotter it is and will die soon. Well nothing to worry, our Sun will probably take another 5 thousand million years to die

starts to collapse on itself due to gravitational attraction. As atoms of gases (mostly hydrogen) collide with each other

more and more frequently it gets heated up. Thus, eventually they coalesce to form helium and the heat generated from this explosion makes the star shine. With increasing heat, pressure is also increased until it is sufficient to balance gravitational attraction and the gases stop contracting. Star will remain stable like this for long time. At last, when the star runs out its fuel, it starts to cool down as well as starts to contract. This theory was 1st understood at the end of 1920s.

In 1928 an Indian graduate student, Subrahmanyam Chandrasekhar worked out on how massive a star should be that it will fail to act against its own gravity after it had used up all its fuel. Actually, there is a limit to repulsion that Pauli exclusion principle can provide. The general theory of relativity limits the maximum difference in the velocities of the matter particles in the star to the speed of light. That means when the star got sufficiently dense the repulsion by exclusion principle would be less than the attraction of gravity.

Chandrasekhar calculated that a cold star of more than one and half times of solar mass would not be

able to support itself against its own gravity. This mass limit is known as

Chandrasekhar Mass Limit:

It is the maximum limit of the mass of a stable dwarf star.

The currently accepted value of Chandrasekhar limit is about 2.765×10^{30} kg

Chandrasekhar mass limit.

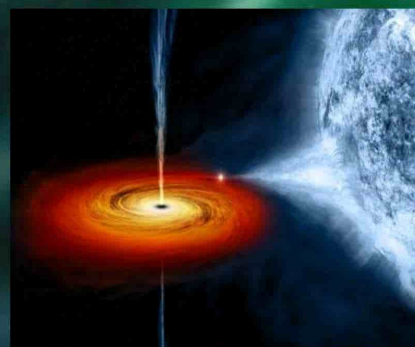
If a star's mass is less than this limit it can eventually stop contracting and settle down to

a possible finite state known as **White dwarf**.

A white dwarf is supported by the exclusion principle of repulsion between the electrons in matter. We can find a large number of white dwarf stars around us. Landau also pointed out that there was another possible final state for a star with a limited mass about one or two times the solar mass but much smaller than white dwarfs. These stars would be supported by exclusion principle of repulsion between neutrons and protons rather than electrons. So, they are called **Neutron stars**.

Stars with masses above Chandrasekhar limit sometimes tries to explode to throw out enough matter to reduce their masses to avoid catastrophic gravitational collapse.

Now such a strong gravitational field can even change the path of light rays from what they would have been had the star not been there. The light cones which indicate the path follows in space and time by flashes of light emitted from their tips, are bent slightly inward near the surface of the star. As the star contracts the gravitational field at its surface gets stronger so the light cones get bent inward more which make it more difficult for light to escape and light appears dimmer and redder to an observer at a distance and finally light can no longer escape from it. As we know nothing can't travel faster than light so everything will be dragged back by the gravitational field. So, one has a set of regions, from which it is literally impossible for anything any news of what happening inside them to reach a distant observer. This region is called **Blackhole**. Its boundary is called **event horizon**, from where nothing (including light) can return.



If you were watching a star collapse you need to remember that according to theory of

relativity there is no absolute time. Time according to someone on the star's surface will be different from someone at distance. Suppose an astronaut on the surface of a collapsing star, collapsing inward with it and sending signal every second to someone on a spaceship orbiting around it. At 10:00 am on his watch the star shrunk below the critical radius, from where gravitational field will be so strong that his signal will no longer will reach the spaceship. As 10:00 approached, his friend watching from the spaceship would find the interval between successive signals from the astronaut getting longer and longer, so the light coming out from it will be fainter and fainter also; but the effect would be very small before 9:59:59. Eventually the star can no longer be seen and all that left in the space is just a hollow with a huge gravitational field known as blackhole. This gravity gets weaker the further you go. But what about the astronaut? The gravitational force on his feet will be quite greater than his head. So, his whole body will tear apart.

Between 1965 and 1970 Roger Penrose and Stephen Hawking showed that according to general relativity at infinite density a singularity always exists. This is rather like big bang at the beginning of the time and it would be end of time too. At this singularity all laws and our ability to predict future would break down. This remarkable fact led Roger Penrose to propose cosmic censorship hypothesis which might be paraphrase as 'God abhors a naked singularity'. Events like gravitational collapse occurs only in places like blackholes where it will be decently hidden from outside by an event horizon.

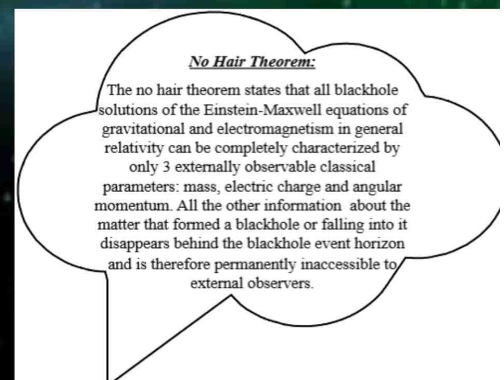
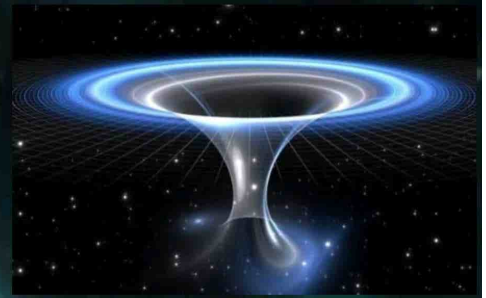
Time travel always amazes us but some solutions of general relativity proves that it is possible. If someone wants to see a naked singularity and maybe able to hit singularity instead of falling through a **wormhole** which opens to another part of universe (parallel universe). But unfortunately, these solutions may all be highly unstable, such things can't really ever happen and also within such

uneven gravitational force nothing can actually reach singularity; rather quite before hitting the singularity they will all just tear apart.

The event horizon, the boundary at the region at space-time from which nothing can escape, acts like a one-way membrane around blackhole that anything falls through it will soon reach the region of end of time and never come out.

General theory of relativity predicts that heavy moving objects emit gravitational waves, ripples in curvature of space. They carry energy away from the objects that emits them. Therefore, a system of massive object tries to settle down to a stationary state. For example, our Earth moving around the Sun also produce gravitational waves and due to energy loss earth changes its orbit nearer to the Sun. the rate of energy loss is very low that it will take thousand billion, million years for the earth to run into the Sun.

In 1970 it was come to light a stationary rotating blackhole had an axis of symmetry like a spinning top. Its size and shape would be depending on its mass and rate of rotation. Then in 1971 Stephen Hawking proved this theory. Using this result in 1973 David Robinson show that blackhole had indeed to be the kern solution. So, after gravitational collapse a blackhole must settle down into a state in which it could be rotating, but not pulsing. As its size does not depend on the nature of the body that had collapse to form, it is known as **no hair theorem** (a blackhole has no hair).



However, in 1963, Maarten Schmidt found a red shift of a faint starlike object in the direction of source called 3C273 (it is a quasar and the name signifies that it was 273rd object on the third Cambridge catalogue of radio source). This red shift caused due to expansion of the universe which in turn meant that the object was at very long distant away and a large amount of energy seemed to be the gravitational collapse not just a star but the whole region of a galaxy.

In 1967, Jocelyn Bell found that objects emit radio waves regularly. Well Hewish assumed that we can even contact with an alien civilization in the galaxy. 1st 4 sources are found named LGM 1-4 (Little Green Men) however it finally came to most unromantic conclusion that these objects named **pulsars**; only emit radio waves and these are a type of neutron star. Actually, only neutron stars just emit radio waves due to complicated interaction between their magnetic fields.

Meanwhile, Hawking realized that the paths of light rays could never approach one another. If these light rays were swallowed up by the blackhole, then they could not have been on boundary. So, the paths of light rays in the event horizon had always to be moving parallel or away from one another. The event horizon is like an edge of shadow of impending doom. Actually, the rays of light in the edge are not approaching to each other. If they really approach the event horizon might stay same or increase with time but it could never decrease. In fact, the area would increase whenever radiation fell into it.

If two blackholes collide and merge together to form a single one with greater or equal to the sum of the areas of the event horizons of mother blackholes. The non-decreasing behavior of blackhole's area was very reminiscent of the behavior of entropy. According to second law of thermodynamics, when 2 systems are joined together the entropy of the combined system is greater than the sum of the entropies of the individual system. Whenever matter carrying entropy fell into blackhole the event horizon increased.

Now a blackhole has entropy as well as temperature. But a body with temperature must emit radiation at a certain rate. Not only highly heated but also bodies with low temperature emits radiation. But blackholes are objects which are supposed to emit nothing. According to quantum mechanical uncertainty principal rotating blackholes should create and emit particles. Then Stephen Hawking also found that non-rotating blackholes also create and emit particles. These particles don't come within the blackhole but from 'empty' space just outside the blackhole's event horizon. So, the 'empty' space can't be completely empty because that would mean that all the fields (like gravitational, electromagnetic etc.) must be exactly zero. However according to uncertainty principal, the more accuracy of one value can cause more error in the calculation of the other. So, in 'empty' space the field can't be fixed at exactly zero. There must be some quantum fluctuations or uncertainty in the value of the field as pairs of particles and antiparticles of light and gravity. If one partner has positive energy other will have negative energy. One with negative energy has to be a short-lived virtual particle because real particles always have positive energy. It must seek out its partner and annihilate with it. A real particle near to a massive body has less energy than it was far away but it is still positive. Inside the blackhole due to huge gravity a real particle can have negative energy there. If a blackhole is present and a particle with negative energy fall into it and become a real particle then in this case it no longer has to annihilate with its partner. Having positive energy, a particle might also escape from the vicinity of the blackhole as a real particle or antiparticle. Hence the positive energy of outgoing radiation would be balanced by a flow of negative energy particles into the blackholes. According to Einstein's equation $E=mc^2$, energy is proportional to mass. Therefore, with energy a blackhole also losses its mass, thus its event horizon gets smaller but the decrease of entropy of the blackhole is more than compensated by the entropy of the emitted radiation, so the second law never violate. With loosing mass eventually, a blackhole becomes extremely

small and with some reasonable guess it would disappear tremendously like explosion of millions of H-bombs.

A blackhole also has an **accretion disk** too which are usually formed when a black hole absorbs matter. These disks are heated by friction and can brighten immensely.

Accretion Disk:

An accretion disk is a structure formed by diffuse material in orbital motion around a massive central body. A central body is typically a star. Friction causes orbiting material in the disk to spiral inward towards the central body. Gravitational and frictional forces compress and rise the temperature of the material, causing the emission of electromagnetic radiation. The frequency range of that radiation depends on the central object's mass.

Till now we find broadly 5 types of blackholes:

1. Super Massive Blackhole or SMBH:

The first is the super massive blackhole or SMBH. This is the largest type amounting to an unmeasurable amount of solar masses. This is usually found at the center of the largest galaxies in space. In our solar system, the SMBH is located at Sagittarius A.

2. Intermediate Mass Blackhole: It is a hypothetical class with a mass ranging from a hundred (100) to a million (1000000) solar masses. Although the existence of intermediate mass black holes has still yet to be proven, there is indirect evidence that they exist using various positions from known stars.

3. Stellar Mass Blackhole: The stellar mass blackhole or stellar blackhole is formed when a massive star collapse. Their masses range from five (5) to a hundred (100) solar masses and can be observed as either a gamma ray burst or a hypernova explosion. These types of black holes are also called collapsars.

4. Mini Blackhole: The last type is known as a micro blackhole or mini blackhole or quantum mechanical blackhole. They were introduced by Stephen Hawking in 1971.

5. Primordial Blackhole: The primordial blackholes formed in the seconds after the big bang and many of them does not exist now as many of them have already evaporated completely.

A blackhole with few times solar mass would have a temperature of one ten millionth of degree above absolute zero. This is much less than the temperature of microwave radiation fills the universe (about 2.1 degree above absolute zero). So blackholes emit even less than they absorb. If the universe is expanding forever then temperature of microwaves eventually decreases. Its temperature would be so low that it would take million, million, million, millions of years (1 with sixty zeros after it) to evaporate completely, more than the age of the universe.

The primordial blackholes with very low mass that were made by collapse of irregularities on the very early stage of the universe. Such blackholes had higher temperature and emit higher radiation with a lifetime roughly equal to the age of the universe. They would already have completely evaporated. But with slightly

greater mass is still emitting X-rays and gamma rays. Such holes hardly deserve the epithet black; they are really white hot and are emitting energy at rate about ten thousand megawatts. They are like individual source of gamma rays. But since gravity

would draw primordial blackholes towards any matter so they should be much more common in galaxies.

The existence of radiation from black holes seems to imply that gravitational collapse is not as final and irreversible as we once thought.



➤ Some Amazing Facts about Blackholes:

1. No-one Can Directly See a Blackhole:

NASA points out that a star happens to get close to blackhole rather blackhole naturally pulls on the star and rips it to shred when the matter from the star begins to bleed toward blackholes, it gets faster and hotter and glows brightly in X-rays.

2. Astrophysical jet: An astrophysical jet is an astronomical phenomenon where outflows of ionized matter are emitted as an extended beam along the axis of rotation. When this greatly accelerated matter in the beam approaches the speed of light, astrophysical jets become **relativistic jets** as they show effects from special relativity. The formation and powering of astrophysical jets are highly complex phenomena that are associated with many types of high-energy astronomical sources. Most of the largest and most active jets are created by super massive blackholes (SMBH) in the center of active galaxies such as quasars and radio galaxies or within galaxy clusters. Such jets can exceed millions of parsecs in length.

3.A Supermassive Blackhole also Can Give Birth to Stars and Determine How Many Stars a Galaxy Gets:

A recent discovery shows that behemoth blackholes occasionally unloose enough material to form new stars and some of them even lend in deep space well beyond their galaxy of origin. Besides formalism of stars, they control how many stars a galaxy gets by directly impacting how quickly the process of star formation turns off more quickly in small galaxies.

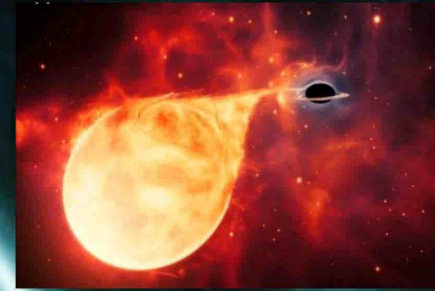
4. It's possible to Stare into

Abyss: The new event horizon telescope powered by 9 of the world's highest resolution telescope recently took the 1st photos of event horizon surrounding 2 blackholes. One is our Sgr A (at the center of milky way and it is an inactive blackhole) and other is at the

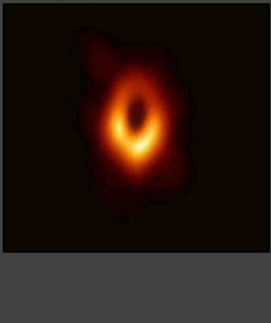
center of galaxy Messier 87,53 million light years away.

5. There Are too Many Blackholes to count:

The Milky way galaxy alone thought to harbour some 100 million stellar massive blackholes and Sgr A at its heart with 100 billion galaxies out there each with 100 million stellar massive and a core supermassive one. It's like trying to count grains of sand.



First image of black hole in M87 telescope clicked by NASA

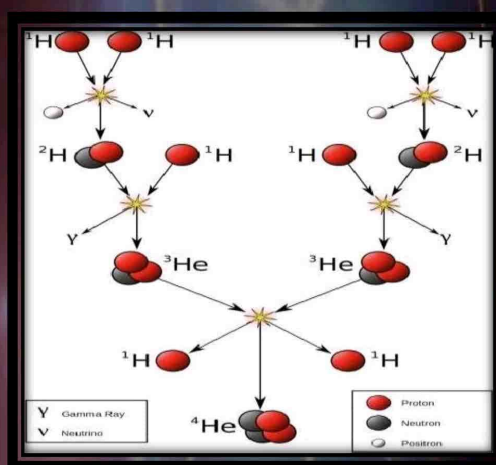


NUCLEAR FUSION AND PLASMA

ANUSHKA KONAR, MANISHA CHOWDHURY, TRISHITA CHATTERJEE
SEMESTER 3, PHYSICS DEPARTMENT

INTRODUCTION

Fusion is the process occurring within the plasma core of our Sun in which the nuclei of lighter atoms link to form a heavier atom. For example, when hydrogen nuclei collide, they can fuse into heavier helium nuclei and release tremendous amounts of energy in the process. What we see as light and feel as warmth coming from the Sun is the result of this fusion reaction process. Since the Sun is a huge plasma ball made up primarily of hydrogen,



the fusion of hydrogen into helium is responsible for 85% of the Sun's energy output. The fusion of hydrogen to form helium is proton- proton chain reaction. A p-p chain reaction is one of the dominating ways by which stars, the size of Sun fuse hydrogen in helium.

Where does the energy come from?

Careful analysis of these reactions shows that the mass of the

resulting He^4 nucleus is very slightly less than the sum of the masses of the reactant particles involved. This lost mass reveals itself as energy released, conforming to Einstein's formula:

$$E = mc^2$$

The tiny bit of lost mass (m), multiplied by the square of the speed of light (c^2), results in a very large amount of energy (E) created by a fusion reaction. The Sun converts about 600 million tonnes of hydrogen into helium every second, releasing an enormous amount of

energy. It has been calculated that the 'lost mass' is 0.7%.

Using these figures, the energy production per second can be calculated as follows:

$$E = [0.007 \times 600 \times 10^6 \times 10^3] \times [3 \times 10^8]^2 \\ = 3.78 \times 10^{26} \text{ J} = 3.78 \times 10^{23} \text{ kJ}$$

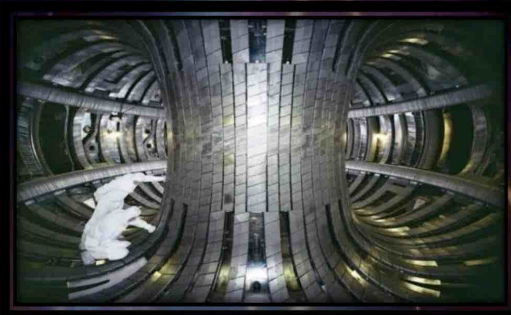
Given that this is occurring every second, it means that the power output of the Sun is close to $4 \times 10^{23} \text{ kW}$.

FUSION ON EARTH

Scientists have thoroughly investigated these reactions in the hope of developing nuclear

fusion reactors that can transform fusion energy into electrical energy for public consumption.

Inside the doughnut-ring reactor of the **JET** is designed to heat hydrogen gas to a high-temperature plasma state



ohmic heating by a vortex electric field, adiabatic compression,

injection of neutral beams or radio-frequency heating, achieved by injecting waves of the electron cyclotron resonance, ion cyclotron resonance

Heating of High Temperature

Plasma: The heating in magnetic plasma confinement systems include

and lower hybrid resonance frequencies. In addition to plasma heating, these methods enable a non-inductive plasma current drive and plasma profile control and contribute to plasma confinement.

THE SUN-FLARE PLASMA DYNAMICS

The flare plasma dynamics and associated thermal evolution during a flare consists of a number of sequential processes. The prime of them are: plasma heating in coronal reconnection sites, chromospheric flare plasma heating (by precipitating non thermal particles/ by downward propagating heat conduction fronts), chromospheric evaporation in the form of up flowing heated plasma & cooling of postflare loops. The initial heating of the coronal plasma requires anomalous resistivity because Joule heating with classical resistivity is unable to explain the observed densities, temperatures and rapid timescales in flare plasmas. The 2nd stage of chromospheric heating is more thoroughly explored, based on

the theory of the thick-target model, with numeric hydrodynamic simulations and with particle-in-cell simulations. Important diagnostics on chromospheric heating are also available from $H\alpha$, white light and UV emission, but quantitative modelling is still quite difficult because of the chromospheric opacities and partial ionization. The 3rd stage of chromospheric evaporation has been extensively explored with hydrodynamic simulations; in particular to explain the observed Doppler Shifts in soft X-ray lines, while application of spatial models to imaging data is quite sparse. The 4th stage of postflare loop cooling is now understood to be

dominated by thermal conduction initially and by radiative cooling later on. Spatiotemporal temperature

modelling of flare plasmas are shown in the figure below:

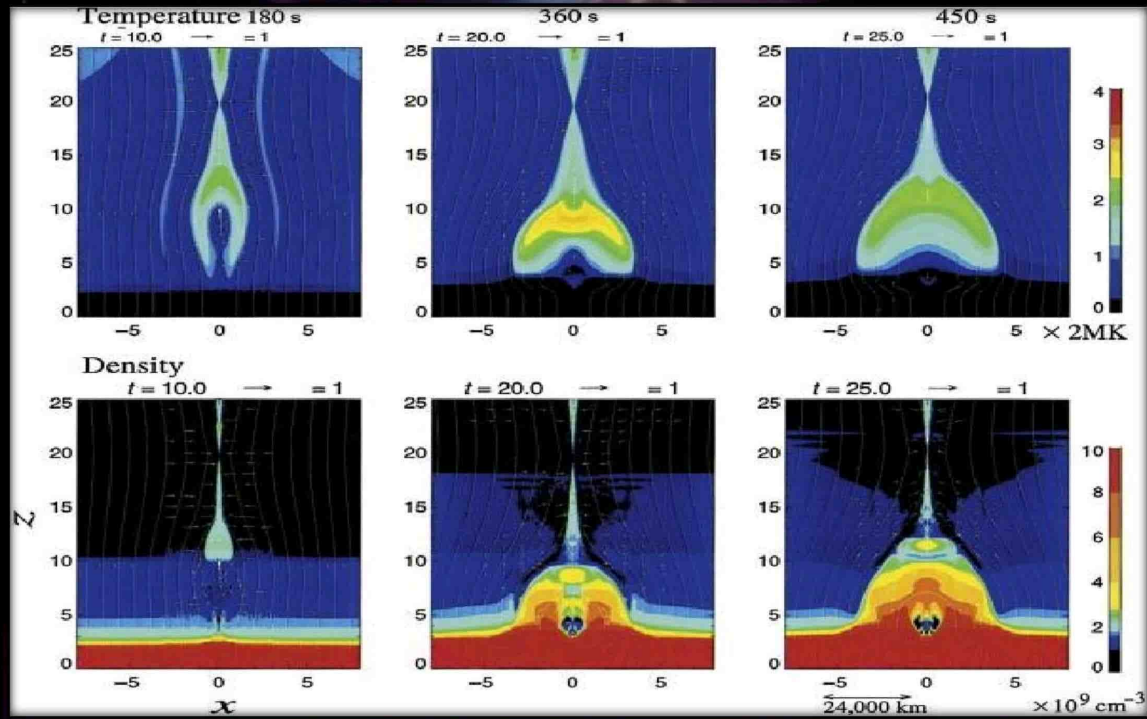


FIGURE: A 2D numerical MHD simulation of a solar flare with chromospheric evaporation and anisotropic heat conduction in the framework of a 2D magnetic reconnecting geometry. The temperature and density scale are shown in the bars on the right side. The simulation illustrates the propagation of thermal conduction fronts and the upflows of chromospheric plasma in response.

The confinement of a high temperature plasma in a stellarator in which the magnetic confinement has tended to shift the plasma from the center of the curved, U-shaped end loops is described. Magnetic means are provided for counteracting this tendency of the plasma to be shifted away from the center of the end loops.

In one embodiment this magnetic means is a longitudinally extending magnetic field such as is provided by two sets of parallel conductors bent to follow the U-shaped curvature of the end loops and energized oppositely on the inside and outside of this curvature.

STATES OF MATTER PLASMA

Plasma is a state of matter that is often thought of as a subset of gases, but the two states behave very differently. Like gases, plasmas have no fixed shape or volume, and are less dense than solids or

"A gas is made of neutral molecules and atoms," said Xuedong Hu, a professor of physics at the University at Buffalo.

1.Charged particles:

A typical gas, such as nitrogen or hydrogen sulfide, is made of molecules that have a net charge of zero. Plasmas,

being made of charged particles, may have a net charge of zero over their whole volume but not at the level of individual particles.

Being made of charged particles, plasmas can do things gases cannot, like conduct electricity. And since moving charges make magnetic fields, plasmas can have them. Most plasmas aren't dense enough for particles to collide with one another very often, so the magnetic and electrostatic interactions become more important.

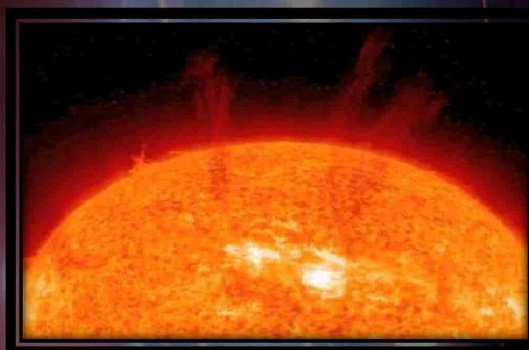
2.Plasmas in action:

One place you can see plasmas in action is in a fluorescent light bulb or neon sign. In those cases a gas (neon for signs) is subjected to a high

liquids. But unlike ordinary gases, plasmas are made up of atoms in which some or all of the electrons have been stripped away and positively charged nuclei, called ions, roam freely.

voltage, and the electrons are either separated from the atoms of the gas or pushed into higher energy levels. The gas inside the bulb becomes conductive plasma. The excited

electrons that drop back into their previous energy levels emit photons - the light we see in a neon sign or fluorescent lamp.



3.Cosmic dust:

The novel device, designed to duplicate the process that causes swirling clouds of cosmic dust

and plasma to collapse into stars and planets, consists of two fluid-filled concentric cylinders that rotate at different speeds. The device seeks to replicate the instabilities that are thought to cause the swirling clouds to gradually shed what is called their angular momentum and collapse into the growing bodies that they orbit.

Such momentum keeps the Earth and other planets firmly within their orbits.

REACTOR CONCEPTS

The energy-producing mechanism in a fusion reactor is the joining of two light atomic nuclei. Fusion reactions are inhibited by the electrical repulsive force, called the Coulomb force, that acts between two positively charged nuclei. For fusion to occur, the two nuclei must

approach each other at high speed in order to overcome their electrical repulsion and attain a sufficiently small separation so that the short-range strong force dominates. In a gas at extremely high temperatures, the average nucleus contains sufficient kinetic energy to undergo fusion.



Such a medium can be produced by heating an ordinary gas beyond the temperature at which electrons are knocked out of their atoms. The result is an ionized gas consisting of free negative electrons and positive nuclei. At the core of experimental fusion reactors is a high-temperature plasma. Fusion occurs between the nuclei, with the electrons present only to maintain macroscopic charge neutrality. The temperature of the plasma is about 10^8K , more than six times the

temperature at the centre of the Sun. A plasma loses energy through processes such as radiation, conduction and convection, so sustaining a hot plasma requires that fusion reactions add enough energy to balance the energy losses.

In order to achieve this balance, the product of the plasma's density and its energy confinement time (the time it takes the plasma to lose its energy if not replaced) must exceed a critical value. Stars, including the Sun, consist of

plasmas that generate energy by fusion reactions. In these natural fusion reactors, plasma is confined at high pressures by the immense gravitational field. It is not possible to assemble plasma on Earth; sufficiently massive to be gravitationally confined. For terrestrial applications, there are two main approaches to controlled fusion—namely, magnetic confinement and inertial confinement.

FUSION TECHNOLOGIES

In magnetic confinement a low-density plasma is confined for a long period of time by a magnetic field.

The plasma density is roughly 10^{21} particles per cubic metre, which is thousands of times less than the density of air at room temperature.

The energy confinement time must then be at least one second—i. e, the energy in the plasma must be replaced every second.

In inertial confinement no attempt is made to confine the plasma beyond the time it takes the plasma to disassemble. The energy confinement time is simply the time it takes the fusing plasma to expand. Confined only by its own inertia, the plasma survives for only

as laser fusion or particle-beam fusion.

The fusion reaction least difficult to achieve combines a deuteron with a triton. Both nuclei are isotopes of the hydrogen nucleus and contain a single unit of positive electric charge. Deuterium-tritium (D-T) fusion thus requires the nuclei to have lower kinetic energy than is needed for the fusion of more highly charged, heavier nuclei. The two products of

the reaction are an α particle at an energy of 3.5 MeV and a neutron at an energy of 14.1 MeV. The neutron, lacking electric charge, is not affected by electric or magnetic fields



about one nanosecond. Hence, breakeven in this scheme requires a very large particle density, typically about 10^{30} particles per m^3 , which is about 100 times the density of a liquid. A thermonuclear bomb is an example of an inertially confined plasma. In an inertial confinement power plant, the extreme density is achieved by compressing a millimetre-scale solid pellet of fuel with lasers or particle beams. These approaches are sometimes referred to

and can escape the plasma to deposit its energy in a surrounding material, such as lithium. The heat generated in the lithium “blanket” can then be converted to electrical energy by conventional means, such as steam-driven turbines. The electrically charged α particles, meanwhile, collide with the deuterons and tritons by their electrical interaction and can be magnetically confined within the plasma, thereby transferring their energy to the reacting nuclei. When

this redeposition of the fusion energy into the plasma exceeds the power lost from the plasma, the plasma will be self-sustaining, or “ignited.” Although tritium does not occur naturally, tritons and α particles are produced when neutrons from the D-T fusion reactions are captured in the surrounding lithium blanket.

Deuterium can be obtained from seawater. Lithium is also abundant and inexpensive.

A practical fusion reactor would also have several attractive safety and

environmental features. First, a fusion reactor would not release the pollutants that accompany the combustion of fossil fuel. Second, the main products of a fusion reaction (He atoms) are not radioactive.

Although some radioactive by-products are produced by the absorption of neutrons in the surrounding material, low-activation materials exist such that these by-products have much shorter half-lives and are less toxic.

NUCLEAR FUSION IS ‘A QUESTION OF WHEN, NOT IF’

A ‘sunny day’ is always welcome by all of us! Apart from brightening up our days, many of us recognise that the Sun is the basis of life.

Fusion energy is attracting as the world’s energy demands keep multiplying. The excessive dependence of fossil fuels and its impact on climate change due to carbon emissions are leading policy makers to consider as good option to explore. THE QUESTION IS WHEN WILL WE GET IT?

The joke has been around almost as long as the dream: *Nuclear fusion energy is 30 years away.* But now, more than 80 years after Australian physicist Mark Oliphant 1st observed deuterium atoms fusing and releasing dollops of energy. Over the past several years, more than two dozen research groups have achieved eye-opening advances in controlled nuclear fusion. They’re building fusion reactors based on radically different designs that challenge the two mainstream approaches, which use either a huge, doughnut-shaped magnetic vessel called tokamak or enormously powerful lasers.

To deliver the fusion concept, countries have focused their energies on a major international co-operative effort called ITER.

WHAT IS ITER?

The International Thermonuclear Experimental Reactor (ITER, “The Way” in Latin) project is a multiphased project, at present proceeding under the auspices of the International Atomic Energy Agency according to the terms of a four-party between The European Atomic Energy Community, The Government of Japan, The Government of the USA and The Government of Russia.

The objective of ITER is to demonstrate the scientific and technological feasibility of fusion energy for commercial energy production and to test technologies for a demonstration fusion power plant.

The main systems of ITER are the superconducting magnet coils and their support, the vacuum vessel and the shield-blanket, the heating and fueling systems, the cryostat, the power supplies and the buildings. Numerous components, experimental packages and test modules will have to be remotely installed and removed from the ITER device in order to test materials properties, component characteristics and material lifetimes.

WHERE IS THE MAJOR EXCITEMENT ABOUT FUSION ENERGY COMING FROM?

The major excitement comes from private companies. They develop by making mistakes & learning from them quickly. They are-

1.First Light:

This company originated in the University of Oxford & their idea involves firing a projectile at a target that contains hydrogen atoms.

2.Commonwealth Fusion System:

This company created by Massachusetts Institute of Technology & they hope to build smaller and cheaper Tokomaks to contain the plasmas required to generate fusion.

3.US Navy:

This company has filed a patent for a "plasma compression fusion device"- it would use magnetic fields to create "accelerated vibration and/or accelerated spin".

4.TAE Technologies:

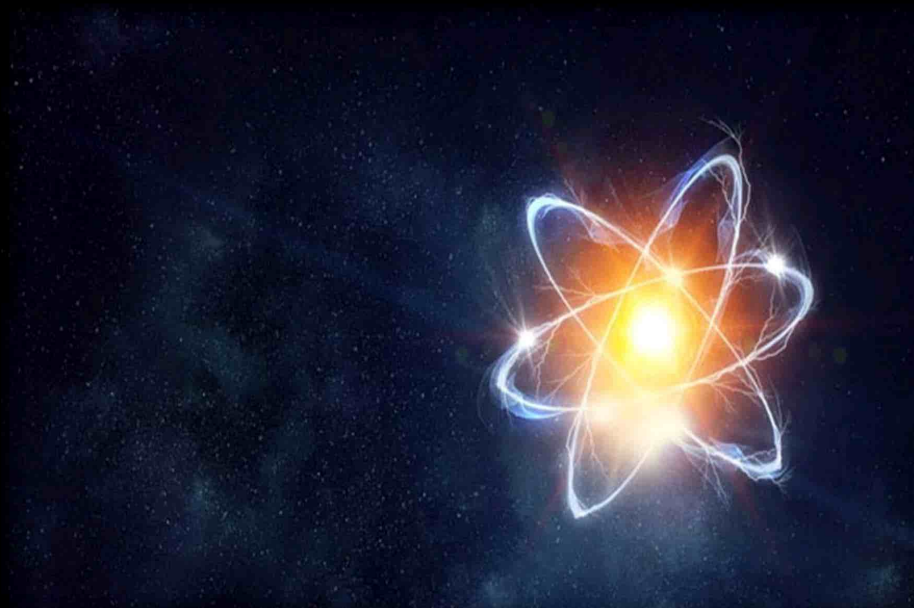
This California based company is using a different mixture of fuel to develop cheaper reactors & they want to use hydrogen and boron as both elements are readily available and non-reactive.

5.General Fusion:

One of the main challengers With ambitions to make fusion work is a company based in British Columbia, Canada called General Fusion. They call their system 'magnetic target fusion'. This approach sees a hot gas plasma injected into a ball of liquid metal inside a steel sphere. It is then compressed by pistons, much like in a diesel engine. They hope to have a working model within few years.

6.Brilliant Light Power or Backlight Power:

This company claims their technology to be based on the chemical process of releasing the latent energy of the hydrogen atom with the formation of a prior form of hydrogen called 'hydrino'.



SOME BIG IDEAS FOR MAKING FUSION POWER A REALITY!!

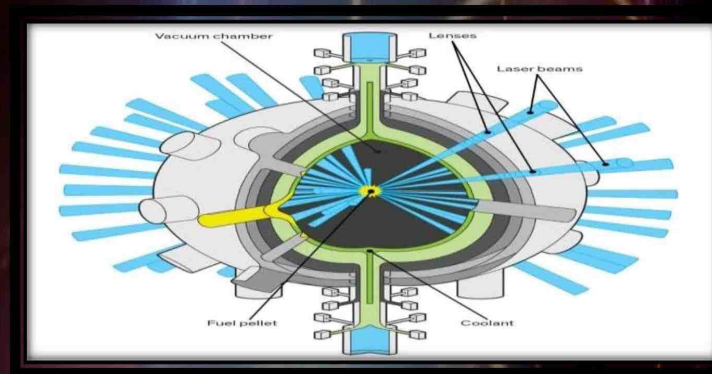
1. Inertial-Confinement Fusion (ICF):

The Big Idea: Powerful pulsed laser/ion beams compress a small fuel pellet to extremely high densities & the resulting shock wave heats the plasma before it has time to dissipate.

Reality Check: Forces exerted on the fuel pellet result

in laser-plasma instabilities to produce high-energy electrons, which heat and scatter much of the fuel before it can fuse

Projects to Watch: First Light Fusion, General Atomics.



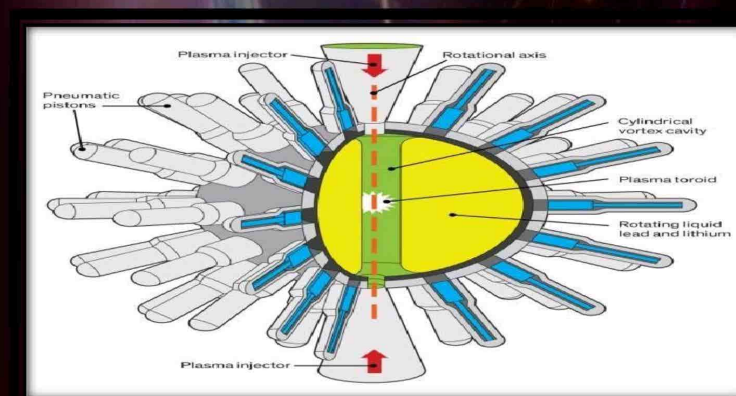
2. Magnetized Target Fusion (MTF):

The Big Idea: This uses magnetic fields to confine a lower-density which is then heated and compressed using an inertial-confinement method such as lasers/pistons.

Reality Check: Scientists have yet to increase the

plasma density to a working level and keep it there long enough for a significant fraction of the fuel mass to fuse.

Projects to Watch: General Fusion, HyperJetFusion.

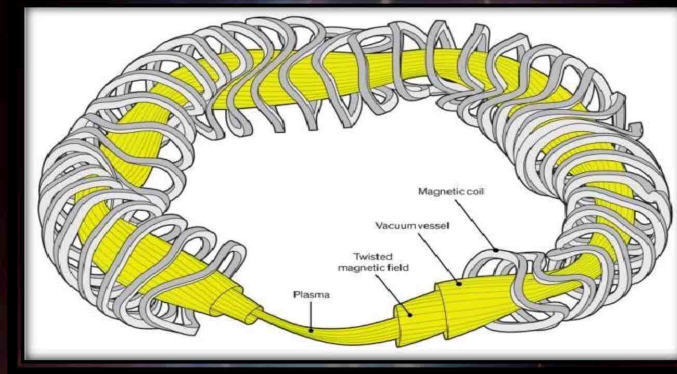


3.Stellarator:

The Big Idea: It's spiralling ribbon shape produces high-density plasma that's symmetrical, allowing the reactor to run for long periods of time.

Reality Check: It's challenging geometry makes it complicated to build and extremely sensitive to imperfect conditions.

Project to Watch: Wendelstein 7-X.



FUSION POWER REMAINS AS TOUGH A PROBLEM AS EVER

There's an abundance of fusion energy in our universe-the sun and other stable stars are powered by thermonuclear fusion-but the task of triggering and controlling a self-sustaining fusion reaction and harnessing its power is arguably the most difficult engineering challenge humans have ever attempted. Most methods involve temperatures that are so high-that matter can exist only in the plasma state. But a high-energy-density plasma is notoriously unstable and difficult to control. But with recent advances in supercomputing and

complex modelling, researchers are unravelling more of the mysteries underlying plasma behavior and developing new tricks for handling it without huge, complex machinery.

So, We are still multiple decades away from commercial-scale fusion. If made possible, the technology could revolutionize energy production. It could solve some of the major problems of renewable energy. At any rate, the future of this power source looks bright. To make it work, you have to go large.

BUT Fusion Energy Is Coming; and Maybe Sooner Than You Think.

NIKOLA TESLA

Kuheli Sinha

Semester I

Physics Department

Inventors always intend to make great inventions to make the world a better place to live. Without them the race would

Tesla was born in Smiljan in present day Croatia on July 10, 1856. He was born during a lightning storm. His mother called him

Child of Light. His father,

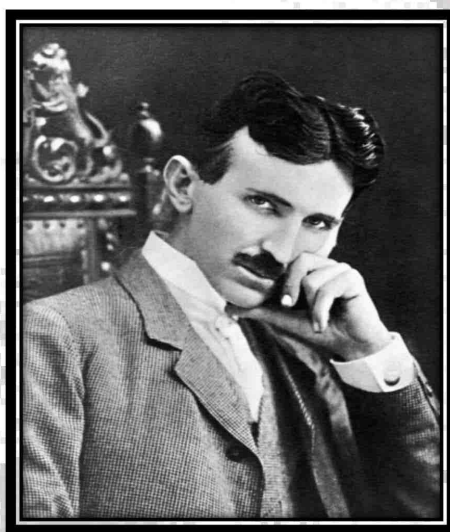
Milutin Tesla was a priest of Serbian Orthodox Church and wanted him to become one too. Djuka Tesla, his mother

was a great woman of rare skill. She used to make small electrical appliances in her spare time. She was the cause

for his love of working with electricity. At a very young age he witnessed his brother's premature death. This incident

left him disconsolate for the rest of his life. As a child he suffered from a peculiar

affliction due to the appearances of images, often accompanied by strong flash of light which marred sight of real object. This never left him. This vision helped him to imagine his inventions in mind before the actual work. At the age of seventeen, young Tesla fell ill with cholera that almost killed him. He was bedridden for nine months. His father promised that, if he recovered he would send him to the best engineering college, just as Nikola had always wanted. After recovering, Tesla began his studies at Polytechnic School in Gratz, Styria. In his first year, Tesla started his days at three o'clock in morning and continued his study till eleven at night. The topic that fascinated him above all others is Electricity. Tesla moved around Europe and eventually ended up in Budapest working as an electrician at a telephone company. While walking around a park in the city, an idea of



have perished a long time ago. In this modern world where electricity plays the lead role in our daily life, we have Nikola Tesla to thank.

developing a new way of generating electricity using alternating current came with a flash of lightning. There was talk of

theoretical Alternating Current but no one had figured out how it would work.

He began to work for the French branch of **Thomas Edison's Electric Company.**

He designed complicated dynamos and motors using Direct Current in Edison's.

Initially Edison was impressed by Tesla but they would become bitter rivals. They disagreed over how

electricity should be delivered

to the world. Edison preferred **Direct Current** as he had all the patents of DC but Tesla wanted **Alternating Current** as it can provide more power and transmit power over longer distances as compare to DC.

He quitted Edison's and built his own electric company **The Tesla Electric Light Company** with the help of a group of inventors. Tesla developed a light that was simpler and more economical than what was being used. He patented the lights and achieved a great success. But all of a sudden the investors took over the company and all the Tesla's patents. After losing his job he had to take a job of digging ditches just to survive. He said that **it was the most depressing time of his life.**

But suddenly his fortune would change. Tesla invented an induction motor that ran on

alternating current. He demonstrated his invention in a heavily publicized lecture. That caught the attention of George Westinghouse who was the rival of Edison. He realized the importance of AC. Tesla sold him his patents for \$60,000. The war of the currents began. Edison claimed that AC is impractical and unsafe but these efforts of Edison could not stop Tesla. In 1893 they got the contract to illuminate the Chicago World's Fair. After the fair everybody realized that AC would be the future. They won the contract to install the first power machinery at Niagara Falls. His statue can be found at Niagara Falls today.

Tesla soon established his own laboratory. He experimented with shadowgraphs (which pioneered the discovery of X-Ray), carbon button lamp, electrical resonance, and various types of lighting. Tesla gave exhibitions in which he lighted lamps without wires by allowing electricity to flow through his body to prove that AC is safe. In 1891 he invented **Tesla Coil** which is widely used today in electronic equipments. He demonstrated wireless remote control miniature boat (ancestor of today's remote controlled drones) at Madison Square Garden in 1898. Tesla was obsessed with wireless communication in the world. He wanted to give the world free energy. He built a huge wireless transmission

station with a tower 187 feet high, having a spherical terminal about 68 feet in diameter called **Wardenclyffe Tower** in a long island of New York. He imagined a world where we could send and receive messages, signals wirelessly. But financial backers did not trust his project. He had no choice but abandon his dream project in 1906.



Tesla also invented **Death Ray**. It was such a powerful weapon that it could obliterate military targets from hundreds of miles away. The mechanism behind Tesla's death ray is not well understood. After Tesla's death his scientific paper about Death Rays vanished. Those were never found.

Nikola Tesla died on January 7, 1943 at the age of 87 at New Yorker hotel. He was alone and broke. He lived in that hotel for the past decade. He considered a flock of pigeons as his only friends in that hotel. One of the greatest scientists of all time faded into obscurity. In his whole life Tesla was not concerned about money. He wanted to make the world better with the help of his inventions.

His inventions are the architect of the modern world-

**“The present is theirs;
The future, for which I really worked
Is mine”**

-NIKOLA TESLA

THE STELLAR SCUFFLE

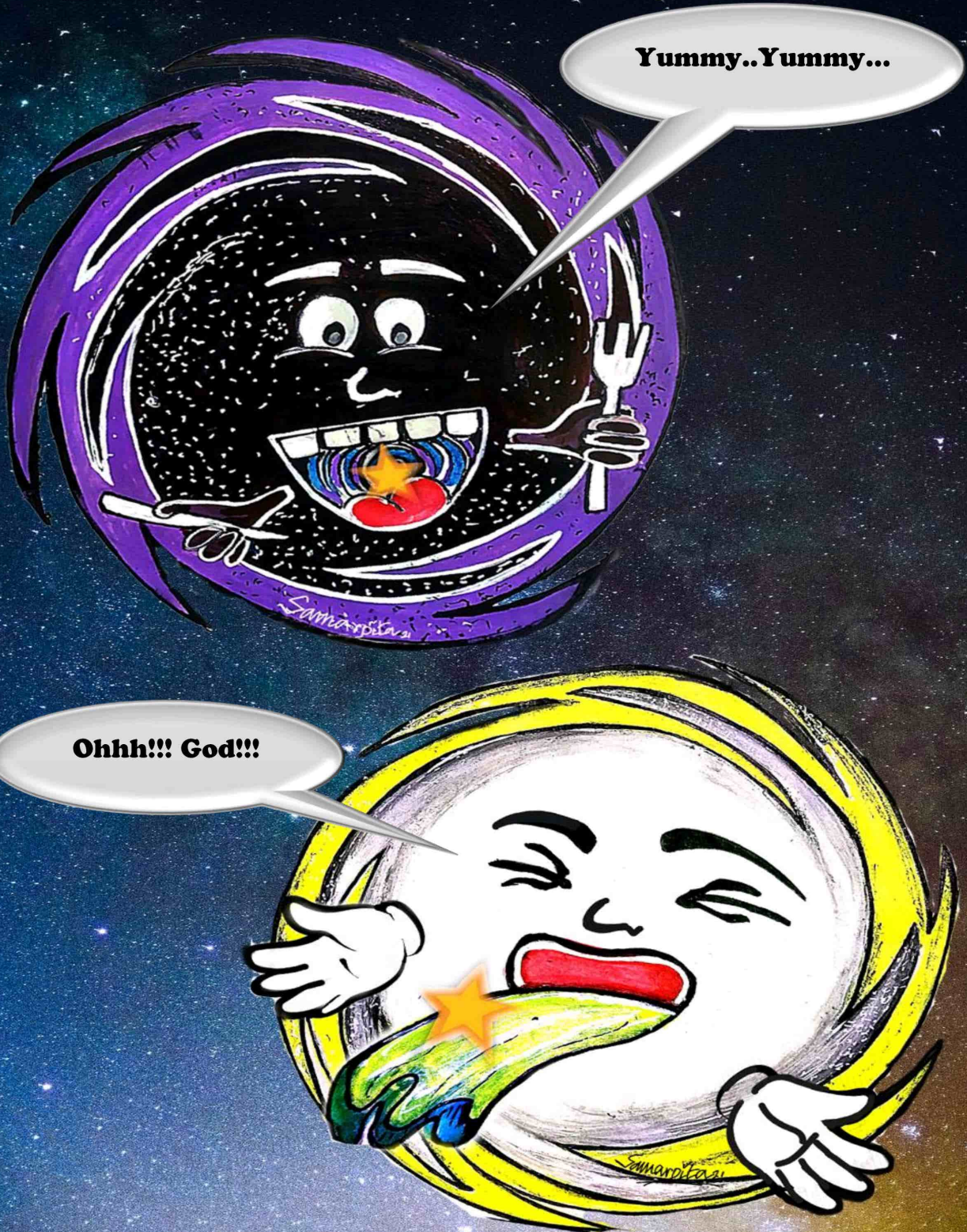
Samarpita Chatterjee

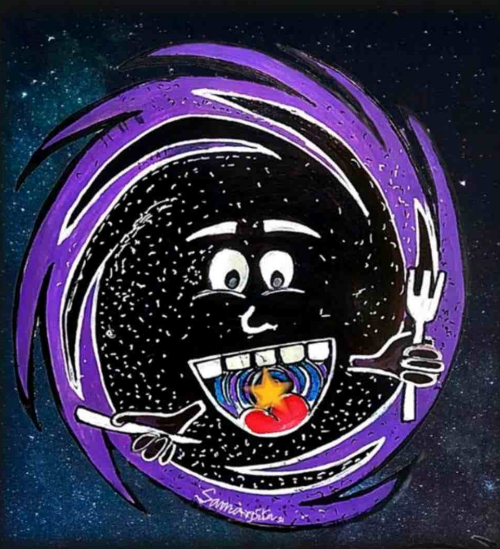
Semester 3

Sahana Chanda Ritoma Chakraborty Srishti Sikdar Debdita Ghosh

Semester 1

Physics Department





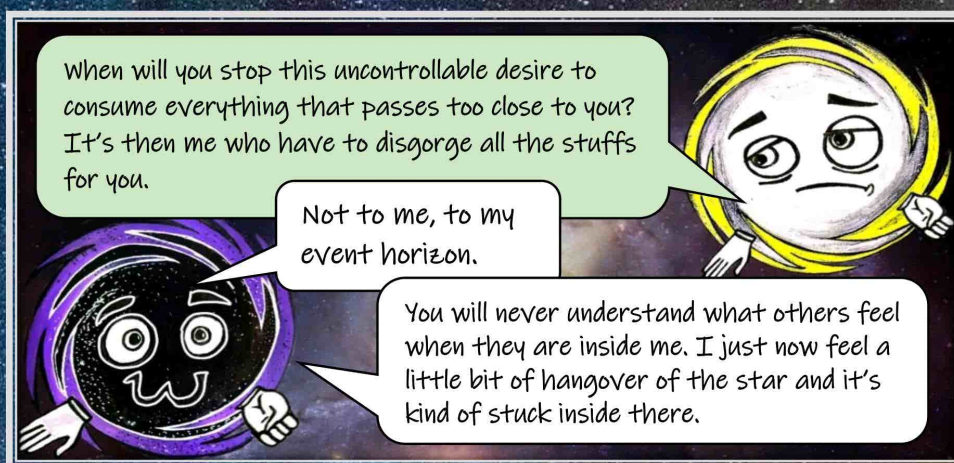
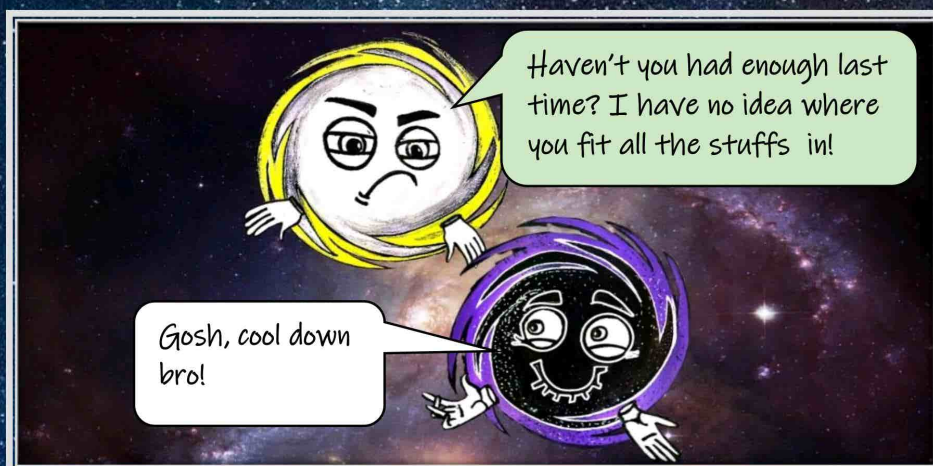
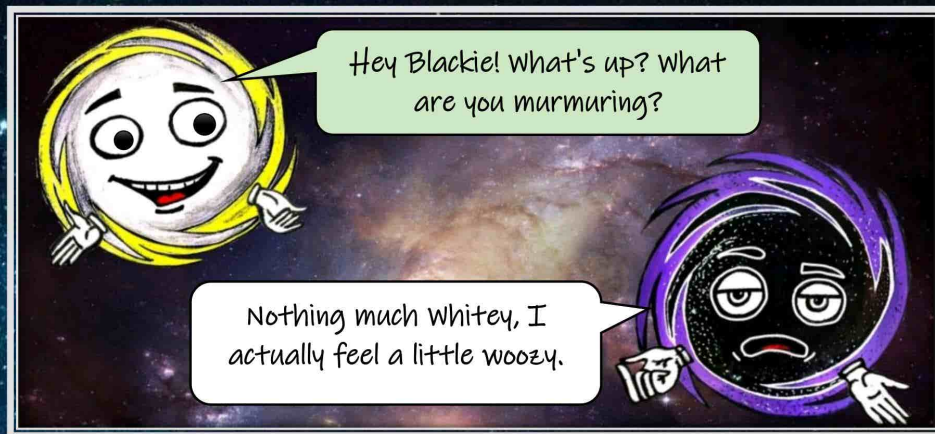
Black hole, cosmic body of extremely intense gravity from which nothing, not even light, can escape. A black hole can be formed by the death of a massive star. When such a star has exhausted the internal thermonuclear fuels in its core at the end of its life, the core becomes unstable and gravitationally collapses inward upon itself, and the star's outer layers are blown away. The

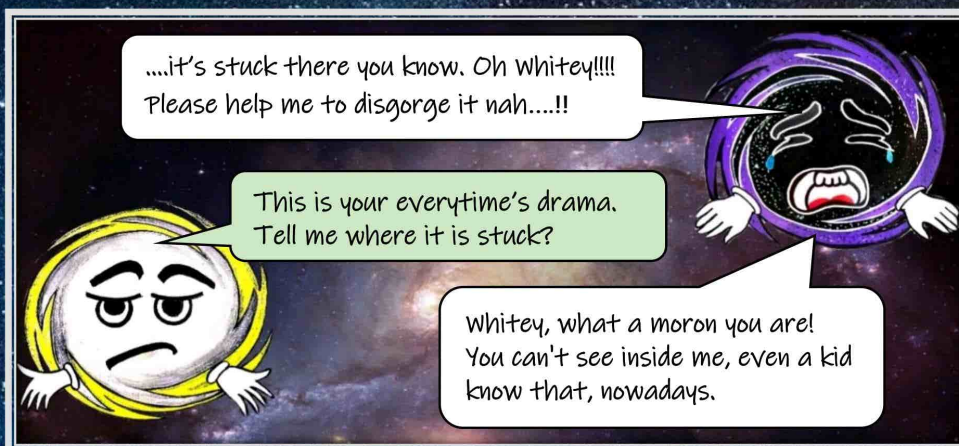
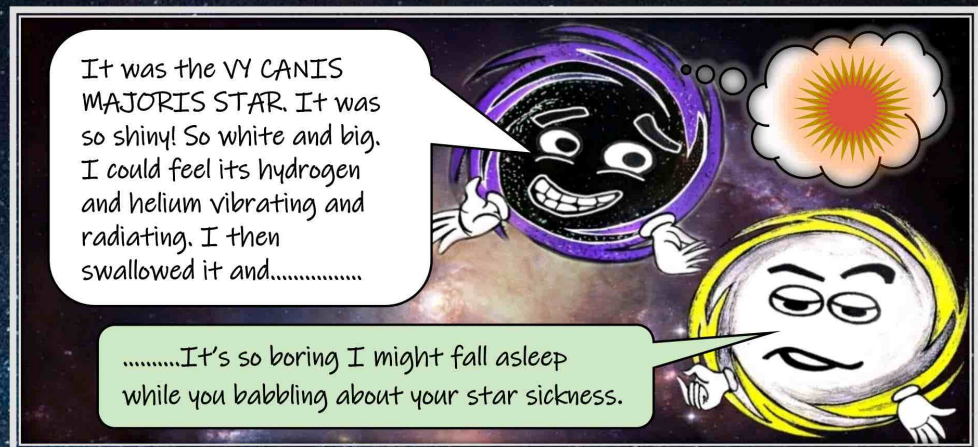
crushing weight of constituent matter falling in from all sides compresses the dying star to a point of zero volume and infinite density called the singularity. Because no light can get out, people can't see black holes. They are invisible. Space telescopes with special tools can help find black holes. The special tools can see how stars that are very close to black holes act differently than other star.

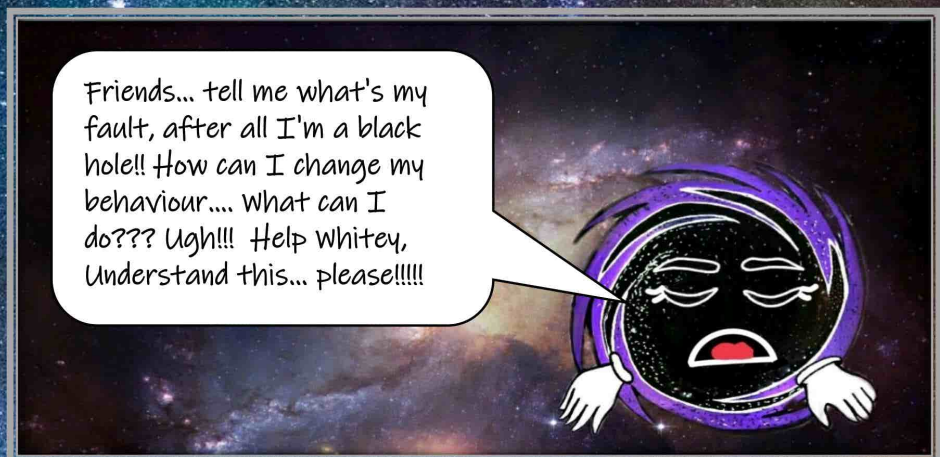
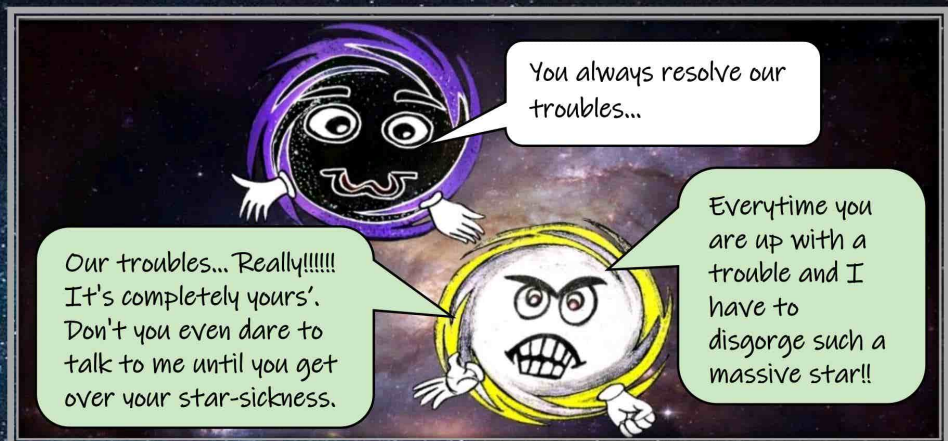
and

White hole is a bizarre cosmic object which is intensely bright, and from which matter gushes rather than disappears. In other words, it's the exact opposite of a black hole. But unlike black holes, there's no consensus about whether white holes exist, or how they'd be formed. They are predicted by Einstein's theory of gravity. White holes are the theoretical opposite of black holes. Matter can and would escape from white holes into the universe.









MAGNUS EFFECT

Mehuli Maity

Semester-3

Physics Department

Ever wonder why a spinning ball curves from its usual trajectory? How to pitch a baseball perfectly or wanna brush up your skills in ping pong game

Suppose you are going to make a sphere fall from a certain height, it just never touches the exact same position present just under the point of fall in the ground but it deflects a bit by making an certain angle with its perfectly vertical path. We all know there is a culprit force behind it, Coriolis force. But if you add a little bit of spin in the sphere while making it fall, it will not only divert from its most probable path (taking Coriolis in account) but also will follow a weirdly parabolic path, as if it's flying through or someone is pushing.

Well yes, something is really pushing the ball though, making it bound to fly in a parabola. This is the so called Magnus effect.

This phenomena was first observed by Newton in 1672, while observing tennis players in Cambridge College. Later in 1742, Benjamin Robins, a British military engineer, explained the deviations of musket balls. But the actual phenomena was described by a German physicist, Heinrich Gustav Magnus (probably you can tell from the name).

The Magnus effect can be explained perfectly from our well known Bernoulli's equation. The equation states that *if the velocity of the moving fluid is increased, the pressure must decrease* (vice-versa).

The theory of Magnus effect can be explained in a relatively simple manner also. When any object is moving through the air, its surface interacts with the thin layer of air, known as

boundary layer. Now let us come to another important terminology, "Wake". Wake can be defined as a region of recirculating flow immediately behind a moving or stationary blunt body, caused by viscosity (and some other factors as well), which is usually accompanied by a flow separation and turbulence.

Now, when a ball with not so perfectly spherical shape travels through air, the boundary layer peels off from the surface, creating a wake or



low pressure region behind the ball. Now this front to back pressure difference which drags the ball behind, slowing down its forward motion. This is the normal air resistance, also called aerodynamic drag.

All of the above description is suitable for a non spinning case. However if the sphere is spinning as it travels through the fluid (here air), the boundary layer separates at its different points on opposite sides of the ball, further upstream on the side of the ball that is turning into airflow, and further downstream on the side of the ball turning backward. As a consequence, the air flowing around the ball is deflected slightly sideways, resulting in asymmetrical wake behind the ball. This

affects the ball's trajectory by generating a pressure difference across the ball, creating a lateral force component that pushes the ball sideways acting perpendicular to the forward motion.

The aforesaid explanation is very much in accordance with our wellknown Newton's 3rd law of motion, '*Every action has an equal and opposite reaction.*'

Here as the ball takes up speed, at one side of the ball, the airflow is in the direction of the ball's spin, so the air tags along with the ball and on the other side where the flow is in the opposite spin, the flow separates from the surface instead of getting deflected.

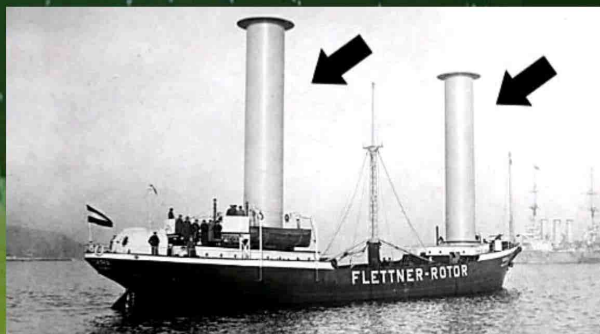
Now this air pushes the ball in one way and by Newton's 3rd law the airflow pushes it the other way, just as a moving object traversing through the fluid flow it pushes the air, so that the air pushes it further to maintain its forward motion.

Though we get the explanation precisely but the question arises, how this magnus force is affected by other factors. The strength of magnus effect is directly proportional to air density, which means the ball at higher altitude tends to curve less.

So, we now know that a force acts on the spinning ball while its forward motion through the air perpendicular to its motion,

which can be perfectly manipulated by a pitcher by changing the spin orientation for a perfect throw.

Magnus effect finds not only an advantage in sports but also it was put to some actual utilisations. In the early 20th century, engineers used large vertical cylinders called Flettner rotors, on boats to propel them forward. This large rotors spin and captures crosswind to propel the ship forward. Though this system is not as efficient as steam engines but in present



a cargo ship called E-Ship 1, utilises four flettner rotors in order to increase the fuel efficiency and decrease its dependence on diesel engines.

Another use was done in airplane. The Plymouth A-A-2004 was made by using to horizontal flettner rotors, where the rotors were spun backwards to generate more lift than traditional wings. But in the end, the eventually crashed as the drag was also too high from that of wings.

AMAZING FACTS

☞ The stitches on the baseball plays a vital role, it increases the magnus force by not only increasing the thickness of boundary layer but also helping the pitcher to put more spin by putting his fingers.

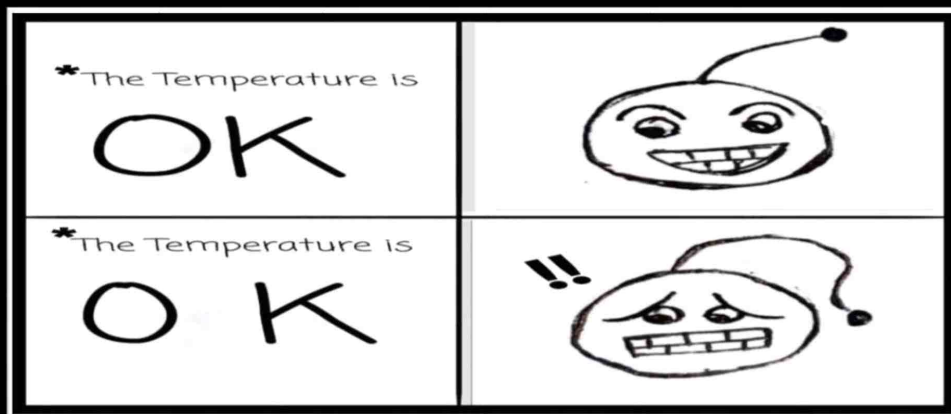
☞ The airflow around a smooth ball actually breaks at the top of the ball slowing down the motion and bottom. But in case of a dimpled ball, it breaks further back, producing less drag. This dimples

also produces extra spin that also shift the wake a little downwards, creating negative pressure above the ball and generating lift.

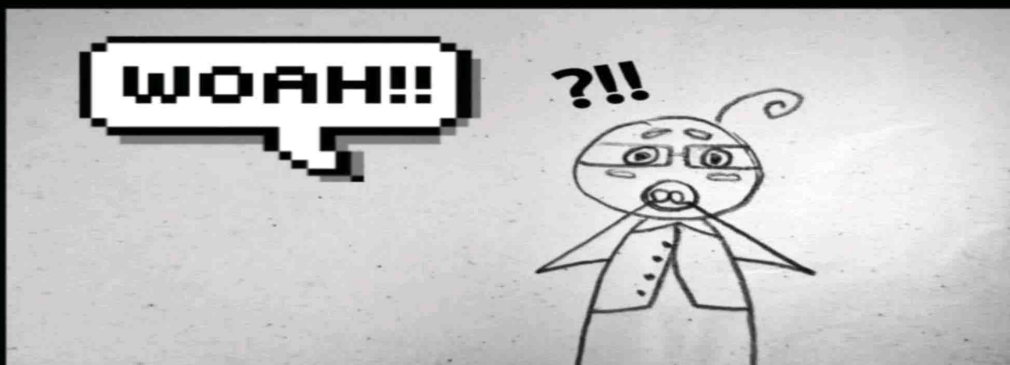
☞ In case of bullets the magnus effect is not that effective such as drag, due to it's shape (magnus effect is seen for only uniformly spherical and cylindrical objects), but in case of bullets there is something else, 'Spindrift', which is highly dependant on factors like lift and weight of the ball etc.

☞ The natural clockwise rotation of a right-handers wrist creates a leftward force (from pitcher's perspective), which causes the ball to curve away from the right-handed batsman and vice-versa for the other hand.

FONTIME ALERT



Mathematicians : derivatives aren't fractions
LaTeX : $\frac{dx}{dy}$
Mathematicians :



Anti-gravity, a Bizarre Concept

SAHANA CHANDA

Semester I

Physics Department

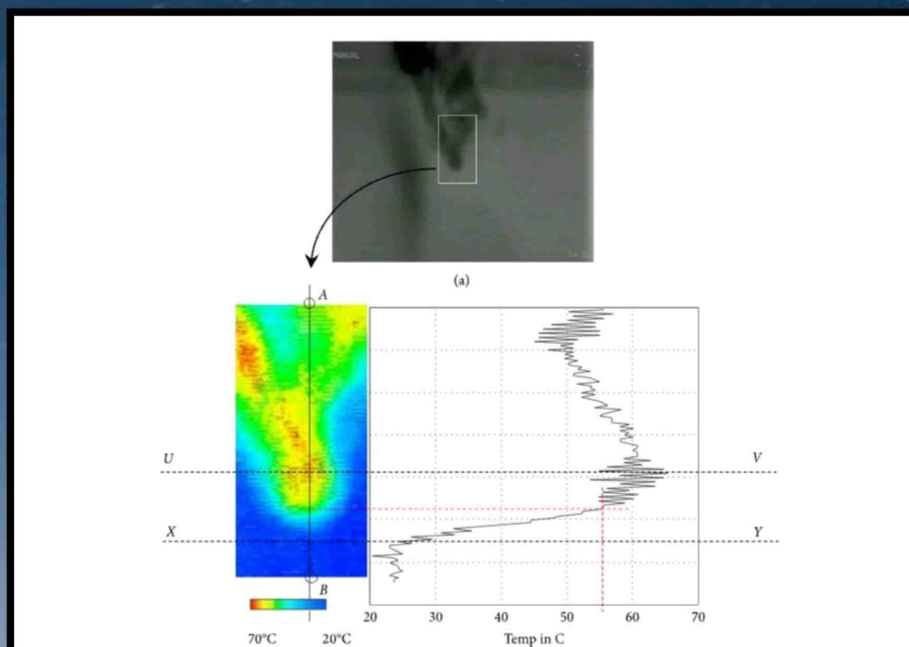
“Of all natural forces, gravity is the most mysterious and the most implacable. It controls our lives from birth to death, killing or maiming us if we make the slightest slip. The expression ‘heavenly being’ implies a freedom from gravity which, at present, we have known only in our dreams.” So wrote Arthur C. Clarke in the 1962 book, “Profiles of the future”.

Gravity is one of the fundamental forces identified in nature, formulated by Sir Isaac Newton as: The Law of universal gravitation. The gravitational attraction is proportional to

the mass which has been experimentally proved for several hundred years. However, the concept of anti-gravity or gravitational repulsion has neither been discerned nor identified within the prevailing scientific laws and concepts until recent past.

Anti-gravity is a hypothetical idea of creating a place or object free from the force of gravity. It does not refer to the lack of weight under gravity experienced in free fall or orbit, or to balancing the force of gravity with some other force such as electromagnetism or aerodynamic lift.

Some Experiments and their Observations:



The adjacent figure (figure1) shows the movement of heated water droplets in still air against the pull of gravity. Thermal image [(a) and (b)] of the path of heated condensed water droplets reveals that, even though the temperature gradient does not support the formation of convection air currents, the condensed water droplets slow down their motion, turn around, and then move upward against gravitational pull.

Figure1

This figure (figure2) shows the upward movement of heated water droplets inside an ice cylinder which inhibits air convection and shows the measurements related to the time-of-fall of a heavy water droplet (Two droplets of masses 4 mg and 9 mg are used).

Here, it is experimentally demonstrated that there exists a cryptic force (upward) which increases with temperature where a linear increase of time-of-fall (slowing down) is observed.

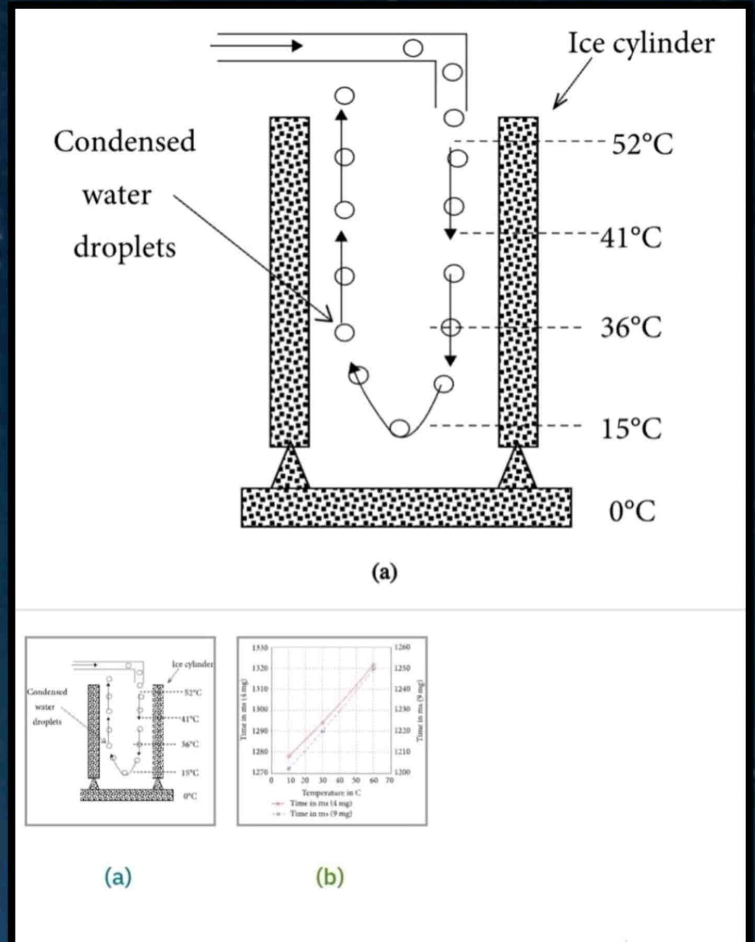


Figure 2

Discussion:

From the above observations, it is concluded that there is a repulsion force against the direction of pull of gravity and it is proportional to the temperature, that is a parameter of the particle's thermal energy, similar to the attraction of gravity that is proportional to the particle's mass. figure3

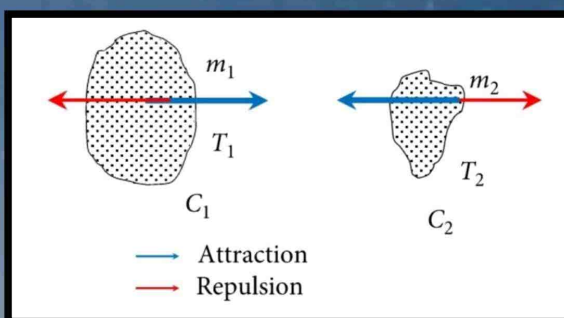


Figure 3

Referring to the results shown in above figures, the figure above (figure3) summarizes the following relationships between two arbitrary particles with masses m_1 , m_2 , temperatures T_1 , T_2 and specific heat capacities C_1 , C_2 . Conventional gravitational law reveals that

$$\text{Attraction force} \propto \text{mass } (m_1, m_2) \quad \dots(1)$$

The findings in experiments state that

Repulsion force $\propto$ thermal energy (H_1, H_2) ... (2)

Thermal energy H is expressed as $H = m \times C \times T$... (3)

Generalizing expressions 1 and 2, resultant forces acting on an object are proportional to the mass and heat energy of objects. Resultant force between any two arbitrary objects $= F_{att} \sim F_{rep} \propto f(\text{mass, heat energy})$... (4)

For the objects with mass m_1, m_2 and thermal energy H_1, H_2 respectively,

Resultant force $= F_{att} \sim F_{rep} \propto f(m_1, m_2, H_1, H_2)$... (5)

Similar to gravitational acceleration g , due to earth's attraction force, a gravitational deceleration can also be proposed due to thermal energy. Repulsive force depends on mass [Equation (3)]. So, it is reasonable to connect this force with "gravitational repulsion" or "anti-gravity".

Expanding Universe:

Concept of anti-gravity can be used to effectively interpret the natural phenomenon of expanding universe. In the observation of an "expanding/accelerating universe" the galaxies are moving apart from each other despite the strong gravitational forces among massive systems. At present, two main theories, Big Bang Theory and Dark Energy, try to interpret this expansion of the universe but the interpretations are not very promising. If only gravitational attraction force exists, the universe must shrink together and finally collapse but it is expanding and the galaxies are repelling each other. So, it is logical to sense a repulsive force among the celestial bodies in the universe and Anti-gravity could replace dark energy as cause of universe's expansion.

This could be easily explained by the thermal energy that every star produces continuously, due to mass-energy conversion ($E = mc^2$). A reduction in mass together with an increase in the heat energy certainly creates anti-gravity grounds for a realistic explanation of the expansion of intergalactic distances with an acceleration. Conversion of mass to energy in a galaxy amounts to a lessening of the attractive gravitational force (less in mass) and conversely an increase in the repulsive gravitational force – which is the anti-gravity force. Therefore, it is reasonable to think that there exist both decreasing attractive and increasing repulsive forces in the universe in order to maintain the dynamic nature of system.

Anti-gravity Device:

Anti-gravity devices produce a force when twisted that operates out of plane and can appear to lift themselves against gravity. A device is shown (figure4) invented by Henry Wallace. His device consists of superconducting ceramic ring and solenoids.

He claimed that by passing current through solenoid results in creating a 'gravitomagnetic' field which shows anti-gravity effect.

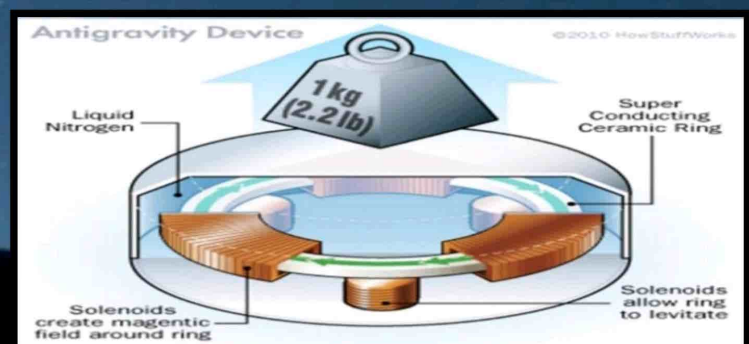


Figure 4

NASA Anti-gravity Machine:

NASA researchers hope to conduct an experiment that could determine if the force of gravity might someday be adjusted manually like the volume of radio.

» In 1992, Dr. Eugene published the results of his experiment with high temperature ceramic superconductor. He devised an experiment in which a disc of superconducting material was magnetically levitated at high speed, up to several thousand rpm, in the presence of an external magnetic field.

» Quantum levitation is a way to succeed in Anti-Gravity. It is a process where scientists use the properties of quantum physics to levitate an object (specifically a

superconductor) over a magnetic source (specifically a quantum levitation track designed for this purpose). The reason for which this works, is called the Meissner Effect and Magnetic flux pinning. The Meissner effect dictates that a superconductor in a magnetic field will always expel the magnetic field around it. The very superconductor material itself will create a force to inhibit any sort of motion in relation to the magnetic field. If the superconductor is tilted, for example, if it is locked or trapped into that position, it will go around a whole track with the same tilt angle. This process of locking the superconductor in place by height and the orientation reduces any undesirable wobble.

Applications of Anti-Gravity:

» Cheap energy can be produced without burning any fossil fuels.

» Human space travel will be possible at low cost and very high velocity of the spaceship can be obtained.

» Unwanted weight from the rockets can be removed which is earlier used to provide thrust to get out of the gravitational field.

» Anti-gravity technology would revolutionize space exploration. With help of anti-gravity, we can explore solar system and outer space.

» Bearings can be manufactured with zero friction as there is no contact with the moving parts.

» Land transport can be improved but for this, magnetic tracks are required.

The presence of anti-gravity force has been in existence in nature but yet to be recognized in the realm of science. The analysis using rising/falling water droplets in still air affords clear evidence of the duality in gravitation. All the above experimental observations call for a hitherto unravelled force “the anti-gravity force” which had been evading science all the time. Also, the concept of dark energy – an elusive idea, may also encompass anti-gravity while explicating it.



BOOM!

PRIYADARSHINI SAHA

SEMESTER 5

PHYSICS DEPARTMENT

“नभःशृशंदीप्तमनेकवर्णव्यान्ननंदीप्तविशालनेत्रम्।
दृष्ट्वाहिंत्वांप्रव्यथितान्तरात्माधृतिंनविन्दामिशमंचविष्णो।”

Orator: Julius Robert Oppenheimer.

Event: Trinity Test.

What is this 'Trinity Test'? A Sanskrit Shloka quoted by an American Theoretical Physicist! — What's the reason? This writing is about some attractive information and story of scientists relating to the 'Manhattan Project.'

The 'Manhattan Project' was a research and development undertaking during Second World War that produced the first nuclear weapons. It was led by the United States with the support of the United Kingdom and Canada. Oppenheimer was the head of this Manhattan Project to develop the atomic bomb and 'Trinity Test' was the first experimental test of atom bomb as a part of this project.

Early in 1939, the World's scientific community discovered that German Physicists had learned the secrets of splitting a Uranium atom. Fears soon spread over the possibility of Nazi scientists utilizing that energy to produce a bomb capable of unspeakable destruction. Then some Scientists took step in 1939 to organize a project to exploit the newly recognized fission process for military purposes. In 1941, the project was put under the direction of the Office of Scientific Research and Development (OSRD) headed

by American Engineer Vannevar Bush (1890—1974). After the U.S. entry into Second World War, the War Department was given joint responsibility for the Project. In 1942, the OSRD formed the Manhattan Engineer District in the New York City. U.S. Army Colonel Leslie Richard Groves (1896—1970) was appointed to lead the project. He decided to follow the custom of naming Corps of Engineers districts for the city in which they are located. The Atomic Bomb Project thus became known as the Manhattan Engineer District (MED) and 'Manhattan Project' became the code name for research work that would extend across the Country.



Much of the early research had been performed at Columbia University, University of Chicago and University of California. In 1942 Fermi led a group of physicists to produce the first controlled Nuclear Chain Reaction under the Grandstands of Stagg field at the University of Chicago. Before 1943, work on the design and functioning of the

bomb itself was largely theoretical, based on fundamental experiment carried out at a number of different locations. Dozens of sites were involved with the Manhattan Project, like — Los Alamos, Oak Ridge, Hanford, Dayton, Chalk River Nuclear Laboratory.

The Manhattan Project weapons research laboratory was located at Los Alamos, New Mexico, 34 miles north of Santa Fe. Los Alamos Laboratory — the creation of which was known as 'Project Y' — was formally established on 1st January, 1943. The complex is where the first Manhattan Project bombs were built and tested. The director of the laboratory was J. Robert Oppenheimer (1904—1967). This laboratory had to develop method of reducing the fissionable product of the production plants to pure metal and fabricating the metal to required shapes. Physicists, Chemists, Metallurgist, Explosive Experts and Military personnel converged in the secret town — Los Alamos, which grew to be the home of thousands of project workers. Meanwhile, the Army was charged with supplying, supporting and guarding the top-secret work being done at Los Alamos.

By July 16, 1945, the first atom bomb called the 'Gadget,' was ready. About 150 miles outside of the Los Alamos, in the remote Jornada Del Muerto Desert near Alamogordo, New Mexico, researchers conducted the 'Trinity Test' — the first atomic explosion. 'Trinity' was the code name of the first detonation of the nuclear device. It was conducted by the United States Army at 5:29:45 AM at the site of Alamogordo Air Base. The Plutonium bomb 'Gadget' generated an explosive power equivalent to 15,000 to 20,000 tons of TNT. The test was successful by creating an enormous mushroom cloud some 40,000 feet high and ushering in the atomic age.

The following month, two other atomic bombs produced by the project code named

'Little Boy' and 'Fat Man.' 'Little Boy' was Uranium-235 gun-type bomb and 'Fat Man' was 21 kiloton Plutonium based bomb.

The Military leaders of the Manhattan Project had identified Hiroshima, Japan as an ideal target for an atomic bomb, given its size and the fact that there were no known American prisoners of war in the area. Although many physicists were opposed to the actual use of these atomic bombs, U.S. President Harry S. Truman believed that the bomb would persuade Japan to surrender without requiring an American invasion. With no surrender agreement in place, on 6th August, 1945, the Enola Gay Bomber plane (B-29) dropped the as-yet untested 'Little Boy' bomb some 1,900 feet above Hiroshima, causing unprecedented destruction and killing at least 70,000 people instantly over an area of five square miles. 10,000 more died later of radiating poisoning.

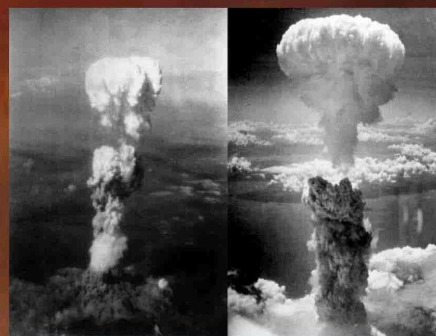
Three days later, with still no surrender declared, on August 9th, the atom bomb 'Fat Man' was dropped over Nagasaki, site of a torpedo-building plant, destroying more than three

square miles of the city. It is estimated that between

40,000 and 75,000 people died immediately following the atomic explosion, while another 60,000 people suffered severe injuries.

Japan informed Washington of their intention to surrender on August 10th and formally Japan surrendered on 14th August, 1945.

Over the next two to four months, the effects of the atomic bombings killed between 90,000 and 146,000 people in Hiroshima and



39,000 and 80,000 people in Nagasaki; roughly half occurred on the first day. People were killed directly or indirectly by the bomb's effects including burns, radiation sickness and Cancer.

The most eminent scientists of the World were directly or indirectly associated with this Manhattan Project. They are — Enrico Fermi (Pope of Physics), Otto Hahn, Eugene Paul Wigner, Leo Szilard, Neils Bohr, Richard Feynman, Klaus Fuchs, Hans Bethe, J.R. Oppenheimer, Edward Teller (Father of the hydrogen bomb) etc. Now, here are some interesting fact or story about some of these scientists. I have collected these materials about the scientists from the Novel "Biswasghatak" written by Narayan Sanyal.

•First of them is **Julius Robert Oppenheimer** as the writing is started with his shloka. He was greatly fascinated for Sanskrit language. He quoted this Sanskrit Shloka noticing the skyscraping view of the 'Trinity Test.' It means, "O Lord! You skyscrapingpowerfu



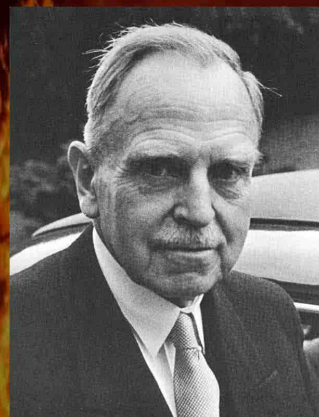
I multicolouredlighted face and bright eyes made my heart painful. I have lost patience. I have lost my peace of mind." He understand that their long-termed research succeeded. This research work in Physics has opened a new era. But this success can spoilt the peace of World. He made such remark with a thought that how the powerfals use it and what will be their aim? Will it be fruitful to the Mankind?

•Now, the story related



to Nobel Laureate **Eugene Paul Wigner**(1902—1995) may be mentioned. He was a man of very gentle, modest, polite and amiable type. Generally he never got angry with anybody. One day he was going somewhere with Leo Szilard. Wigner himself was driving the car. Suddenly breaking the traffic rule a car rushed in front of Wigner's car. Wigner controlled the break somehow and avoid the accident. The driver of the opponent car was wholly drunk. In great anger Wigner shouted, "Go to the hell." Immediately he concluded his sentence with "Please." Now the sentence became, "Go to the hell please." How peculiar character! Could not behave rudely with anybody. Wigner's such behavior astonished Szilard.

•Hope everyone knows the famous Nobel Laureate **Otto Hahn**(1879—1968). He was a student of Neils Bohr. In his whole life Otto Hahn never stood second. When he won the Nobel Prize in 1944. Though he was not directly connected with the Manhattan Project.



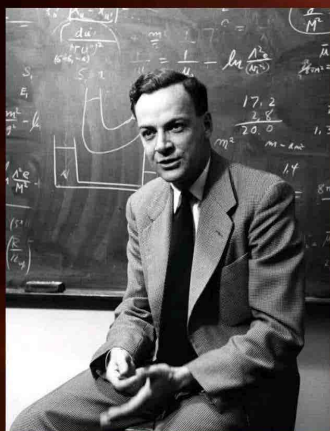
The renowned Curie couple succeeded to complete their research and this research attracted Otto Hahn. He was the first man who consciouslyfissione d the Uranium atom. This was the fifth step of developing the atom bomb.

•Who does not know the famous Nobel Laureate Professor **Neils Bohr**(1885—1962)! All the scientists related to the Manhattan Project were given a Pseudonym. They were called in these names. This



way Prof. Bohr was renamed as 'Nicholas Baker.' But he often forgot it. According to the book 'Biswasghatak' by Narayan Sanyal — 'In a meeting when someone required Prof. Bohr's opinion calling him as Mr. Baker, Bohr sat indifferently. One of his fellow perhaps whispered to his ears, "Sir, you are asked—", then he surprised and said, "Who? Me? Good heavens! I never recall that my name is Baker and not Bohr!" Then all present in the meeting could understand who's pseudonym was Nicholas Baker.' What a situation!

•Nobel Laureate **Richard Feynman**(1918—1988)



was an amazing person. He was very notorious. The Writer of Los Alamos's history wrote in the book 'Manhattan Project'— "It also afforded Feynman great amusement to work-out the combination

numbers of the steel safes in which the most secret and important data of research were kept. In one case he actually succeeded, after weeks of study, in opening the main file-cupboard at the records centre in Los Alamos, while the officer-in-charge of it was absent for a few minutes. Feynman contented himself, in the brief period during which he had all the atomic secrets at his disposal, with placing in the safe a scrap of paper on which he had written: Guess Who?" How funny!

•**Dr. Klaus Fuchs**(1912—1988) is the scientist who associated with the Manhattan Project handed over the important data of atom bomb to the Russia(USSR) through a Russian Agent, successfully evading the ever watchful U.S. Intelligence. During the Second World War he became successful to do this in his own effort.



According to the human civilization history this is the most high profiled betrayal on the basis of economic evolution and he became the traitor. This is the man who calculated the critical size of the atom bomb, which was the final step of making atom bomb. This critical size of atom bomb is regarded as the most extreme secret data still today.

These scientists' direct indirect research works invented the World's first atom bombs. This Manhattan Project opened a new era in Atomic Physics. This project led to increased research in ionizing radiation and eventually cancer treatment. But the atom bombs of the Manhattan project was the cause of huge disaster in Hiroshima and Nagasaki. These bombs made one of the most fatal blast in the history of Mankind. These were the first nuclear weapon, the first man-made nuclear explosion—

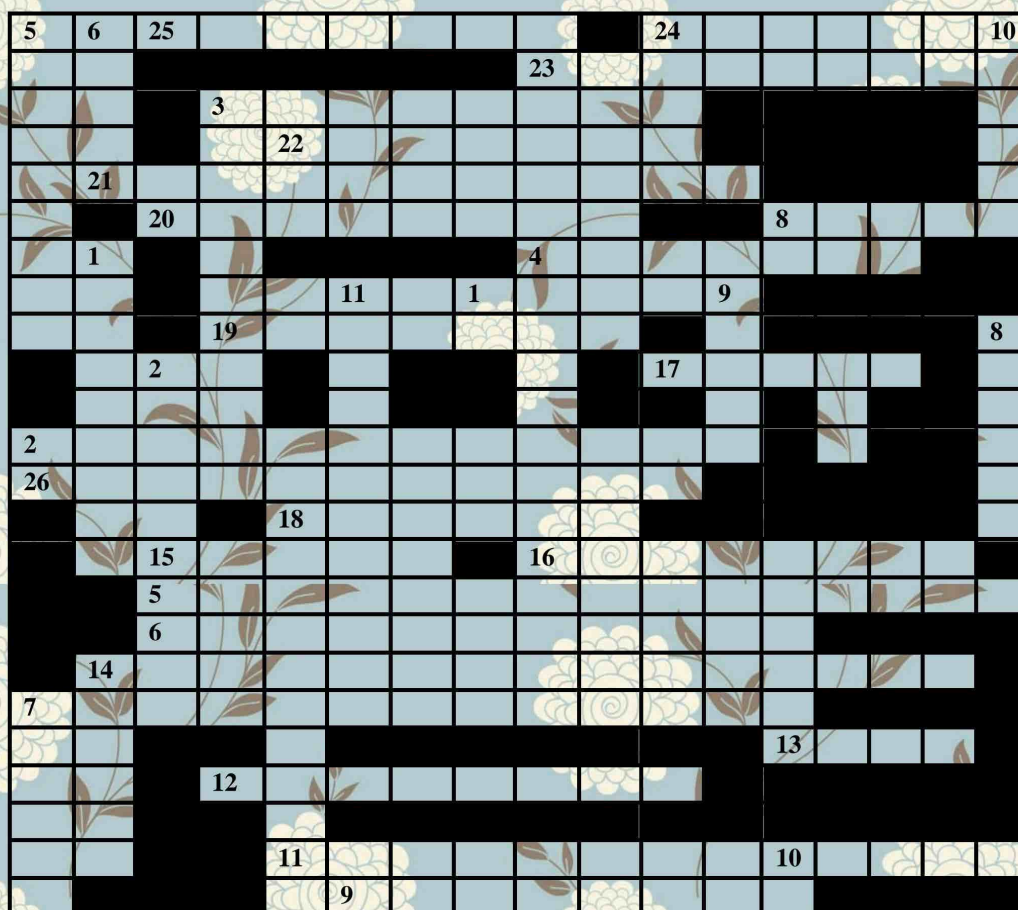
BOOM!

CROSSWORD

Alolika Roy; Semester-1

Srijita Hazra; Semester-3

Physics Department



ACROSS

1. Unit of work done
2. It's also called axial vector
3. A thermodynamic quantity which often interpreted as the degree of disorder or randomness in the system.
4. The rate at which charge flows past a point on a circuit
5. One type of blackhole
6. The wave equation of electrons is given by him
7. Field produced by charged particle
8. A system for detecting the presence, direction, distance, and speed of aircraft, ships, and other objects, by sending out pulses of radio waves which are reflected off the object back to the source.
9. The force which resists the relative motion of solid surfaces, fluid layers, and material elements sliding against each other.
10. Idea of the quantity we get from Newton's 2nd law
11. In thermodynamics system & surrounding together is called
12. Suspended particle in colloidal solution exhibits this type of motion
13. An astronomical object consisting of a luminous spheroid of plasma held together by its own gravity
14. A thermodynamic quantity which is a measure of the potential for reversible or maximum work that may be done by a system at constant temperature and pressure

15. A unit of measurement of magnetic induction, also known as magnetic flux density
16. The process in which energy is emitted as particles or waves
17. He gives the diffraction law $2d\sin\theta = n\lambda$
18. Package of light energy
21. A celestial object of very small radius (typically 30 km) and very high density, composed predominantly of closely packed neutrons
22. It is a nuclear reaction or a radioactive decay process in which the nucleus of an atom splits into two or more smaller, lighter nuclei
23. It is a region of spacetime where gravity is so strong that nothing—no particles or even electromagnetic radiation such as light—can escape from it

DOWN

1. Power per unit area
2. This follows $PV = nRT$
3. A state of balance
4. Electric charge flows with this material
5. Viscosity, conductivity & diffusion all are a special type of phenomena
6. An electromagnetic wave whose wavelength is ranging from 10 picometers to 10 nanometers
7. The capacity for doing work
8. A nuclear reaction in which two or more atomic nuclei are combined to form one or more different atomic nuclei and subatomic particles (neutrons or protons)

19. This means setting up a fixed level of current, so that there is a constant voltage drop across the transistor, so that the signal is proper amplified
20. Who gives theory of relativity
24. Who gives us laws of motion & law of gravitation
25. He gives us a special type of mathematical transform that decomposes functions depending on space or time into functions depending on spatial or temporal frequency, such as the expression of a musical chord in terms of the volumes and frequencies of its constituent notes
26. Slightly repelled by magnet

9. A measure of the estimated difference between the observed or calculated value of a quantity and its true value
10. A quantity that has both magnitude and direction
11. The property of a body that is a measure of its inertia, that is commonly taken as a measure of the amount of material it contains

ANSWER IN THE LAST PAGE

Synchronization of Fireflies

Aindrila Paul Chowdhury

Semester 1

Physics Department

As a kid, one of the most amazing things to spot was the glow of a firefly, despite the size the glow managed to make our minds wonder greater things. Interestingly the tiny glowing bugs radiate something more than light. Let us talk about the synchronization of fireflies.

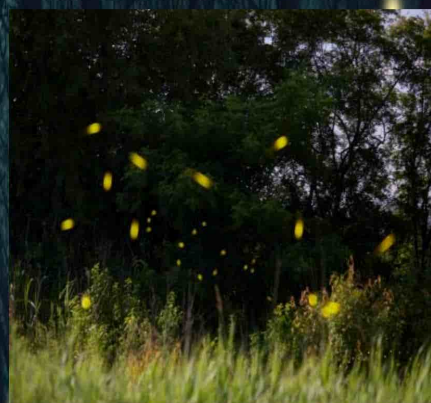
Synchronous flashing in Fireflies is perhaps the first observed natural phenomenon displaying synchronization of a large ensemble. During a long time, this collective behavior was not recognized and validated as synchronous, but nowadays it constitutes a paradigmatic example of synchronization. All living beings exhibit oscillatory behavior manifested internally in metabolic, cellular, and molecular processes. Among those, glycolytic oscillations observed in muscles and yeast, oscillations of cyclic AMP found in *Dictyostelium amoebae*, mitotic oscillations

leading to cell division cycle in eukaryotes, the pulsatile hormone signaling, the calcium oscillation observed

at the level of internal part of cells, and circadian rhythms.

Nevertheless, the animated

matter is also able to manifest oscillatory features that can be perceived by the senses of other living beings and especially by human.



What is Synchronization

Synchronization is a widespread phenomenon both in nature and in artificial systems; it consists in the adjustment of the time scales

among oscillators due to a weak coupling implying the emergence of structural order analogous to phase transitions.

The Light of Fireflies

The first question that arises concerning the glowing insects is how and why fireflies emit light flashes?

First of all, it is important to grasp the mechanisms leading to fireflies' bioluminescence. We can approach this phenomenon considering three viewpoints

① Phenomenologically, in which, macroscopic aspects of the light are important such as the functionality of the emission comprising defense, offense, communication and propagation.

② Chemically, as firstly stated by Dubois in 1887, the processes involved in the production of light might be seen as complex machinery, where two key substances luciferin (LH2) and luciferase (Luc) allow the phenomenon to take place in the presence of oxygen (O₂). This mechanism is common to several species exhibiting bioluminescence.

③ Physically, the reactions in which single-electron-transfer seems to be essential for the mechanism leading to the production of the photon involved in bioluminescence.

❖ What is Luciferase ?

The enzyme that turns on the rainbow of colored lights that occur in different firefly species is called luciferase.

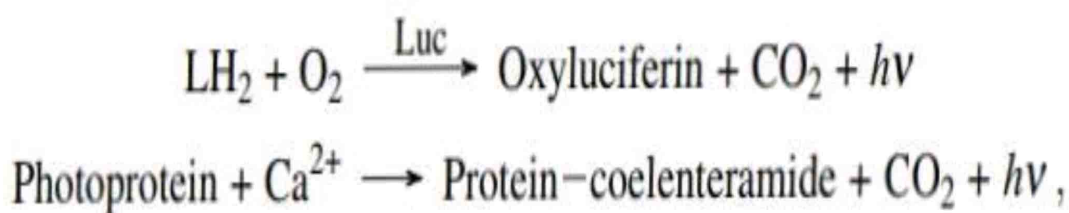
❖ What is Luciferin?

An organic substance, present in luminescent organisms such as fireflies, that produces light when oxidized by the action of the enzyme luciferase is called luciferin.

As above mentioned, Dubois identified the essential substances for the chemical reactions conducting to the light emission, and also generalized the idea that these chemical substances might be similar in different phosphorescent animals. Several qualitative observations have been made in diverse fireflies' species. Firstly, studying mating behaviors, and then focusing on the control of flashing in fireflies, or on the effects of chemical compounds and physical variables

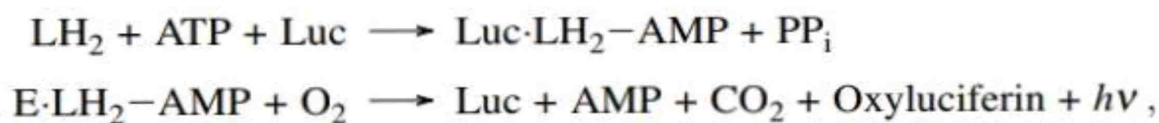
on the flashing features, such as temperature, light, static magnetic fields or pulsed ones.

From a chemical point of view, the term bioluminescence introduced by Harvey in 1916 is a fundamental concept to explain the cold light emission by living organisms, in particular by fireflies. The chemical aspects related to fireflies light emission had started to be developed since the origin of the identification of LH2 and Luc. There were some works where these types of substances were extracted to show their phosphorescence properties. After the discovery of these compounds in fireflies, scientists realized their importance and significant role in the production of light. The mechanisms of bioluminescence were unraveled both generically in all the living beings exhibiting this feature, and particularly in fireflies. It is possible to summarize the bioluminescent processes by simple chemical reactions as those shown below:



Where the first reaction depicts the oxidation of luciferin giving place to the protein bound Oxyluciferin and a photon with frequency ν . On the other hand, in the second reaction, a

conventional Photoprotein activated by calcium ions results into protein bound coelenteramide. Specifically for fireflies, the reactions are



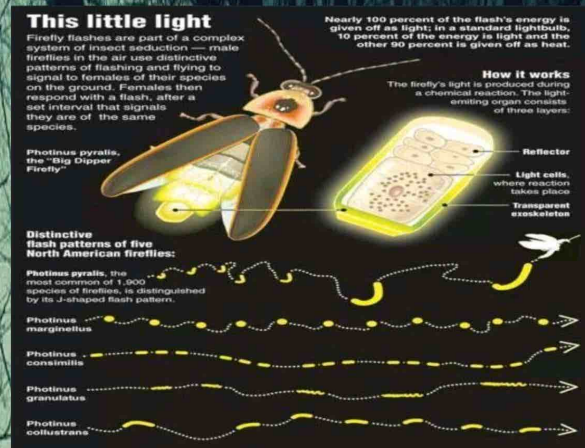
With a wavelength photon $\lambda_{\text{max}}=560$ nm (yellow-green).

Finally, from a physical viewpoint, apart from some variables susceptible to affect the firefly flashing (temperature, light, static and pulsed magnetic fields, etc.); there are microscopic aspects especially in relationship with the process of oxidation. More specifically, the oxygen supply mechanism or the single-

electron-transfer pathway for the critical oxidative process. These microscopic studies are carried out using modern experimental techniques such as synchrotron phase-contrast microtomography and transmission x-ray microscopy.

Why fireflies synchronize?

The succession of observations made to conclude that the primary function of synchronization in fireflies is that of courtship has meant a long and tortuous road that has often led to incorrect interpretations. Fortunately, the scientific approach was imposed, and it is now possible to state that fireflies' collective flashing is perhaps the most cited phenomenon as an example of synchronization.



Courtship and Mates

Display, courting, and mating behavior of the aggregative, synchronously flashing firefly *Pteropteryx* were analyzed with the aid of high-gain video recording. Males flash synchronously with other males under a variety of conditions, including flight and many phases of courtship, competition with other males, and mating. The courting male perches on the back of the female, rocks backwards and forwards, flashes his lantern directly into her eyes, and strikes her abdomen with his hind pair of legs. Characteristic flash

exchanges occur before copulation, which is also accompanied by flashing by both sexes. The behavior of interloping males and the counter-behavior of the primary male are described. The import of these behaviors is discussed in relation to theories of the evolution and adaptive significance of synchronous flashing. It is suggested that the brilliant illumination of the female's eyes by the male may prevent her from seeing signals from other males or they from recognizing her emission.

How fireflies synchronize

Synchronous fireflies get in sync by slightly adjusting the timing of their light cycles based on nearby flashes. And these can be altered by the presence of other fireflies, or even artificial light inputs.

Firefly flashes are species-specific, and it may be that in places with multiple types of fireflies, these coordinated flashes help members of the same group find each other. The intermittent pauses of darkness may also help males to see females.

Types of fireflies and their synchronization

There are thousands of firefly species spread across temperate and tropical zones all over the world. A few are mentioned here.

❖ Every year near the Elkmont Campground in the Great Smoky Mountains National Park, tens of thousands of a species of firefly,

known as *Photinus carolinus* put on quite a show, lighting up the entire forest in a brilliant twinkling display.

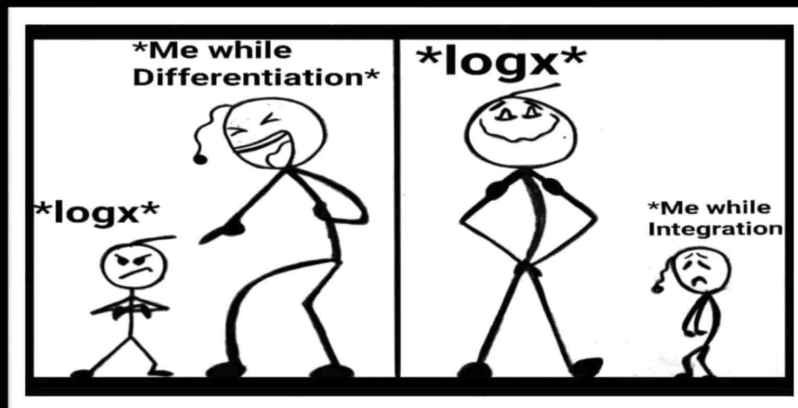
❖ The Smoky Mountains has the largest population of synchronous fireflies in the Western Hemisphere. A courageous male will

begin flashing around 9:30 p.m., right at dusk, and after a few minutes the rest will coordinate their luminescent lanterns. The males flash for a period of two to four seconds, and then pause for an eight second break in which the females will respond with a quick double-flash. This synchronized biological light show will continue until midnight or later.

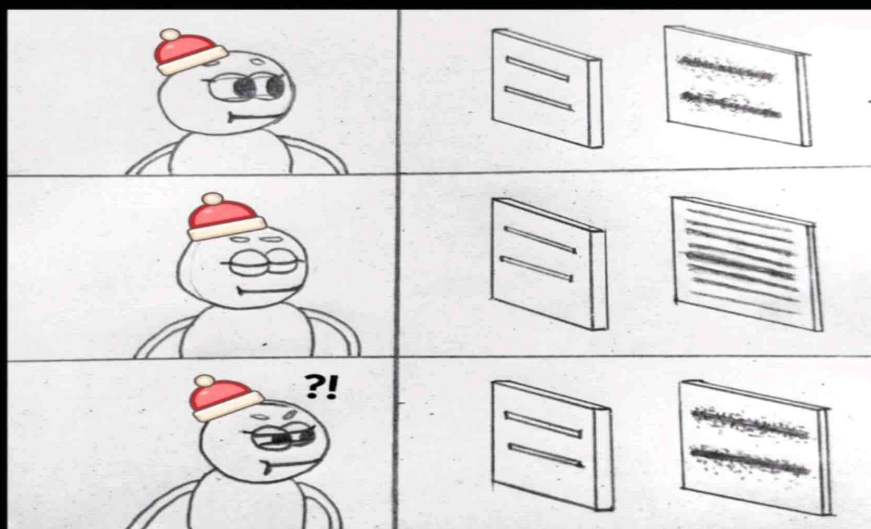
❖ Four species of synchronous fireflies can also be found in the jungles of Southeast Asia (particularly in Malaysia, Thailand and the Philippines), but they don't fly and flash the way they do there. They [fireflies in Southeast Asia] perch on trees and flash. And they're completely synchronous, meaning they flash both on and off together.

In this writing I just tried to give a brief idea about synchronization of fireflies. There is so many different explanation and ideas on this topic. Synchronization of fireflies is a mystery; so many researchers are recently working on this topic.

FUNTIME ALERT



*Quantum Physicists :



A BIOGRAPHY OF SHANKAR ABAJI BHISE

Anuskha Barua

Trisha Pal

Semester 1, Physics Department.

“Shankar Abaji Bhise : The ‘Indian Edison’ who Dazzled The World with His Inventions.”

Shankar Abaji Bhise (1867-1935) is probably the most remarkable Indian inventor you have never been heard of.

Hailed as the ‘Indian Edison’ Bhise was on the cusp of revolutionizing the printing industry with his Bhisotype (Type-casting machine). However, the inability to market it successfully alongside financing problems hindered his efforts.

What's remarkable about the self-trained man is that he came up at a time when India, under British colonial rule barely offered any industrial support to potential scientists and inventors like the IITs do today.

It was his own ingenuity and hard work, which took him from the crowded streets of Bombay to international acclaim. Growing up in Bombay, Bhise showed a real aptitude for the sciences, constructing a “Small apparatus at home which made coal gas” at the age of just 14. As a teenager he would spend days reading various issues of the reputed scientific American magazine, and in fact told one New York publication year later, “I owe everything to the mechanical education I received from that American magazine.”

He also understood that science was collaborative pursuit and began a club in Bombay and “by his early 20s, began

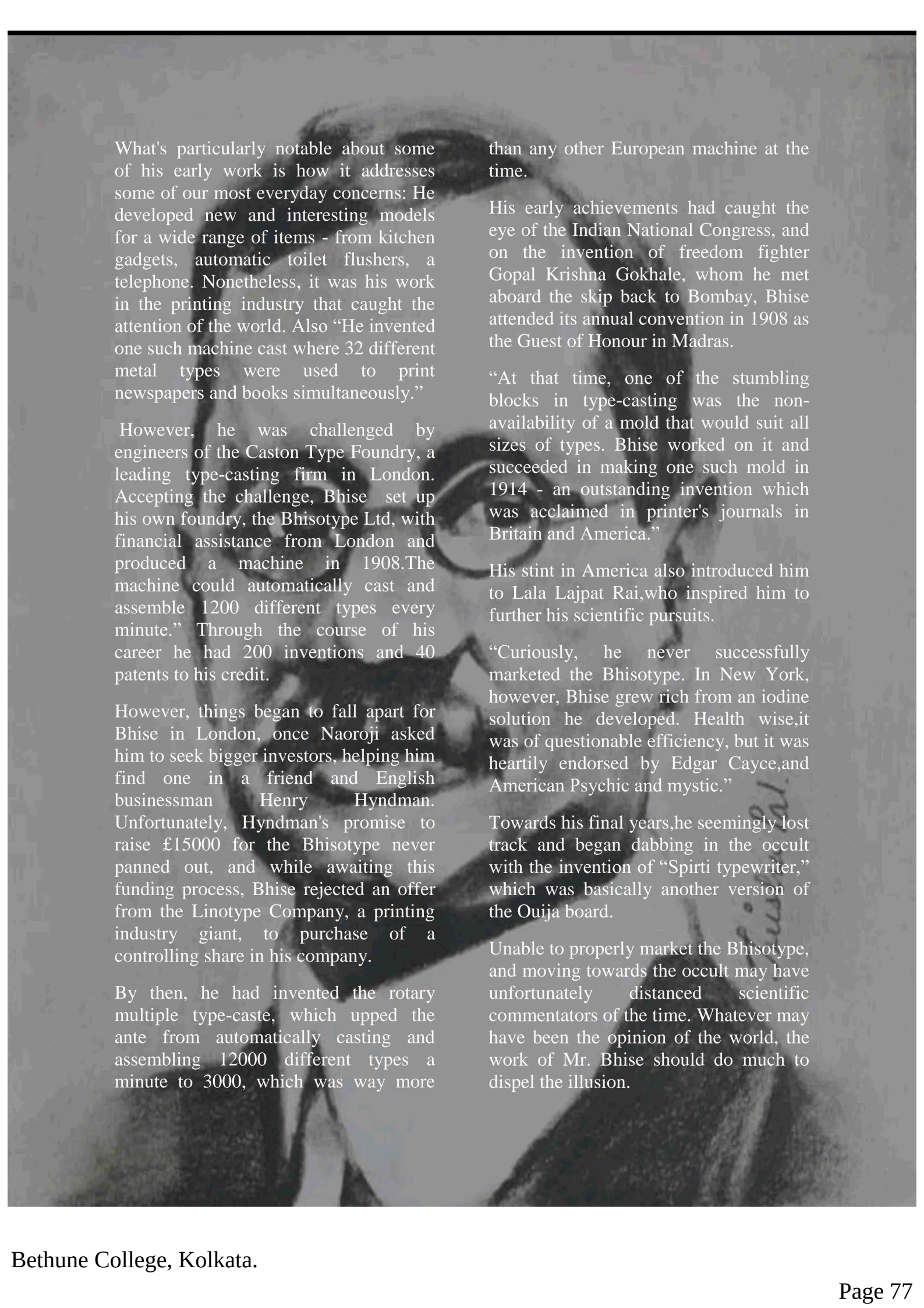
designing a slew of gadgets and machines :Temper-proof bottles, electric bicycle contraptions, a station indicator for Bombay's suburban railway system.”

Bhise even wrote columns in the Marathi science magazine called Vividh Kala Prakash, through which he communicated the importance of science to ordinary people.

However, he really came up of age sometime in the late 1890s, when he won a competition organized by ‘Inventors’ Review and scientific Record,’ a British publication, by developing the design for a machine that would weigh groceries.

Defeating a whole host of British contestants, the local administration took an interest in his work and helped finance his trip to London, where he sought to attract investors. Just before his trip to London, he also came into contact with the secretary of the Indian National Congress in Bombay and a shrewd businessman Dinsh Wacha, whose letter of introduction got Bhise into contact with Dadabhai Naoroji.

Wacha and Naoroji both men soon inked a businessman argument whereby Naoroji agreed to invest in Bhise's work. Following the argument, Bhise set out to work from a workshop in North London.



What's particularly notable about some of his early work is how it addresses some of our most everyday concerns: He developed new and interesting models for a wide range of items - from kitchen gadgets, automatic toilet flushers, a telephone. Nonetheless, it was his work in the printing industry that caught the attention of the world. Also "He invented one such machine cast where 32 different metal types were used to print newspapers and books simultaneously."

However, he was challenged by engineers of the Caston Type Foundry, a leading type-casting firm in London. Accepting the challenge, Bhise set up his own foundry, the Bhisotype Ltd, with financial assistance from London and produced a machine in 1908. The machine could automatically cast and assemble 1200 different types every minute." Through the course of his career he had 200 inventions and 40 patents to his credit.

However, things began to fall apart for Bhise in London, once Naoroji asked him to seek bigger investors, helping him find one in a friend and English businessman Henry Hyndman. Unfortunately, Hyndman's promise to raise £15000 for the Bhisotype never panned out, and while awaiting this funding process, Bhise rejected an offer from the Linotype Company, a printing industry giant, to purchase of a controlling share in his company.

By then, he had invented the rotary multiple type-caste, which upped the ante from automatically casting and assembling 12000 different types a minute to 3000, which was way more

than any other European machine at the time.

His early achievements had caught the eye of the Indian National Congress, and on the invention of freedom fighter Gopal Krishna Gokhale, whom he met aboard the ship back to Bombay, Bhise attended its annual convention in 1908 as the Guest of Honour in Madras.

"At that time, one of the stumbling blocks in type-casting was the non-availability of a mold that would suit all sizes of types. Bhise worked on it and succeeded in making one such mold in 1914 - an outstanding invention which was acclaimed in printer's journals in Britain and America."

His stint in America also introduced him to Lala Lajpat Rai, who inspired him to further his scientific pursuits.

"Curiously, he never successfully marketed the Bhisotype. In New York, however, Bhise grew rich from an iodine solution he developed. Health wise, it was of questionable efficiency, but it was heartily endorsed by Edgar Cayce, and American Psychic and mystic."

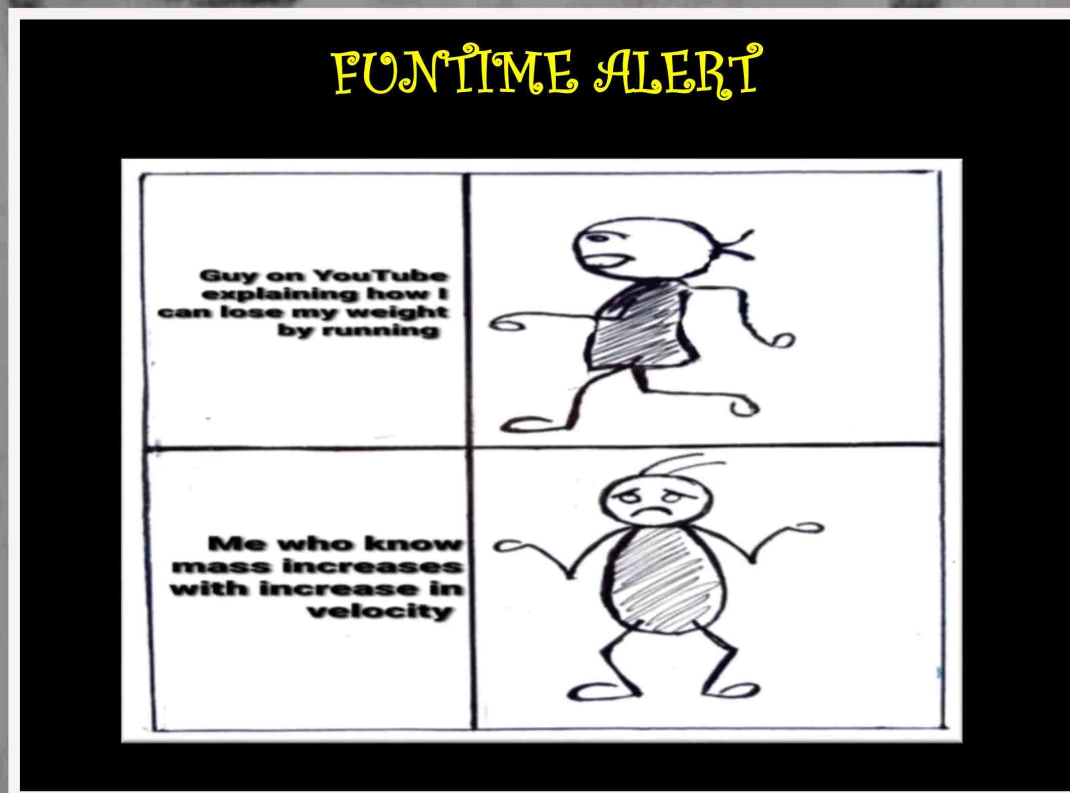
Towards his final years, he seemingly lost track and began dabbling in the occult with the invention of "Spirti typewriter," which was basically another version of the Ouija board.

Unable to properly market the Bhisotype, and moving towards the occult may have unfortunately distanced scientific commentators of the time. Whatever may have been the opinion of the world, the work of Mr. Bhise should do much to dispel the illusion.

He passed away on 7th April 1935, in New York at the age of 68. Despite his late life quirks, he was a true believer in the freedom struggle, attending anti-colonial demonstration alongside Naorojiin London, while supporting and spreading the gospel of Mahatma Gandhi's ideas during his time in New York.

Unfortunately, Bhise slipped into obscurity, but nonetheless, there is an attempt by many to revive his scientific legacy. This is just another attempt at it.

BACKGROUND ILLUSTRATION BY TRISHA PAL



"COSMIC RIPPLES"

A new era of Astronomy begins

Saptashi Chatterjee

Madhuparna Das

Sangita Paul.

Semester 3 Physics Department

"ARE YOU LIKE GRAVITATIONAL WAVES.....

COZ I KNOW YOU EXIST BUT IT'S QUITE HARD FOR ME

TO FIND YOU....."

- Viks

We are all truly eager to know what basically the gravitational wave is!! How the universe has evolved and what causes the late time acceleration of the universe? What is causing the rotation curves of galaxies? And how could we relate quantum mechanics with gravity? It takes many decades to reveal the truth behind these arousing questions. Even in recent days physicists are still working on this field, looking for more further information. Only the concept of gravitational waves in space-time fabric could describe all unsolved questions. Gravitational waves have the potential to provide expected and unexpected clues to these questions that we can use to put together the jigsaw puzzle of our mysterious Universe.



In order to know about the G.M wave, in the first instance we have to know, What truly the gravity is(the accident definition by Newton)??

According to Newton's law of gravitation , any two particle of matter attracts each other with a force which is proportional to the product of their masses and inversely proportional to the square of the distance between them. And we are already familiar with this law and the force of gravitation from our classical knowledge. But astonishingly the most famous prediction of Einstein had changed the thought of our gravity totally when his famous paper on general theory of relativity had published. Now to understand the ripples of whole universe firstly we think about two black holes that are orbiting each other from millions of years. Now if they come closer, they began to circle each other more faster and faster. Finally they collided and merged into a single even bigger black hole. Now the miracle is, a fraction of a second before their crush, they sent a vibration across the universe at the speed of light, exactly as the marriage invitation card of any marriage. This signal was first detected by the physicist, when the Laser Interferometer Gravitational-Wave Observatory (LIGO), a pair

of detectors in Washington and Louisiana, spotted two black holes spiraling into each other, generating infinitesimal ripples in space time. $(36M(BH)+29M(BH)-62M(BH)+3M$ gravitational wave), this is the equation of the

collision which was detected by LIGO first. So we now realize that the signal which was detected, is the gravitational wave.

Generally, Gravitational waves are nothing but are produced by masses moving space-time in a

Einstein's prediction

Einstein in the year 1915, with his radical General theory of relativity, gave a complete new perspective of gravity.

The concept is mathematical and quite sophisticated, but can be defined simply as "Matter curves space and objects responds to that curvature." i.e. Gravity is not a force as such, but a curvature caused in the space time fabric due to the presence of an object with mass.

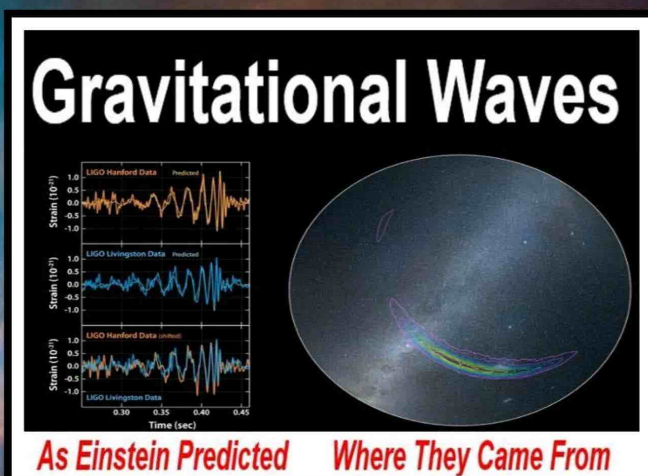
To visualize it, imagine a ball in a stretched rubber sheet, the presence of the ball causes a dip to form and the sheet curves depending on the weight of the ball, now another smaller ball, if rolled to the bigger ball follows the curved space. Roughly this is how earth revolves around the sun. Even though this analogy is not true cent percent, for visualization this will suffice.

What is gravitational wave in short

The denser the mass is, the greater the curvature of space-time. As objects with mass move around in space-time, the curvature also changes to the trail of the moving masses. At times accelerating objects are generating changes in this curvature, which propagate outwards in a wave-like manner. These propagating phenomena are known as

special way. Now we are going to know the mysterious history behind this waves of universe.

Dragging of space time by spinning objects- Frame Dragging. The beauty of Einstein's work lay on the fact that each one of his predictions are physically tested and verified. There was one last incredible prediction which was never



As Einstein Predicted Where They Came From
directly observed, i.e. Gravitational waves. Now this is history!

gravitational waves. These are outflowing fluctuations of expanding and contracting space time. The simplest system that produces gravitational waves is two masses orbiting around their common center of mass. One of the most common such system is a binary star system – two stars orbiting each other's common center of mass.

Properties of gravitational wave

☛ Since G-waves are distortions in space-time, if it passes through a free standing body, the body may experience rhythmic stretching or shortening, without an unbalanced external force. But one may not even notice this stretching, one reason is that these stretching are negligibly miniscule, other reason, everything gets stretched equally, relatively thus the effect will be nullified.

☛ G- Waves can pass through any intervening matter without being scattered significantly. Whereas light from distant stars may be blocked out by interstellar dust, for example, gravitational waves will pass through essentially unimpeded. This feature allows G-Waves to carry information about astronomical

phenomena which never before observed by humans. With this detection we will be able to turn the Universe into our own laboratory.

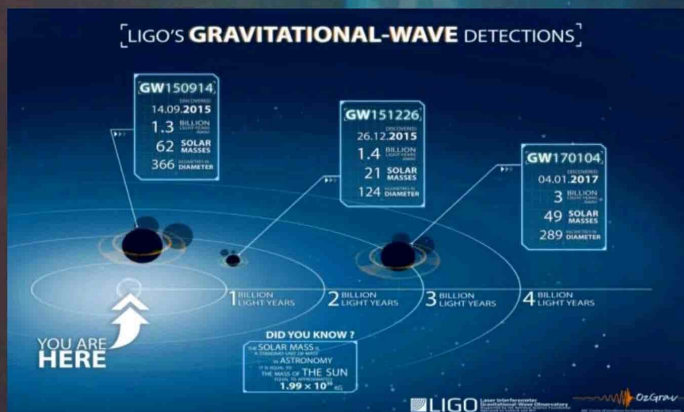
☛ Gravity being a very weak force when compared to nuclear force or electrostatic force, one need really massive object or something accelerating at a high rate to have g-waves capable in order to detect.

☛ At some point they may become so intense that direct detection by their effect on objects on Earth is possible. This time frame is only a few seconds. LIGO (Advanced Laser Interferometer Gravitational-Wave Observatory)achieved sensitivities to detect such a microscopic blip in the cosmic noise.

How can we detect gravitational waves

The detection of G.M wave is the one of the most historic one. The detection of gravitational

and lasers to measure that distance. Test masses are set at a large distance from each other – the large distance helps to make any change in their distance which may be large enough to measure. The masses are then shielded from all disturbances except gravity, which we cannot shield against. Then lasers make continuous measurements of the distance between each of the test masses. The masses are free to move in response to gravity so that when a gravitational wave passes, space-time stretches and the time it takes is same as light travels through when space-time fabric curve changes. Gravitational waves were first detected by the ground-based LIGO detectors in 2015 using ground-based facilities in Washington and Louisiana.



waves requires measurements that detect changes in distance which is less than the size

of an atomic nucleus - that's tiny! To do this, scientists use interferometry, which consists of two parts: test masses separated by a distance

What will we learn from the detectors

Gravitational waves are helping physicists and astronomers to understand some of the most fundamental laws of physics. They tell us about the dynamics of large-scale events in the universe like the formation and growth of galaxies and the super massive black holes at

their centers. With LISA, scientists will be able to probe through space and time, to observe the universe just a fraction of a second after the Big Bang. Using this information, we may be able to learn more about how the universe began and evolved.

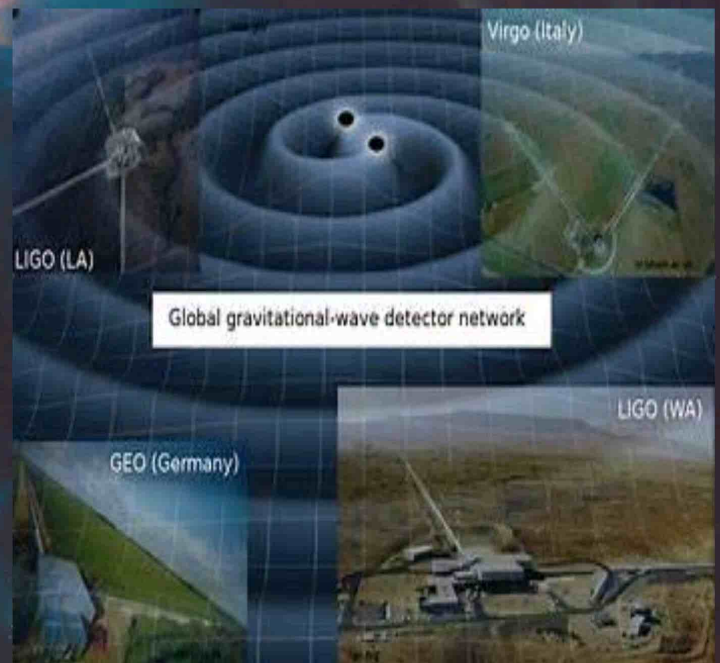
Can people feel gravitational waves

The effect that gravitational waves have on Earth is thousands of times smaller than the width of a proton, (one of the particles that makes up an atom's nucleus). That said, gravitational waves be weakened, the farther they travel, just as like ripples on a pond. The closer one are to two merging black holes, the more one would be stretched and strained. But as trippy as it sounds, a gravitational wave

stretches and compresses a given object as a percentage of the object's size. If Earth were as far from the black-hole merger that yielded LIGO's first detection as it is from the sun, gravitational waves would have stretched the planet by more than three feet. But peoples' bodies would be strained by just a millionth of a meter, far less than the compression one can feel when he jump up and land on the ground.

Where are gravitational-wave observatories

In 2017, the European observatory Virgo opened outside of Pisa, Italy, joining LIGO and Germany's GEO600 detector. And more such facilities are coming online: Japan's KAGRA detector, the first built underground, should be opening soon, and India is making plans to build its own detector. Meanwhile, astronomers keep monitoring arrays of pulsars to track very low-frequency gravitational waves. The thinking is that as a wave sweeps through, it would temporarily alter the timing of each pulsar's rotation. In a few decades' time, we'll be able to hear the universe as never before, from the deep rumble of merging super massive black holes to the zippy chirps of colliding neutron stars. The universe is full of light; now we know it's also full of music

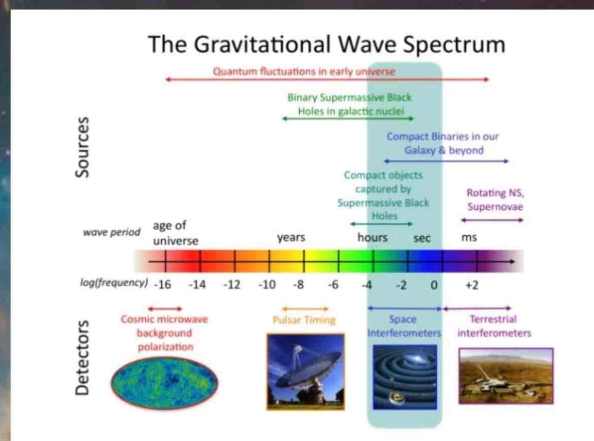


What can we learn from gravitational waves

The analogy that some physicists use is that gravitational waves let us “hear the universe.” To be clear, sound and gravitational waves are very different things. But by watching events play out in the universe at different wavelengths of light, while also watching out for the vibrations of gravitational waves, we can embark on what's known as multi-messenger astronomy. Today's gravitational wave detectors can spot waves created by the mergers of neutron stars and black holes. As of the end of 2018, we've seen 10 mergers of black hole pairs and one merger of two neutron stars. As more sightings build up, astronomers will be able to see patterns in the numbers and masses of known black holes, which helps inform theories of how they form and change over time. Physicists were also able to use the detection to test Einstein's theory of relativity as never before. Relativity predicts that light and gravitational waves from the same event should travel through space the same way. Other

theories of gravity, however, predict that the two should arrive at Earth at markedly different

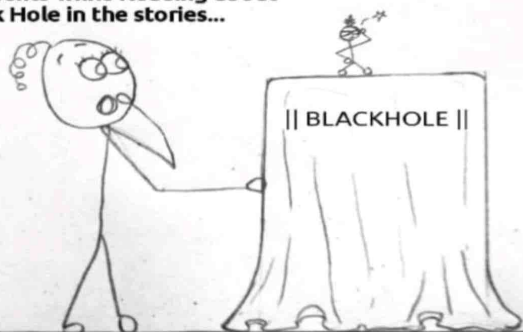
times. In the actual event, the light and gravitational waves arrived within seconds of each other—which means that gravitational waves and light react to obstacles in almost exactly the same way, within one part in a



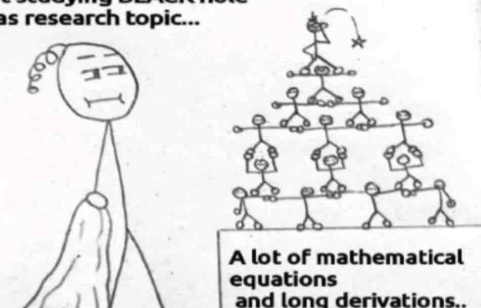
million billion. Gravitational waves also help clarify other aspects of our universe's foundation. This discovery is sure to usher a new era in Gravitational wave astronomy and will enable us in finding answers to fundamental questions on the origin of the universe, on how a primordial singularity Big Banged into the vast vistas of the cosmos.

FUNTIME ALERT

***Students while Reading about Black Hole in the stories...**



***Student studying BLACK hole theory as research topic...**



ANSWER OF WORDSEARCH

S	P	I	R	A	L	G	A	L	A	X	Y	E	C	F	J
C	O	U	E	N	T	R	O	P	Y	K	N	V	X	O	N
A	L	R	D	I	A	M	A	G	N	E	T	I	S	M	Y
P	O	V	G	A	N	Y	M	E	D	E	O	P	A	C	O
I	N	Q	I	T	C	E	F	F	E	N	A	M	E	E	Z
L	I	Z	A	C	O	N	D	U	C	T	O	R	C	J	K
L	U	E	N	E	R	G	Y	W	D	N	E	V	T	I	P
A	M	O	T	N	O	Z	I	R	O	H	T	N	E	V	E
R	F	O	R	C	E	S	C	O	O	P	B	X	V	L	O
Y	A	C	T	I	O	N	H	W	R	E	U	Y	T	T	P

ANSWER OF CROSSWORD

❖ ACROSS:

1. Joule 2. Pseudovector 3. Entropy 4. Current
5. Active Blackhole (No space in between) 6. Schödinger
7. Electric field (No space in between) 8. Rader 9. Friction
10. Force 11. Universe 12. Brownian 13. Star 14. Gibb's free energy (No space in between)
15. Gauss 16. Radiation 17. Bragg
18. Photon 19. Biasing 20. Einstein 21. Neutron Star (No space in between)
22. Fission 23. Blackhole 24. Newton 25. Fourier 26. Diamagnetic

❖ DOWN:

1. Intensity 2. Ideal gas (No space in between) 3. Equilibrium
4. Conductor 5. Transport 6. Xray 7. Energy 8. Fusion 9. Error 10. Vector
11. Mass

BONTONTV

BIBLIOGRAPHY

☛ THE COSMOS UNDER THE SEA

- ◆ The Cosmos in Antikythera Mechanism by Tony Freeth and Alexander Jones (dlib.nyu.edu/awdl/isaw/isaw-papers/4/)
- ◆ The Discrete Charm of the Machine: Why the world became digital by Ken Steiglitz
Princeton University Press
- ◆ https://en.wikipedia.org/wiki/Antikythera_mechanism

☛ THE FERMI PARADOX AND ITS POSSIBLE SOLUTION

- ◆ https://en.wikipedia.org/wiki/Fermi_paradox
- ◆ <https://cosmosmagazine.com/space/what-is-the-fermi-paradox/>
- ◆ <https://waitbutwhy.com/2014/05/fermi-paradox.html>
- ◆ <https://www.space.com/25325-fermi-paradox.html>
- ◆ <https://www.bbvaopenmind.com/en/science/physics/five-solutions-to-the-fermi-paradox/amp/>
- ◆ <https://astronomy.com/news/2020/11/the-great-filter-a-possible-solution-to-the-fermi-paradox>
- ◆ <https://www.space.com/amp/25325-fermi-paradox.html>

☛ AS TIME GOES BY...

- ◆ A Brief history of Time- Stephen Hawking
- ◆ The Order of Time – Carlo Rovelli
- ◆ <https://www.nature.com/articles/d41586-018-04558-7>
- ◆ https://en.wikipedia.org/wiki/Four-dimensional_space
- ◆ <https://fs.blog/2014/10/what-is-time/>
- ◆ <https://www.thoughtco.com/what-is-time-4156799>
- ◆ <http://www.exactlywhatistime.com/physics-of-time/relativistic-time/>

- ◆ <https://www.quora.com/What-is-time-2>
- ◆ <https://www.nytimes.com/1986/12/30/science/is-there-a-past-in-the-future.html>
- ◆ <https://plato.stanford.edu/entries/newton-stm/>
- ◆ [https://en.wikipedia.org/wiki/Arrow_of_time#:~:text=The%20arrow%20of%20time%2C%20also,or%20%22asymmetry%22%20of%20time.&text=Yet%20at%20the%20macroscopic%20level,\(or%20flow\)%20of%20time.](https://en.wikipedia.org/wiki/Arrow_of_time#:~:text=The%20arrow%20of%20time%2C%20also,or%20%22asymmetry%22%20of%20time.&text=Yet%20at%20the%20macroscopic%20level,(or%20flow)%20of%20time.)
- ◆ <http://web.physics.ucsb.edu/~quniverse/arrows.html>
- ◆ <https://www.thedailybeast.com/neil-degrasse-tyson-breaks-down-interstellar-black-holes-time-dilations-and-massive-waves>
- ◆ <https://www.quantamagazine.org/print>

☛ RING DYNAMICS

- ◆ <http://burro.astr.cwru.edu/Academics/Astr221/SolarSys/Rings/dynamics.html#:~:text=Saturn's%20rings%20are%20200%2C000%20km,spread%20across%20a%20football%20field.%22&text=The%20velocity%20dispersion%20in%20Saturn's,of%20their%20orbital%20velocity%20!>
- ◆ https://en.m.wikipedia.org/wiki/Rings_of_Uranus
- ◆ <https://sciencing.com/planet-rings-jupiter-saturn-19909.html>

☛ ANTI BUBBLE

- ◆ ¥ http://math.mit.edu/~bush/?page_id=484
- ◆ £ Correspondence to: kudo@ist.hokudai.ac.jp
- ◆ § <https://www.stem.org.uk/news-and-views/opinions/what-are-antibubbles-and-how-are-they-changing-world>

☛ THE BOY WHO FIXES RADIOS BY THINKING

- ◆ Surely You're Joking Mr. Feynman - R.P. Feynman & Ralph Leighton (Bantam Publishing)
- ◆ What Do You Care What Other People Think - R.P. Feynman & R. Leighton (Bantam Publishing).

☛ BLACK HOLE

- ◆ A Brief history of Time- Stephen Hawking
- ◆ Chandrasekhar, S. (1931). "The Maximum Mass of Ideal White Dwarfs". Astrophysical Journal. 74: 81–82.
- ◆ <https://ui.adsabs.harvard.edu/abs/1931ApJ....74...81C>
- ◆ doi: <https://doi.org/10.1086%2F143324>
- ◆ <https://physicsworld.com/a/black-hole-is-hairless-reveals-analysis-of-gravitational-waves/#:~:text=The%20no%2Dhair%20theorem%20is,head%20with%20few%20defining%20features.>
- ◆ https://www.physicsoftheuniverse.com/topics_blackholes_event.html
- ◆ <https://www.space.com/15421-black-holes-facts-formation-discovery-sdcmp.html>
- ◆ <https://astronomy.swin.edu.au/cosmos/B/Black+Hole>
- ◆ <https://www.nationalgeographic.com/science/article/black-holes#:~:text=There%20are%20four%20types%20of,forms%20is%20by%20stellar%20deat h.>
- ◆ <https://www.nasa.gov/audience/forstudents/k-4/stories/nasa-knows/what-is-a-black-hole-k4.html>
- ◆ <https://science.nasa.gov/astrophysics/focus-areas/black-holes>
- ◆ <https://youtu.be/cN7eXULeGLA>

☛ NUCLEAR FUSION AND PLASMA

- ◆ <https://www.sciencedirect.com/topics/earth-and-planetary-sciences/plasma-heating>
- ◆ https://www.google.com/url?q=https://www.iaea.org/topics/energy/fusion/background&usg=AFQjCNFw27TLdzkVmkxeeiD_0tyOfky7eg
- ◆ <https://spectrum.ieee.org/energy/nuclear/5-big-ideas-for-making-fusion-power-a-reality>
- ◆ <https://www.bbc.com/news/science-environment-50267017>

☛ BIOGRAPHY ON NIKOLA TESLA

- ◆ My Inventions : The Autobiography of Nikola Tesla by Ben Johnston and Nikola Tesla. Experimenter publishing company, Inc., New York

https://books.google.co.in/books/about/My_Inventions.html?id=6vWFDwAAQBAJ&printsec=frontcover&source=kp_read_button&redir_esc=y

◆ https://en.m.wikipedia.org/wiki/Nikola_Tesla

◆ <https://www.teslasociety.com/biography.htm>

☛ MAGNUS EFFECT

◆ <https://youtu.be/2OSrvzNW9FE>

◆ https://en.m.wikipedia.org/wiki/Magnus_effect

☛ ANTI-GRAVITY: A Bizarre Concept

◆ <https://en.m.wikipedia.org/wiki/Anti-gravity>

◆ <https://books.google.co.in/books?id=rk5UlsjKHWAC&printsec=copyright#v=onepage&q&f=false>

◆ <https://www.inverse.com/science/physicists-discover-antigravity/amp>

◆ <https://www.hindawi.com/journals/ahep/2020>

Boom!

◆ [https://en.m.wikipedia.org/wiki/Manhattan_Project#:~:text=The%20Manhattan%20Project%20was%20a,Tube%20Alloys%20project\)%20and%20Canada](https://en.m.wikipedia.org/wiki/Manhattan_Project#:~:text=The%20Manhattan%20Project%20was%20a,Tube%20Alloys%20project)%20and%20Canada)

◆ <https://www.britannica.com/event/Manhattan-Project>

◆ <https://www.history.com/topics/world-war-ii/the-manhattan-project>

◆ [https://en.m.wikipedia.org/wiki/Trinity_\(nuclear_test](https://en.m.wikipedia.org/wiki/Trinity_(nuclear_test)

◆ https://en.m.wikipedia.org/wiki/Atomic_bombings_of_Hiroshima_and_Nagasaki

◆ "Biswasghatak" by Narayan Sanyal (Dey's Publishing)

☛ SYNCHRONIZATION OF FIREFLIES

◆ <https://www.nps.gov/grsm/learn/nature/fireflies.htm>

◆ <https://www.nationalgeographic.com/animals/2020/06/synchronous-fireflies-rare-look-congaree-national-park/>

◆ G.M. Ramírez Ávila, J. Kurths & J.L. Deneubourg. "Fireflies: A paradigm in synchronization" en M. Edelman, E.E.N. Macau & M.A.F. Sanjuán. Chaotic, Fractional, and Complex Dynamics: New Insights and Perspectives. 35-64. Springer, Cham

☛ COSMIC RIPPLES : A New Era of Astronomy Begins

◆ <https://www.britannica.com/science/gravitational-wave>

◆ <https://www.nationalgeographic.com/science/space/reference/gravitational-waves/>

◆ <https://www.accessscience.com/topics/physics/physics-general>

◆ “RELATIVITY –(THE SPECIAL AND GENERAL)” by ALBERT EINSTEIN
(Published by Henry Holt And Compqny in 1920 ,New York)

☛ THE BIOGRAPHY OF SHANKAR ABAJI BHISEY

◆ https://www.google.com/url?sa=t&source=web&rct=j&url=https://www.thebetterindia.com/188809/india-thomas-edison-shankar-abaji-bhisey-bombay-bhisotype-bombay/amp/&ved=2ahUKEwiSz4-Yp6fuAhWCcn0KHce5C38QFjAXegQIGhAB&usg=AOvVaw363ezEJIUZpceauwnJI6_h&cf=1



thank
you