



**E-MAGAZINE OF
DEPARTMENT OF PHYSICS,
VICTORIA INSTITUTION
(COLLEGE)**

FIZIKA

Principal's Message

Dr. Nibedita Chakrabarti
M.Sc., Ph.D., FIICERAM



I am happy to announce that the students of the Physics Department of Victoria Institution College are scheduled to publish a scientific E-Magazine, "FIZIKA". When the world is battling the highly infectious Covid 19 disease, such a scientific magazine is refreshing and critical for rolling the wheel of technology forward. During this pandemic, for our own physical benefit, we are in a strict lockdown. But at the same time, this lockdown has made it impossible for us to socialize and has taken a toll on our mental health. We, humans, are social creatures, and this lack of in-person communication with others has led to a rise in the cases of severe depression globally. However, overcoming all the odds thrown at us in the past year and a half, our students were able to create FIZIKA. FIZIKA discusses the latest development in Science and Technology. Such discussions are vital towards the growth of young minds. Young students are always motivated by the fascinating, state-of-the-art research conducted in our country. These motivated young individuals then join the nation's research initiative contributing significantly towards a technologically enhanced society. I am sure that FIZIKA will motivate the students to think, create, and choose the scientific field as their career path. I congratulate the creators of FIZIKA and wish their magazine all the success that it truly deserves. Lastly, I would like to wish the best for all the students at Victoria Institution College and hope for their success even during this terribly difficult time.

Message from the Department of Physics

We are elated and appreciate the sincere endeavor of our students to create the E-Magazine "FIZIKA" in this hard time. This kind of activity not only boost up the independent thinking capability and management skills to carry out team work of the students but also enhance their overall development.

"FIZIKA" is full of clear explanation of interesting scientific phenomena from diverse fields of physics starting from relativity, electro-magnetic theory, quantum physics, nuclear and particle physics to astrophysics, quantum computation and nano-materials.

Moreover, the students also have highlighted some of the benchmark technological developments and scientific projects of the internationally acclaimed national scientific organizations like DRDO, ISRO. Discussion on the historical Manhattan project complements their interest about the indigenous scientific progress.

It is our immense pleasure to see that the students have acknowledged the contributions of the women physicists in the development of this field. Articles on the application of physical laws in sports, physics in popular culture and the two science fiction stories act as the topping to the variety of this e magazine. We give the appraisal to our Student Editors for efficiently completing the painstaking job of editing.

Finally, we want to thank our Principal madam for her constant support and encouragement in publishing this magazine. We wish that this little effort made by our students will be appreciated by the readers.



Dr. Pratibha Pal



Dr. Gayatri Pal



Dr. Subhendu Chandra



Dr. Shinjinee Das Gupta



Smt. Swarnalekha Bandyopadhyay



Smt. Kathakali Biswas

Welcome to the E-Magazine of Department of Physics, Victoria Institution (College). We are really proud and exuberant to acclaim that we are ready with new hopes and hues to bring out the issue.

Our magazine's name is '**FIZIKA**' which is a Russian word for 'PHYSICS'. The enthusiastic articles of our writers are indubitably sufficient to hold the interest and admiration of the readers. The magazine covers different topics like astrophysics, modern physics, nanotechnology etc.

We are sure that the positive attitude, hard work and sustained efforts exhibited by our writers will surely stir the mind of the readers. We have put in relentless efforts to bring excellence to this treasure trove.

We take the opportunity to thank all the contributors as their contribution is the reason that makes this magazine endearing with our readers.

Helen Keller rightly says that the world is moved along not only by the mighty shoves of its heroes, but also by the aggregate of the tiny pushes of each honest worker. This herculean task of editing this magazine would not have been possible without the support of the members of the Editorial Board.

We are thankful to all our Professors who dipped their oars into the turbulent water of the e-magazine and have sailed it to the shore of publication.

We are really thankful to our Principal madam for entrusting us with the responsibility of publishing this e-magazine.

We heartily convey our best wish to the readers.

HAPPY READING!

**Editors: Nirupama Mitra, Indrani Ghosh (VIth Sem)
Sweta Pal Majumder (IVth Sem) and Tanusri Santra (IInd Sem)**

OUR TEAM



From left : Taniya, Afirah, Dewannshi, Bidisha, Indrani, Meghna, Rupsa, Mohima, Sema and Nirupama . (VIth Sem)



From left: Debarati, Nayema, Simran, Riya, Sweta and Sima. (IVth Sem)



From Left: Solanki, Saptaki, Chirantani, Sayani, Ahana, Tanusri, Eshita, Sumona, Nandini and Swastika. (IInd Sem)

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PHYSICS IN SPORTS

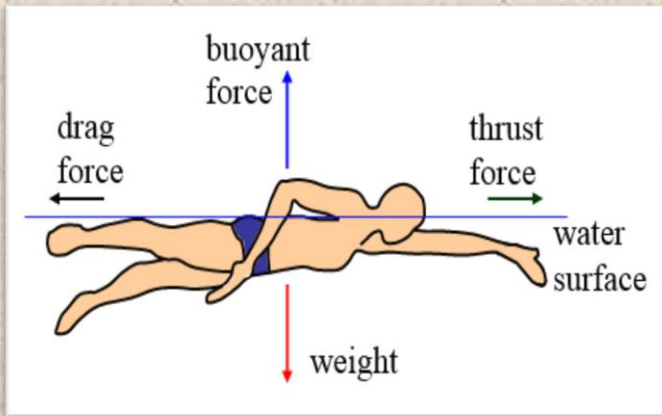
Bidisha Bag, VIth Sem

The Physics Of Swimming and Newton's Laws Of Swimming



The physics of swimming involves an interaction of force between the water and the swimmer. The biggest difference is that water is much more dense than air. When you are in the water gravity is much less important because your buoyancy largely cancels it .

Among the most fundamental rules of physics, these three basic principles are enough to explain completely. The first law outlines the concept of inertia. The second law explains the connection between the force and acceleration: the greater the force you apply, more the acceleration you get (in case the mass is constant).



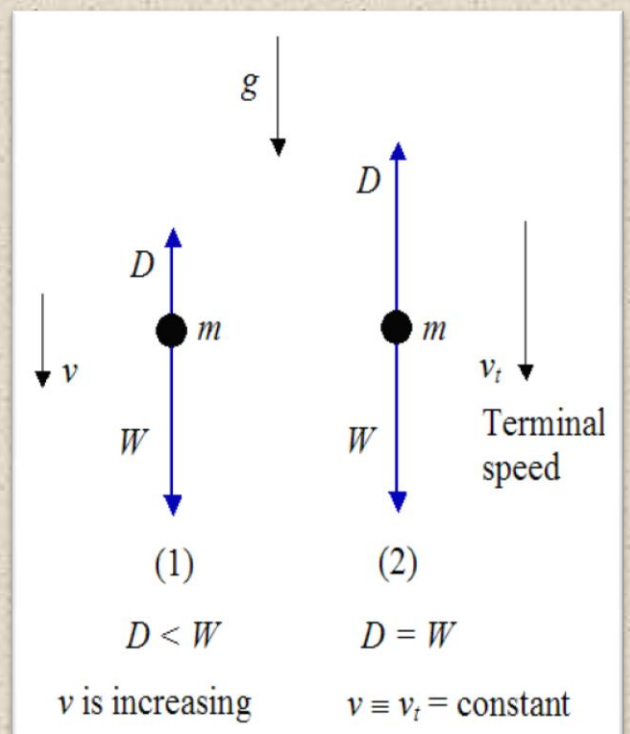
According to the third law when you apply a force to an object, the object will return the favour and will apply an equal force to you in the opposite direction. In order to swim in the forward direction through the water, you have to pull water backward with your hands. If you want your body to stay up, floating on the surface, you need to kick down with your legs. If while swimming anyone want to stop suddenly and stand up, then he can pull his hands down in front of him and his legs will swing down behind him , so that he can land in an upright position on his feet.

If you are swimming completely under the surface (for example, Scuba diving), you are moving through relatively still water, other times, you are going to be moving along at the more turbulent interface between water and air, with your head, legs , arm and body moving from one element to other and back again speeding up or slowing down as they cross the border.

The Physics Of Skydiving



The physics behind skydiving involves the interaction between gravity and air resistance. A skydiver when jumps out of a plane he starts accelerating downwards, until he reaches a terminal speed, This is the speed at which the drag from air resistance exactly balances the force of gravity pulling him down.



The general equation for drag force (D) acting on a body acting upwards is,

$$D = \frac{1}{2} C \rho A v^2$$

where C , ρ and A are the drag coefficient, density of the air through which the body is moving, projected cross-sectional area of the body perpendicular to the flow direction (that is, perpendicular to v) respectively.

The force of gravity pulling the skydiver down is,

$$W = mg$$

where g is the acceleration due to gravity, which is 9.8 m/s^2 , m is his mass, v is the speed at which he falls

The terminal speed v_t is reached when $D = W$ so,

we have,

$$mg = \frac{1}{2} C \rho A v_t^2$$

Solving for terminal speed v_t we have,

$$v_t = \sqrt{\frac{2mg}{C\rho A}}$$

Thus it can be seen, that for smaller value of cross-sectional area A , there will be a higher value of terminal speed. The mass of the object is also an important factor.

The final drag force that the skydiver must experience is from releasing his parachute which slows him down enough to land safely.



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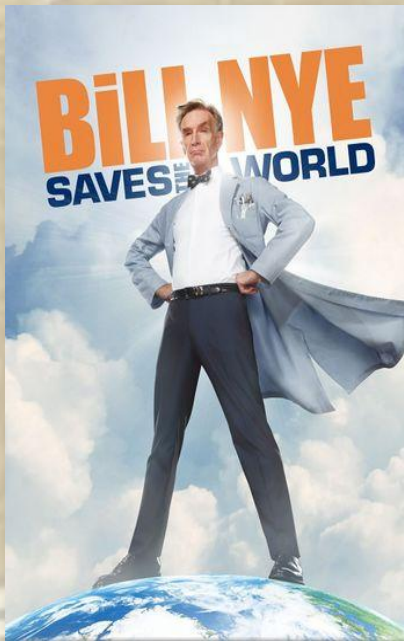
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SCIENCE AND PHYSICS IN POPULAR CULTURE

Dewannshi Poddar, VIth Sem

The inclusion of scientific themes and issues in Television, cinema, music, and literature began in the 19th century. It was made to challenge the traditional beliefs and also intrigue the common mass with questions they never thought of before.



Bill Nye ~The Science Guy

“Science fiction” is an offshoot wherein the laws of nature may not necessarily apply, thus creating endless possibilities of new worlds or alternate dimensions where everything is possible.

Star Wars (film series):

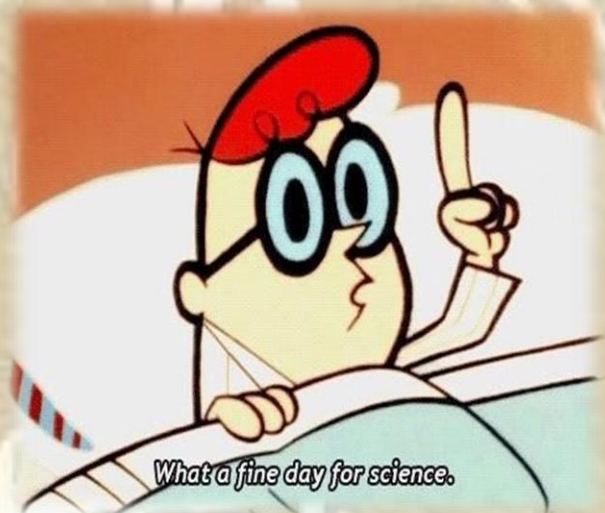
The first thing that comes in mind when we hear about science fiction is the Star Wars films which became hugely popular in the 1970s. It presents us with a concept where humans co-exist with androids or robots in galaxies far away from Earth. It gave us some iconic characters like Princess Leia and Darth Vader and the most common phrase to be heard from a Physics student—“May the Force be with you”!



Star Wars Film Poster

The Big Bang Theory (TV series):

The TV series which went on to have 10 seasons, follows the life of Dr Sheldon Cooper, a theoretical physicist and a child prodigy with no social skills. His friends are Dr. Leonard, an experimental physicist; Dr. Rajesh Koothrapalli, an Indian origin Astrophysicist and, Howard who is an MIT engineer. The show has cameos of the likes of Steve Wozniak and Stephen Hawking himself.



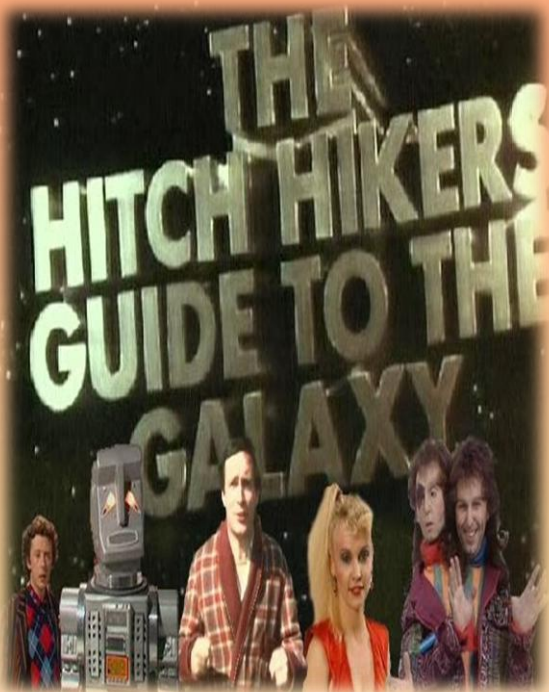
Dexter's Laboratory



Dr. Cooper with Stephen Hawking

The Hitchhikers guide to the galaxy (Novel series):

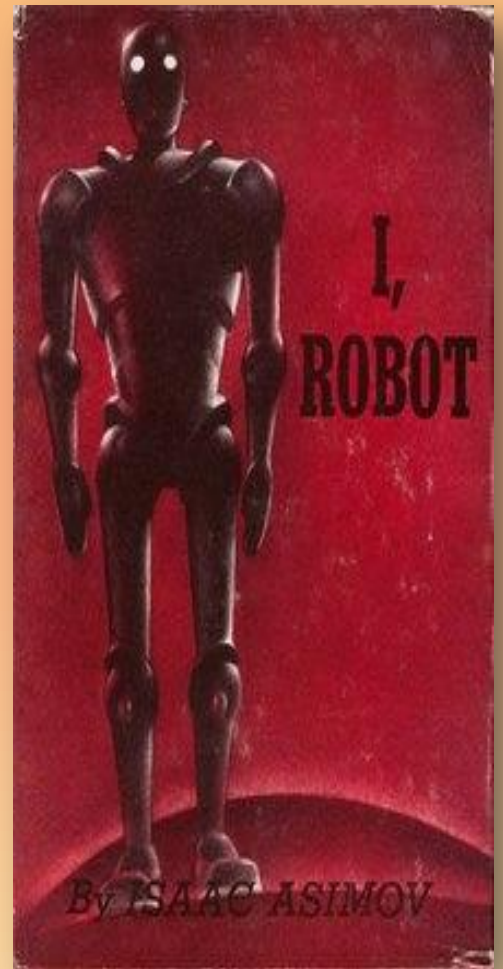
Written by Douglas Adams, the novel brings about a unique combination of humor, wit and, sarcasm along with the physical concepts of space and time. The series are an account of the misadventures of human Arthur Dent and his fellow human-lookalike-alien friend Ford Prefect. The series also features characters like Zaphod Beeblebrox, whose favorite catchphrase is “Holy Photons!”, Marvin or the “paranoid android” and Trillian.



The Hitchhikers Film

I, Robot (Short Stories Collection):

“A robot may not injure a human being or, through inaction, allow a human being to come to harm”. “A robot must obey the orders given it by human beings except where such orders would conflict with the First Law”. “A robot must protect its own existence as long as such protection does not conflict with the First or Second Law “. These are the set of rules devised by Isaac Asimov, a science fiction author and are called the laws of robotics that first appeared in this book. Dr, Susan remembers her working experience with the robots as a chief robopsychologist. The book had huge influence on later science fiction and raised questions regarding the morality and ethics of artificial intelligence and the human urge for superiority and control.



I,Robot Book Covert Book Cover

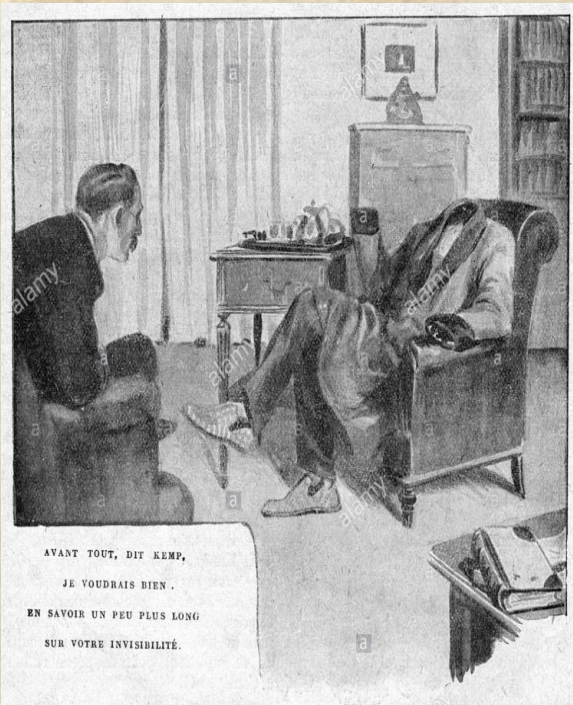
The Invisible Man (book):

The book was written in the 19th century by H.G.Wells, often referred to as the “Shakespeare of Science fiction”. We all wanted to become invisible at some point or the other of our lives and this childhood fantasy comes true for Griffin in this novel. Griffin has dedicated his entire life to study optics and eventually finds a way to change the refractive index of his body to that of air so that no light reflects or refracts rendering him invisible. Though scientifically incorrect as pointed out by scientists later, the invisible man was still able to leave a legacy of its own in popular culture.



Victor Frankenstein

Apart from these there are many forms of literature and cinema that use scientific themes in their stories like Gravity, Interstellar, Dr.Who Series and, even DC Comics superheroes like Superman and Spiderman, books like The Time Machine, A Wrinkle in Time and the Martian; all explore the countless possibilities of a world where nothing is limited to the laws of nature and is in fact far away from the real truth.



Invisible Man illustration

Frankenstein (book):

Frankenstein or the Modern Prometheus ,by Mary Shelley, is argued by many to be the first science fiction ever written. The novel explores the themes of birth and creation, alienation and, Insane pursuit of knowledge.”Frankenstein “ is often used to refer to the monster rather than his creator, Victor Frankenstein. In the novel he exclaims that- ”...it was the secrets of heaven and the earth that I desired to learn..”, which drives him to go against the laws of nature, to “create “ a creature just like God created Adam. A dangerous tale of going beyond the human thirst for knowledge , Frankenstein made a huge impact in popular culture that is relevant even now.

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Forgotten Women Physicists of India

Indrani Ghosh, VIth Sem

India has come a long way since her independence. Today, India's contribution towards scientific discoveries has earned international recognition. But what was it like a few years back when people still feared old beliefs and strongly believed in omens? Let's dig up the forgotten history.



Vijayalakshmi



Vijayalakshmi, affectionately known as 'Viji' had to fight against feudalistic academia. Though her life was cut short, she had contributed eleven papers to her credit in international journals by the age of thirty-three. Her field of work included studies of relativistic equations of higher spin in external electromagnetic and gravitational fields. Though her work was ground-breaking, she had to face vehement opposition from administration. She was very vocal about her displeasure with the academic set up, which resulted in considerable dissent from her peers and department-mates. She lost her battle to cancer in 1985.



The well-known scientist Dr. Bibha Chowdhury is on the left with others at the International Conference in Pisa, Italy (1955).

Purnima Sinha



Dr. Sinha contributed in the world of X-ray crystallography and interestingly her research was funded by Assam Oil Company. In that era, research-industry collaboration was unheard of. She was not only one of the first female students in the field of experimental physics in India, but she was also one of the first female students of renowned tabla player Pandit Jnan Prakash Ghosh. Clearly, ahead of her time, she mastered a percussion instrument that not many women choose to learn even today. She was also trained in Hindustani Classical Music from Yamini Ganguly and painting from renowned painter Gopal Ghosh. She was the first Bengali woman to receive a PhD in Physics (Calcutta University, 1956).

Bibha Chowdhuri

Bibha Chowdhuri was the first woman particle physicist in India and one of the first Indian women to earn a PhD in physics (University of Manchester). Scientist Debendra Mohan Bose and Bibha Chowdhuri co-discovered the subatomic particle, pi-meson (pion). Due to the lack of instruments and funding, they could not follow up the meson research. A few years later C.F. Powell, an English physicist, made the same discovery using similar methods and he was awarded the Noble Prize. Dr. Chowdhuri, thus, missed her tryst with history! The IAU has re-christened the star HD 86081 as Bibha after her.



Purnima Sinha with S N Bose and Paul Dirac

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DRDO'S AIP SYSTEM

Nirupama Mitra, VIth Sem

The Defence Research and Development Organisation (DRDO) is an agency under the Department of Defence Research and Development in the Ministry of Defence of the Government of India, charged with the military's research and development, headquartered in Delhi, India. It was formed in 1958 by the merger of the Technical Development Establishment and the Directorate of Technical Development and Production of the Indian Ordnance Factories with the Defence Science Organisation.



Five missiles, named "Agni", "Prithwi", "Naag", "Trishul", and "Akash" have been made for India's protection. DRDO provides Advance Sensor, weapon, platform, equipment production to Defence service of our country. These missiles and the warplanes are often exhibited on the Delhi highways on behalf of the DRDO on the Republic Day of India. Although there are some foreign missiles and tanks among them, most of them are made with domestic technology.

With a network of 52 laboratories, which are engaged in developing defence technologies covering various fields, like aeronautics, armaments, electronics, land combat engineering, life sciences, materials, missiles, and naval systems, DRDO is the India's largest and most diverse research organisation. The organisation includes around 5,000 scientists belonging to the Defence Research & Development Service (DRDS) and about 25,000 other scientific, technical and supporting personnel.



An important part of the defense of our country is the Navy. The Indian Navy is always keenly protecting the water boundaries of the country. The DRDO has supplied the Indian Navy with submarines and warships equipped with modern technology. Recently, the DRDO has been working on a new technology that will further strengthen the navy. According to latest news, this new technology is called "Fuel Cell based AIP system".

**MINISTER OF DEFENCE
PRESS OF RELEASE**



Logo of DRDO



Logo of Indian Navy

**Fuel Cell based Air Independent Propulsion
(AIP) System Crosses Important Milestone of
User Specific Tests**

Posted On: 09 MAR 2021 2:09PM by PIB Delhi

“Defence Research and Development Organisation (DRDO) has achieved an important milestone in the development of Air Independent Propulsion (AIP) System by proving the land-based prototype on 8 March 2021. The plant was operated in endurance mode and max power mode as per the user requirements. The system is being developed by Naval Materials Research Laboratory (NMRL) of DRDO.

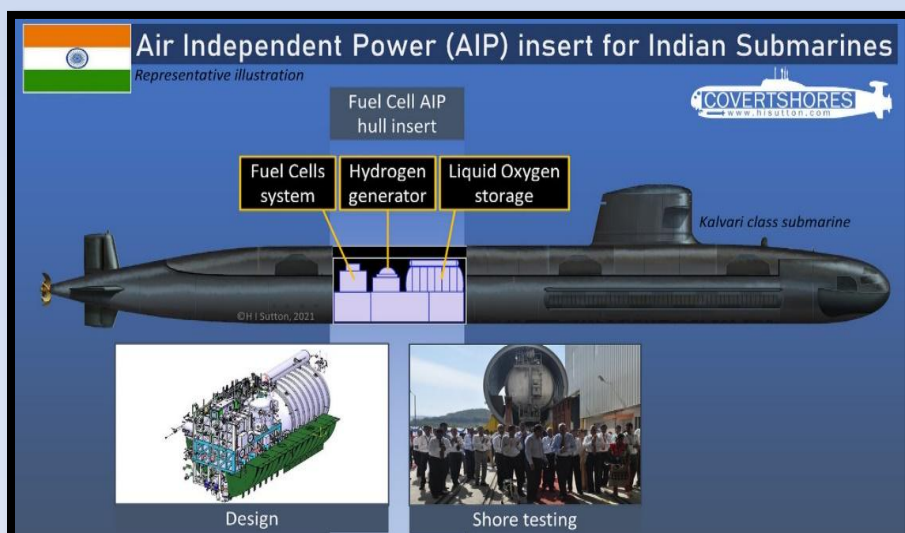
AIP has a force multiplier effect on lethality of a diesel electric submarine as it enhances the submerged endurance of the boat, several folds. Fuel cell-based AIP has merits in performance compared to other technologies.”

“While there are different types of AIP systems being pursued internationally, fuel cell-based AIP of NMRL is unique as the hydrogen is generated onboard. The technology has been successfully developed with the support of industry partners L&T and Thermax. It has now reached the stage of maturity for fitment into target vessels.

Raksha Mantri Shri Rajnath Singh congratulated DRDO, Indian Navy and Industry for the achievement.

Secretary DDR&D and Chairman DRDO, Dr G Satheesh Reddy appreciated the efforts of the teams involved in the successful development. He called upon the DRDO fraternity to come up with more such advanced technological achievements by putting extraordinary efforts.”

DRDO'S AIP system - a big jump to its achievement



Model of DRDO'S newly developed AIP system

AIP or Air Independent Propulsion system is an advanced technology being integrated in the modern diesel-electric submarine of the current generation that helps the submarines to remain under water for a longer period of time than the one without such system. Actually a diesel-electric submarine gets its power from the batteries it is equipped with. But those batteries can last only for 4-5 days on a single charge after which the submarine needs to float above the water surface so that it can recharge the batteries with the help of the diesel running generator that requires fresh air (oxygen) to burn the fuel. This process dilutes significantly the basic capabilities of a submarine of being unseen to the enemy systems. With the AIP system integrated, the time span of being submerged under water can be extended up to 15 -30 days. However nuclear power submarines doesn't require such systems for endurance.

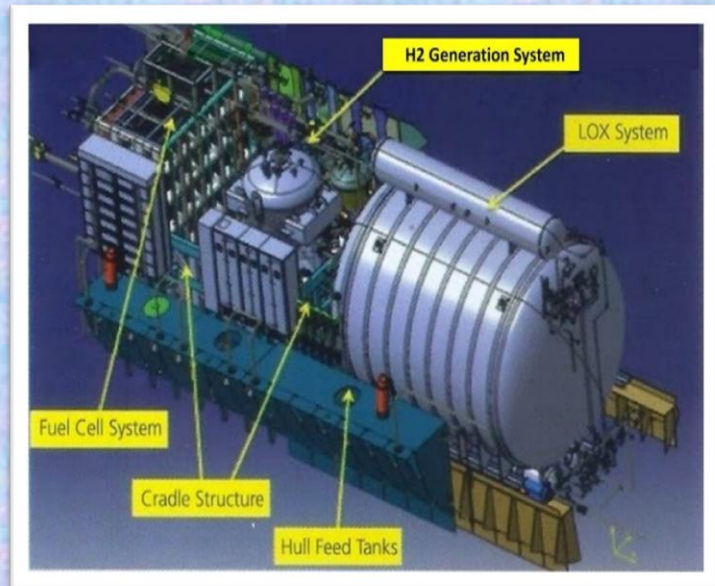
Types of AIP systems available

Currently there are four types of AIP system used widely,

- 1) Closed-cycle diesel engines.
- 2) Closed-cycle steam turbines.
- 3) Stirling cycle engines.
- 4) Fuel cells.

Among the four systems, fuel cell technology is the most advanced and capable AIP system with least numbers of drawbacks. Unlike other three it doesn't contain any heavy moving part that produces considerably high noise. The good news is that DRDO succeeded in developing the most advanced one i.e. the fuel cell AIP system.

The very basic principle of the fuel cell technology is to convert the chemical energy to the electrical energy. A typical fuel cell system uses a fuel along with an oxidizing material to produce the electric energy. Usually such system uses the heat generated by the water and the by-products to convert the hydrogen and oxygen to electricity by applying electrolysis in the fuel cell stack containing anode and cathode and a specific material as electrolyte.



Main components of DRDO's AIP system

DRDO's AIP system uses hydrogen as fuel while oxygen as oxidizer. Oxygen is stored in liquid form under high pressure to carry large amount of oxygen in a comparatively small container.

Main components of DRDO's AIP system are the LOX or a liquid oxygen reservoir or tank, the H₂ generation system, the fuel cells system and the thermal management system.

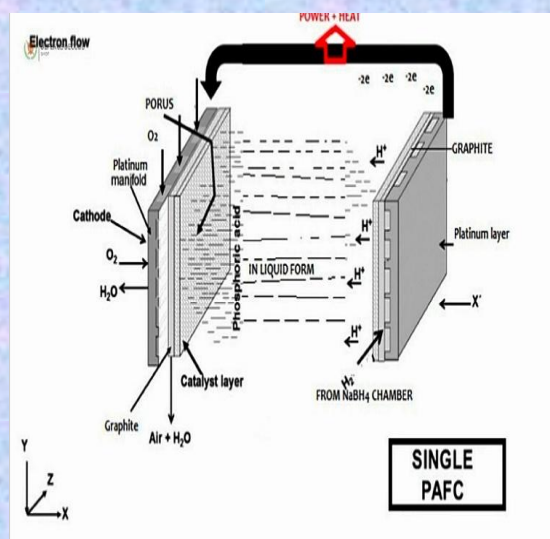
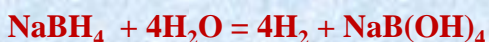


Fig.3: Reaction in a single fuel cell stack

Working Principle

DRDO here chooses to use NaBH_4 to generate Hydrogen, which can emit considerable amount of hydrogen with the contact of water (i.e. via hydrolysis reaction).

For smoother reaction catalyst particles are used and the rate of hydrogen generation in this process is a function of quality of the catalyst + weight ratio of the water into NaBH_4 .



This hydrogen and the stored liquid oxygen are used in the fuel cell for electrolysis to generate Power.

The most important part of the system is the fuel cell. Unlike normal batteries fuel cells are energy generating device rather than energy storing device. The electrode in a fuel cell doesn't use the material of the electrodes for electrolysis, rather it uses the stored oxygen and generated hydrogen along with the two parallel plates of same metal usually platinum as the cathode and the anode. Between them an electrolyte material is placed as usual. The hydrogen fuel reach the anode and the positive ions pass through the anode and then travel through the electrolyte and reach the cathode. While the negative ions pass through a wired path above the electrolyte and reach to the other side.

Thus the oxidation occurs there. In cathode portion the oxygen reaches from the reservoir. The positive H^+ ions and electrons reach cathode via electrolyte and wired path respectively and react with the oxygen to produce water vapor.

Thus the process produce heat, water (H_2O) and electricity which is then used to charge the batteries of the submarine. Thus as long as the supply of oxygen and hydrogen continue, the batteries can be charged without using the diesel generator motor.

A single fuel cell stack consists of two end plates, gas channel plates, anode & cathode plates, membrane electrode assembly (MEA) and other components along with electrolyte (electrolyte can be liquid or solid).

Many numbers of such fuel cell stacks are used together as a combination system to generate sufficient power. However the performance of the AIP system depends on the supply of oxygen, speed of the submarine and also on the efficiency of the fuel cells.

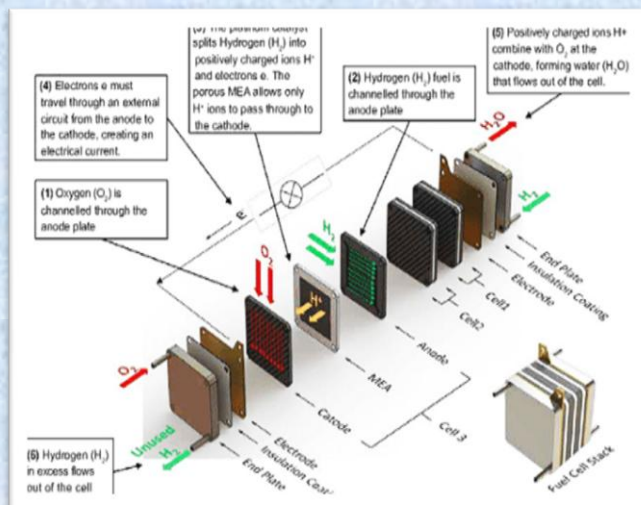


Fig. 6: components of a single fuel cell stack

Different types of Fuel cells can be used, e.g. alkaline fuel cell (AFC), proto cells (can be of different types depending on the electrolyte and the exchange membrane (PEM)), direct methanol fuel cell (DMFC), molten carbonate fuel cell (MCFC), phosphoric acid fuel cell (PAFC), and solid oxide fuel cell(SOFC).

As per DRDO's approach, they have used phosphoric acid fuel cell or PAFC for developing indigenous AIP system.

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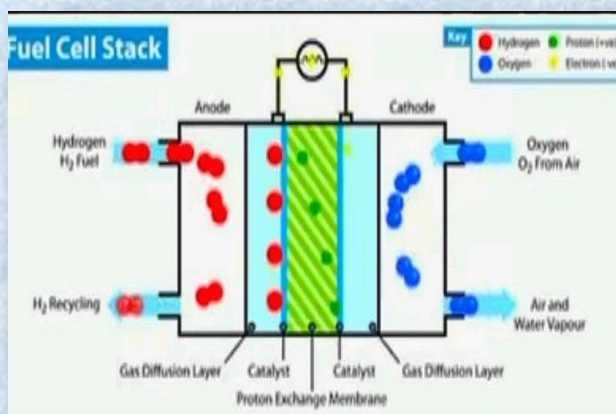


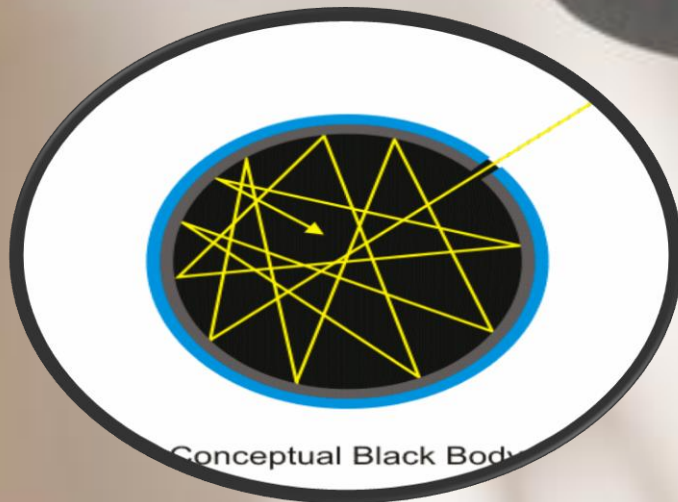
Fig.4: Energy generation in a single fuel cell stack

ULTRAVIOLET CATASTROPHE

Meghna Majumder, VIth Sem

The ability of a body to radiate is closely related to its ability to absorb radiation--a body at a constant temperature must absorb energy from surroundings at a same rate as it emits energy. An object that absorbs all radiation incident upon it, regardless of frequency, is called 'Black Body' and the 'Black-body Radiation' is the thermal electro-magnetic radiation within or surrounding a body in thermodynamic equilibrium with its environment, emitted by a black-body (idealized opaque, non-reflective body). It is found that all black bodies at same temperature emits radiation in all frequency ranges but its intensity rapidly tends to zero at very high frequencies. The 'Ultraviolet Catastrophe' (Rayleigh-Jeans catastrophe), was the prediction of late 19th century

that an ideal black body emits more energy as the frequency increases (Error at the short wavelengths). The term was first introduced in 1911 by Paul Ehrenfest, but the concept originated with the 1900 statistical derivation of Rayleigh-Jeans law. The phrase suggests to the fact that at radiative frequencies, i.e., at the frequencies below 10^5 GHz, Rayleigh-Jeans law was predicted the experimental black curve successfully, but it begins to diverge with experimental observation at the frequencies above 10^5 GHz, i.e., the frequencies at ultraviolet region of the electro-magnetic spectrum.

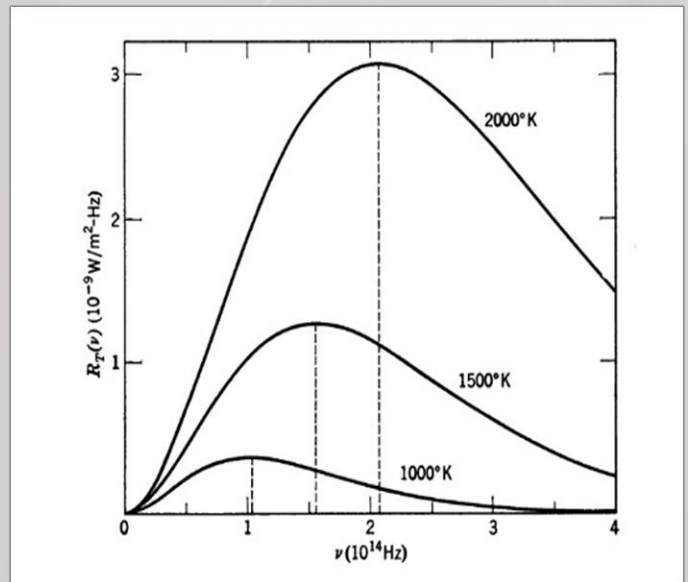


A cavity in a body by a small hole to the outside. Radiation incident on the hole is completely absorbed after successive reflections on the inner surface of the cavity. The holes absorbs like a blackbody. In the reverse process, in which radiation leaving the hole is built up of contributions emitted from the inner surface, the emits like a blackbody.

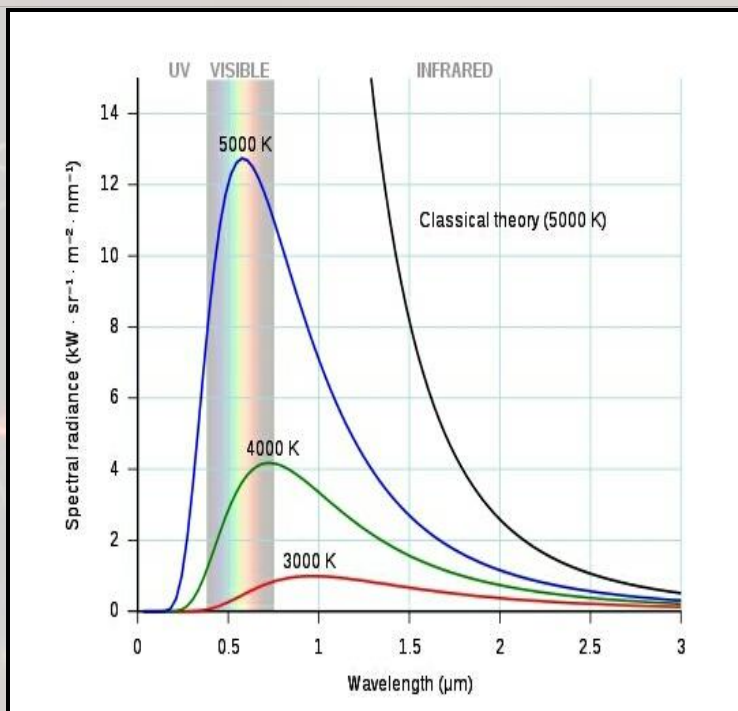
Failure of Classical Theory explaining Black Body radiation

WIEN'S LAW:

The spectral distribution of black body radiation is specified by $R(\nu)$, called spectral radiance, which is defined so that $R(\nu)d\nu$ is equal to the energy per unit time in radiation of frequency in the interval ν to $\nu+d\nu$ from an unit area of the surface at absolute temperature T . So, the total energy emitted per unit time per unit area at temperature T is defined as Radiance, $R = \sigma T^4$ (σ =Stefan's constant). But the emitted radiation is not confined to a single wavelength rather is spread over a continuous spectrum. So, how is the total energy distributed amongst the different wavelengths?



The spectral radiance of a black body radiator as a function of the frequency of radiation, shown for temperature of the radiator of 1000°K, 1500°K and 2000°K. Note that the frequency at which the maximum radiance occurs, increases linearly with increasing temperature and that the total power emitted per square meter of the radiator (area under curve) increases very rapidly with temperature. (Fig: above)

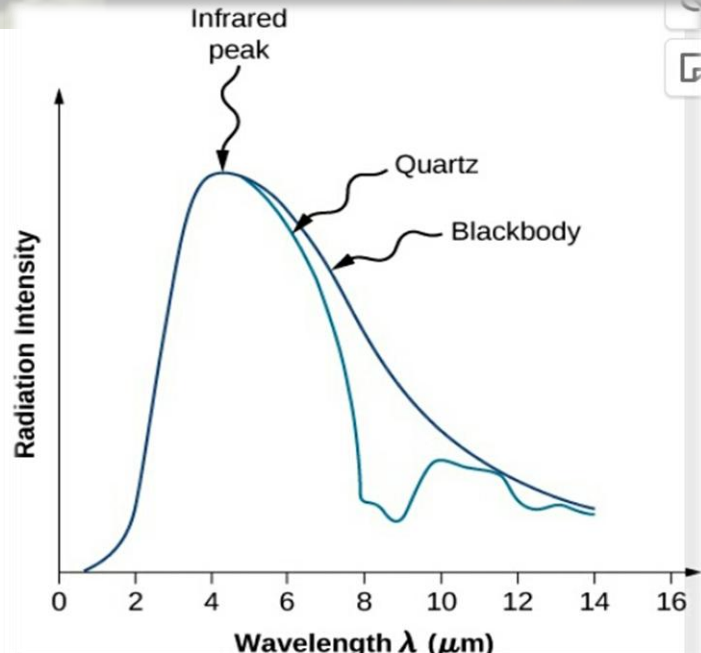
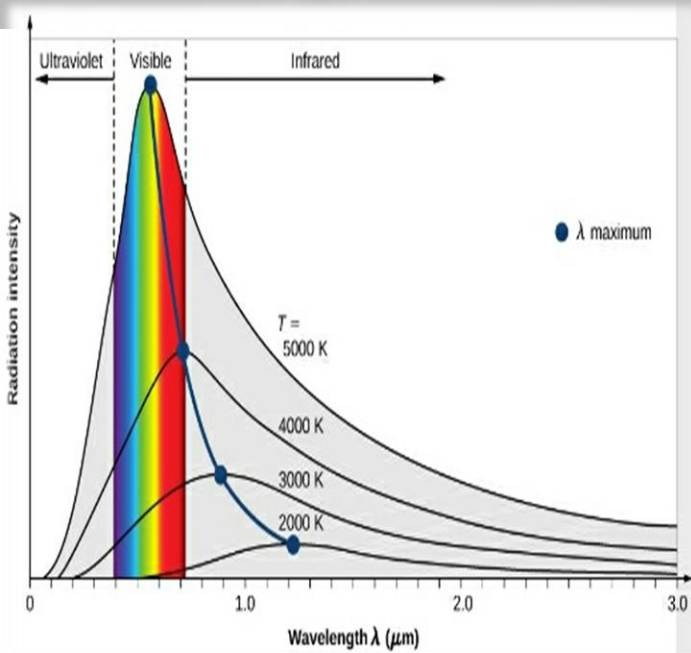


The ultraviolet catastrophe is the error at short wavelengths in the Rayleigh-Jeans law (depicted as 'classical theory' in the graph) for the energy emitted by an ideal black body. The error much more pronounced for short wavelengths, is the difference between the black curve (as classically predicted by the Rayleigh-Jeans law) and the blue curve (the measured curve as predicted by Planck's law).

In 1893, Wien showed that spectral distribution of energy emitted by a black body at temperature T , can be expressed as Wien's law of energy distribution--- $R(\nu)d\nu = (A\nu^5/c^5)e^{-a\nu/cT}(c/\nu^2)d\nu$, where, A , a =constant.

Wien also showed that if radiation of a particular wavelength at a certain temperature is adiabatically changed to another wavelength, then the temperature will change in the inverse ratio, i.e., $\lambda mT = \text{Constant} = 0.2898$ centimeter-degree Kelvin (Wien's displacement law). Thus R vanishes for $\lambda=0$ or $\lambda=\infty$. But it also makes R finite for $T=\infty$ which contradicts T^4 law of Stefan.

Wien's law of the shift of the radiative power maximum to higher frequencies as the temperature is raised expresses in a quantitative form commonplace observations. Warm objects emit infrared radiation, which is felt by the skin, near $T=950\text{K}$ a dull red glow can be observed; and the color brightens to orange and yellow as the temperature is raised. Tungsten filament of a light bulb is $T=2,500\text{K}$ hot and emits bright light, yet the peak of its spectrum at this temperature is still in the infrared, according to Wien's law. The peak shifts to visible yellow when the temperature is $T=6,000\text{K}$, like that of the sun's surface.



The intensity of blackbody radiation vs the wavelength of the emitted radiation. Each curve corresponds to a different blackbody temperature, starting with a low temperature to a high temperature

The spectrum of radiation emitted from a quartz surface (blue curve) and the black body radiation curve (black curve) at 600K

RAYLEIGH-JEANS LAW:

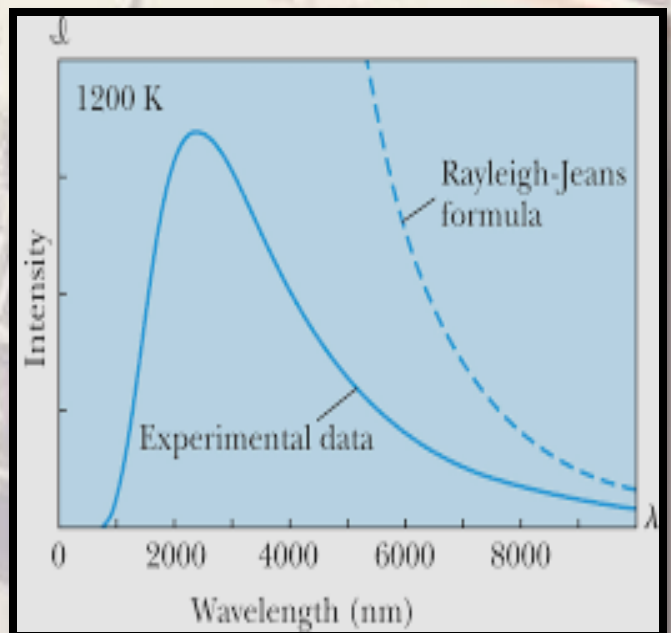
After the failure of Wien's radiation law to account for the experimental results at longer wavelengths, Rayleigh and Jeans made a calculation of the energy density of cavity radiation and introduced a relation, $R(\nu)d\nu = (8\pi^2KT/c^3)\nu^2d\nu$ of spectral distribution of energy. Rayleigh-Jeans formula contains everything that classical physics can say about the spectrum of the black body radiation. As the frequency ν increases towards the ultraviolet end of the spectrum, this formula predicts that the energy density

should increase as ν^2 . In the limit of low frequency the classical spectrum approaches the experimental results but as the frequency becomes large the theoretical prediction goes to infinity! In reality, the energy density falls to 0 as $\nu \rightarrow 0$. The grossly unrealistic behavior of the prediction of classical physics at high frequencies, is known as "Ultraviolet Catastrophe". This term is suggestive of the importance of the failure of classical theory.

:PREDICTION OF ULTRAVIOLET CATASTROPHE:

- 1. All objects should radiate extreme amounts of ultraviolet light.**
- 2. As an objects get hotter its light will change from dull red to blue white.**
- 3. A black body can absorb an infinite amount of radiation if the radiation is in the uv region.**
- 4. The radiated energy approaches zero as the wavelength approaches zero.**

The Rayleigh-Jeans prediction (dashed line) compared with the experimental results (solid line) for the intensity of the blackbody cavity, showing the serious discrepancy called the 'Ultraviolet Catastrophe'.



Quantum theory of Black Body radiation

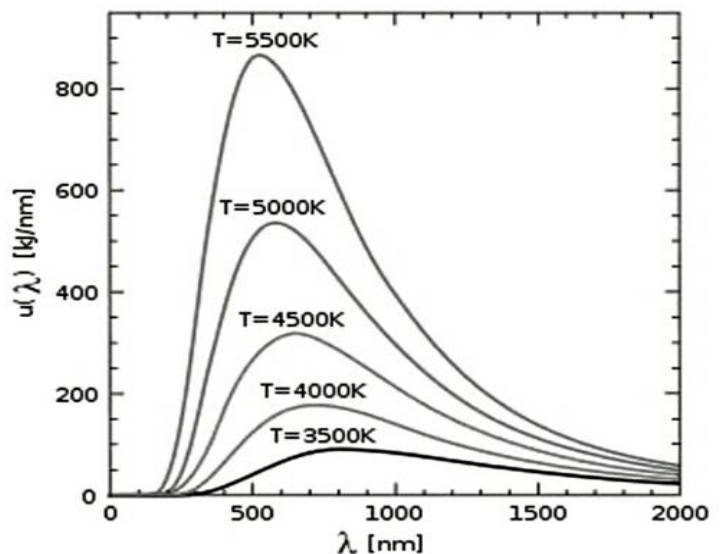
PLANCK'S LAW:

The laws of thermal radiation as deduced theoretically from the classical principle by Wien and Rayleigh-Jeans however failed to interpret the experimentally observed energy distribution amongst the different wavelengths of black radiation. Calculating the black body curve was a major challenge in theoretical physics during the late 19th century. At this critical juncture, Max Planck (in 1901) put forward his daring hypothesis of discontinuous process of exchange of energy and arrived at the most satisfactory formula (both theoretical and experimental) to solve the problem of energy distribution. By making changes to Wien's radiation law (not displacement law) consistent with thermodynamics and electromagnetism, he found the mathematical expression---

$R(\nu)d\nu = (8\pi h^3/c^3) \nu^3 d\nu / e^{(h\nu/KT)} - 1$
 $R(\lambda)d\lambda = (8\pi hc/\lambda^5) 1/e^{(hc/\lambda KT)} - 1$
which is fitting with the experimental data satisfactorily. Planck assumed that the energy E could take only the certain discrete values and these values were uniformly distributed, i.e., $E=0, \Delta E, 2\Delta E, 3\Delta E, \dots$ where ΔE is the uniform interval between successive values of energy and ($\Delta E \propto \nu$), i.e., $E=h\nu$ where h = Planck's Constant. The quantized energy modes are attenuating the spectrum at high frequencies in agreement with experimental observation and resolving the catastrophe. The Classical Electromagnetism will be superseded by Quantum Electrodynamics by introducing the concept of Quanta (called Photons).

N.B=> The black body cavity was thought of as containing of a gas of photons.

Planck's energy density of black body radiation at various temperatures as a function of wavelength. Notice that the wavelength at which the curve is maximum decreases as the temperature increases.



The traditional spectrum curve of the blackbody radiation.

UV Catastrophe!

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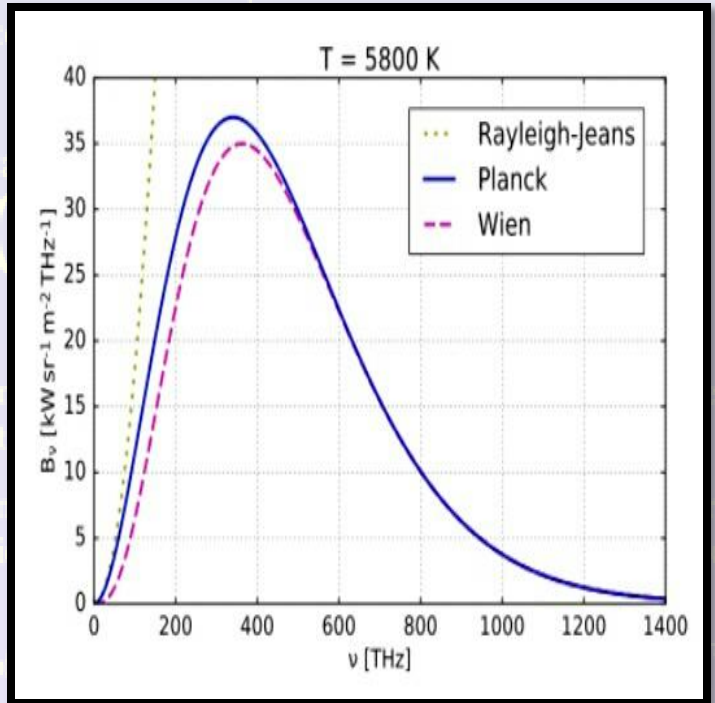
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10. [fig: libretexts.com](http://fig.libretexts.com)

which matches observed data.

No catastrophe!

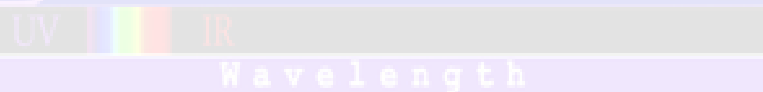


Difference between classical laws(Wien's law & Rayleigh-Jeans law) and quantum law(Planck's law) of Blackbody radiation with showing the discrepancy "Ultraviolet Catastrophe".

He has saved us from the ultraviolet catastrophe!
He amazed us with his plan to quantize the energy.
He has saved us from the ultraviolet catastrophe.
Playin' violin with Einstein in pre-war Germany.
Nobel Prize for Physics
in a state of constant hardcore!
Six point six two six times ten to negative thirty-four!

$$h = 6.626 \times 10^{-34} \text{ J}\cdot\text{s}$$

Saved us from catastrophe!



GAGANYAAN

A DREAM TO EXPLORE THE SKY

Rupsa Kar, Mohima Chatterjee, Sem 6

Gaganyaan is an Indian crewed orbital spacecraft intended to be the formative spacecraft of the Indian Human Spaceflight Programme.

It was initially envisaged that the Rs 10,000 crore Gaganyaan mission aims to send a three-member crew to space for five to seven days by 2022 when India completes 75 years of independence. “First unmanned mission is planned in December 2021” Budget space allocation is Rs 13,949 crore.

“As a part of the Gaganyaan mission activities, *four Indian astronauts* are being trained on Generic Space Flight aspects in Russia. The first unmanned launch is slated for December 2021,”



Gaganyaan launch

Vyommitra is a female-looking spacefaring humanoid robot being developed by the Indian Space Research Organisation to function on-board the Gaganyaan, a crewed orbital spacecraft. *Vyommitra* was first unveiled on 22 January 2020 at the Human Spaceflight and Exploration symposium in Bengaluru.



ISRO plans to send a human into space for the first time by 2022. It is racing against time to develop a crew module and rocket systems that will ensure the safe travel and return of the Indian astronaut. Other countries that have successfully launched humans into space did so after having used animals for conducting tests of their rockets and crew recovery systems, while ISRO will use the humanoid to test the efficacy of its GSLV Mk III rocket to transport a human to space and back.

Gaganyaan Impact

The success of Gaganyaan can lead to many more experiments with spaceflight missions. It will also give a fillip to India's dream of setting up its own space station.

Gaganyaan Spacecraft & Launch Vehicle

The spacecraft consists of a service module and a crew module, collectively known as the Orbital Module. The launch vehicle used for this mission will be the Geosynchronous Satellite Launch Vehicle GSLV Mk III. GSLV Mk III has the required payload capacity for the mission.

Gaganyaan Human Space Flight

The human spaceflight is expected to take about 16 minutes to reach the intended low earth orbit.

1. The three astronauts will leave for space in the crew module, which would have a 3.7 m diameter and a height of 7 m.
2. The astronauts' orange space suits were created by the Vikram Sarabhai Space Centre, Thiruvananthapuram.
3. The suit can hold one oxygen cylinder which will permit the astronauts to breathe in space for an hour.
4. The manned mission will rotate around the earth every 90 minutes.
5. The astronauts will be able to see sunrise and sunset, see India from space every 24 hours, and will also perform experiments on microgravity.
6. The spacecraft will take about 36 hours for the return journey and will land in the Arabian Sea off the Gujarat coast.
7. In order to take this mission to fruition, ISRO has worked on crucial technologies such as crew escape system, re-entry mission capability, thermal protection system, crew module configuration, deceleration and flotation system, and subsystems of life support systems.

Training for the astronauts

ISRO has signed a contract with a subsidiary of ROSCOSMOS (the Russian space agency), called Gavkosmos for preparing the Indian astronauts selected for the mission.

The four selected astronauts are undergoing medical and physical training, apart from learning the Russian language, which is considered one of the important languages of space communication.

The astronaut candidates will also be trained in simulations in a centrifuge and in a hyperbaric chamber (pressurized room) to prepare them for conditions like G-force, hypoxia and pressure drops during spaceflight.

The training would be tough since they have to get acclimatized to gravitational changes that will cause physiological changes.

Changing gravity can cause fluctuations in the blood pressure particularly during re-entry to earth or landing, and can even cause unconsciousness sometimes. Astronauts may also face motion sickness while experiencing weightlessness in space.

The training in Russia will be for a year after which the astronauts will receive module-specific training in India.

All the candidate astronauts are pilots from the Indian Air Force. They were shortlisted from about 25 pilots by the Air Force.



The rocket **GSLV-MK-III** will lift off from **Sriharikota** with an orbital module comprising crew and service module. It will carry three Gagannauts. Orbital module will reach to the low Earth orbit at an altitude of 300-400 km space within 16 minutes. For a week, Gagannauts will stay there and conduct micro-gravity and other important scientific experiments.

During the return journey, the orbital module will reorient itself with respect to Earth. Service and crew module will get separated at the height of 120 km and both will fall towards Earth. The speed of the crew module will be reduced by applying aerobrake. Just before splashdown in **Arabian sea**, parachute will open and crew module will fall safely.

If trouble happens in splashdown in Arabian sea, **Bay of Bengal** may be chosen as alternative.



LIST OF FLIGHTS Development timeline of GAGANYAAN

Flight	Date	Regime	Crew	Notes	Outcome
Re-entry Test	18 December 2014	Sub-orbital	N/A	Sub-orbital test of scaled down Boilerplate Gaganyaan capsule, launched aboard the sub-orbital first test flight of ISRO's GSLV Mark III rocket.	Success
Pad Abort Test	5 July 2018	Atmospheric	N/A	4-minute test of Gaganyaan's Launch abort system from launch pad at Satish Dhawan Space Centre.	Success
Gaganyaan 1	December 2021	LEO	N/A	First orbital test flight of Gaganyaan capsule.	Planned
Gaganyaan 2	2022	LEO	N/A	Second orbital test flight of Gaganyaan capsule.	Planned
Gaganyaan 3	2023	LEO	TBA TBA TBA	First crewed flight of Gaganyaan, will carry 1-3 Indian astronauts on a short orbital test flight.	Planned

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UNIQUENESS OF THE SOLUTION OF MAXWELL'S EQUATION

Sema Karmakar, VIth Sem

We can write down Maxwell's equation for a particular charge density ρ and current density \vec{J} as,

1. $\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon_0}$
2. $\vec{\nabla} \cdot \vec{B} = 0$
3. $\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$
4. $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J} + \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t} = \frac{1}{c^2 \epsilon_0} \vec{J} + \frac{1}{c^2} \frac{\partial \vec{E}}{\partial t}$

The solution of Maxwell's Equation gives the value of electric field $\vec{E}(\vec{x}, t)$ and magnetic field $\vec{B}(\vec{x}, t)$. Now, if we look at the above equations we get 8 equation with 6 variables and mathematically we can say that we get an over-deterministic case here, *i.e.* the solution of Maxwell's equation will no longer remain unique. From the glance of physics, we can claim that for a particular charge and current density we can not have multi-value of field and the crucial question is what is going here?

To solve the problem, let's focus on field equation, there is actually six equations with six variables. But we can choose the solution as,

$$\begin{aligned}\vec{E}' &= \vec{E} + \vec{\nabla} \phi_E \\ \vec{B}' &= \vec{B} + \vec{\nabla} \phi_B\end{aligned}$$

They also satisfy the curl equation. Here ϕ_E and ϕ_B are scalar function of position only.

Let the boundary condition for solving Maxwell's equation is satisfied on boundary surface S of a volume V . Boundary condition is satisfied on surface S for all t as,

$$1. \vec{E}(\vec{x}, t) \Big|_{\vec{x} \in S} = \vec{E}'(\vec{x}, t) \Big|_{\vec{x} \in S}$$

$$2. \vec{B}(\vec{x}, t) \Big|_{\vec{x} \in S} = \vec{B}'(\vec{x}, t) \Big|_{\vec{x} \in S}$$

$$\implies \vec{\nabla} \phi_E \Big|_S = 0 \text{ and } \vec{\nabla} \phi_B \Big|_S = 0$$

Now, in another region except boundary we have to prove that $\vec{\nabla} \phi_E$ and $\vec{\nabla} \phi_B = 0$. Then only the solution would be unique.

Now, from the source equation,

$$\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon_0} = \vec{\nabla} \cdot \vec{E}'$$

$$\text{or, } \vec{\nabla} \cdot \vec{E} + \nabla^2 \phi_E = \frac{\rho}{\epsilon_0}$$

$$\implies \nabla^2 \phi_E = 0 \left[\text{for all points in } V \right]$$

Similarly, $\nabla^2 \phi_B = 0$.

So, source equation restrict us for the choice of ϕ_E and ϕ_B . We will have to choose ϕ_E and ϕ_B such that $\nabla^2 \phi_E$ and $\nabla^2 \phi_B = 0$.

$$\begin{aligned}\text{Now, } \vec{\nabla} \cdot (\phi_E \vec{\nabla} \phi_E) &= \left| \vec{\nabla} \phi_E \right|^2 + \phi_E \nabla^2 \phi_E \\ &= \left| \vec{\nabla} \phi_E \right|^2 \left[\text{since, } \nabla^2 \phi_E \text{ is zero for all } \vec{x} \in V \right]\end{aligned}$$

From the concept of Gauss divergence theorem, we can write,

$$\int_V \vec{\nabla} \cdot (\phi_E \vec{\nabla} \phi_E) d^3x = \oint \phi_E \vec{\nabla} \phi_E d^2S = 0$$

$$\left[\text{since, } \vec{\nabla} \phi_E \Big|_S = 0 \right]$$

$$\text{So, } \int_V \vec{\nabla} \cdot (\phi_E \vec{\nabla} \phi_E) d^3x = 0 = \int_V \left| \vec{\nabla} \phi_E \right|^2 d^3x$$

Now, $\left| \vec{\nabla} \phi_E \right|^2$ is strictly positive and the above equation gives us zero implies that $\left| \vec{\nabla} \phi_E \right|^2$ is zero for all points belongs to V .

$$\text{Similarly, } \left| \vec{\nabla} \phi_B \right|^2 = 0 \left[\text{for all } \vec{x} \in V \right].$$

So, Fields are unique for a particular region with a specific value of charge and current density.

Reference:

Classical Electrodynamics by John David Jackson

BLACK HOLE THERMODYNAMICS

TANIYA SIKDAR.6TH SEMESTER

INTRODUCTION

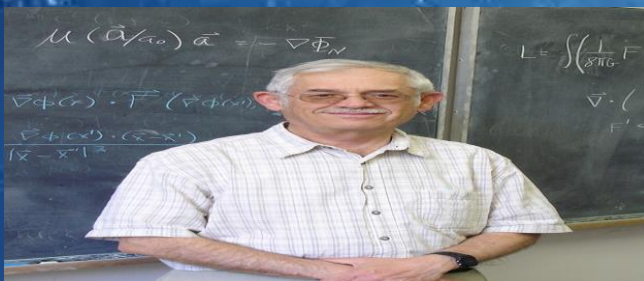


Black hole thermodynamics is the area of study that seeks to reconcile the laws of thermodynamics with the existence of black hole event horizons.

Pressure caused by nuclear fusion in the star stabilizes it against gravitational collapse, all nuclear fuel is used up. Massive stars with masses in the range 2 to 3 solar masses, end their lives by supernova explosion and the remnants become black holes.

The second law of thermodynamics requires that black holes have entropy otherwise it would be possible to violate the second law by throwing a mass into the black hole. The increase of entropy of the black hole more than compensates the decrease of entropy carried by the object that was swallowed.

NO HAIR THEOREM

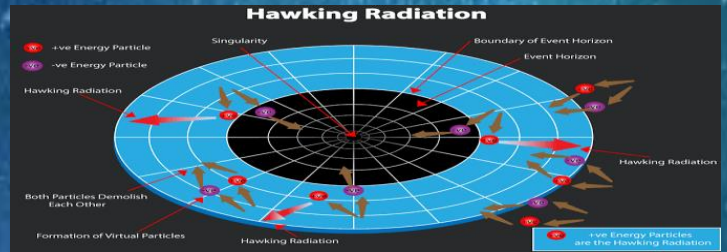


In 1972, Jacob Bekenstein conjectured that black holes should have entropy, he also proposed "NO HAIR THEOREM"---- "All black hole solutions of the Einstein-Maxwell equations of gravitation and electromagnetism in general relativity can be completely characterised by only three externally observable classical parameters----mass, electric charge and angular momentum".

In 1973, Bekenstein suggested $\frac{\ln 2}{8\pi} \approx 0.0273$ as the constant of proportionality.

$S_{BH} = \frac{k_B A}{4l_p^2}$, where A is the area of the event horizon, k_B is the Boltzmann constant and $l_p = \sqrt{G \hbar / c^3}$ is the Planck length.

HAWKING RADIATION



Hawking predicted that a radiation similar to black body radiation is released by black holes because of quantum effects near the black hole event horizon.

In 1974, Stephen Hawking showed that black holes emit thermal radiation corresponding to a certain temperature (Hawking temperature). He confirmed Bekenstein's conjecture and fixed the constant of proportionality at $\frac{1}{4}$.

ANALOGY OF BLACK-HOLE MECHANICS WITH CLASSICAL THERMODYNAMICS

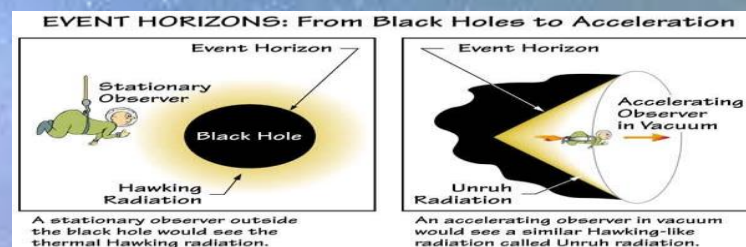
The four laws of black hole mechanics are based on the physical properties of black holes which are believed to be satisfied by them and are analogous to the laws of thermodynamics. These laws were discovered by Bekenstein, Carter and Bardeen. But Stephen Hawking made further considerations.

Zeroth Law

BLACK HOLES	CLASSICAL THERMODYNAMICS
For a non-rotating black hole, the event horizon has constant surface gravity k .	For a system in thermal equilibrium, that system has constant temperature T .

Analogous to Unruh Effect Hawking, showed that black holes emit *Hawking Radiation* at a temperature T_H , given by $T_H = \frac{\hbar k}{2\pi c}$.

Unruh Effect



The Unruh Effect is the hypothetical prediction that an accelerating observer will observe a thermal bath, like blackbody radiation, whereas an inertial observer would observe none.

First Law



<i>BLACK HOLES</i>	<i>CLASSICAL THERMODYNAMICS</i>
$dM = \frac{k}{8\pi G} dA + \Omega dj$ Relates the change in mass to the change in surface area and change in angular momentum.	$dE = T dS - P dV$ Relates the change in energy to the change in entropy.

Since $T_H = \frac{k}{2\pi}$ and $S_{BH} = \frac{A}{4}$,

$$(k/8\pi) dA = (2\pi T_H)(1/8\pi)(4 dS_{BH}) = T_H dS_{BH}$$

i.e. the first term is just the product of the black hole temperature and its change of entropy.

Second Law



<i>BLACK HOLES</i>	<i>CLASSICAL THERMODYNAMICS</i>
The surface area of a black hole is non-decreasing, $dA \geq 0$	The entropy of an isolated system is non-decreasing, $dS \geq 0$

Initially, this law was $\frac{dA}{dt} \geq 0$,

but it was superseded by Hawking's discovery that black holes radiate, which causes both the black hole's mass and the area of its horizon to decrease over time.

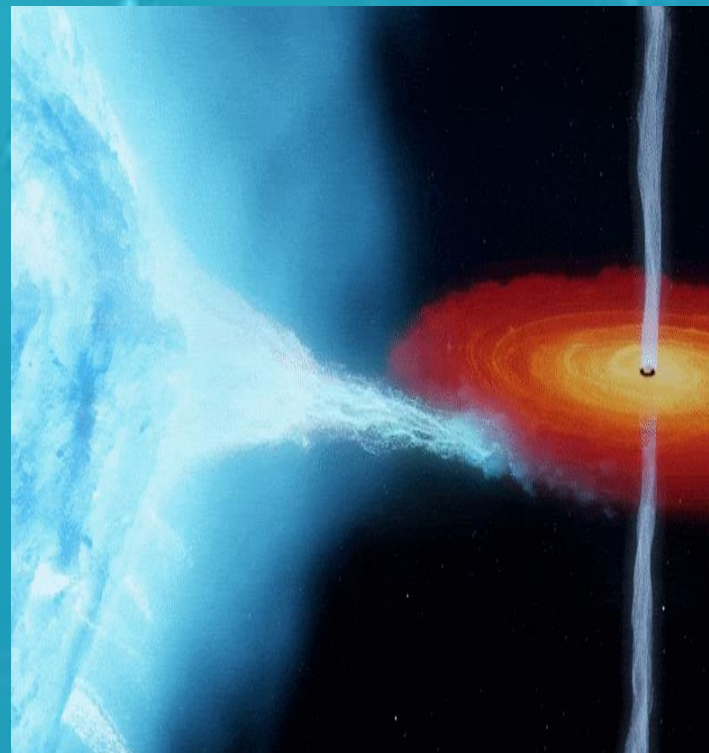
Now it's introduced as,

Total entropy = black hole entropy + outside entropy
 Or, $d(S_{BH} + S_{matter}) \geq 0$

Third Law



<i>BLACK HOLES</i>	<i>CLASSICAL THERMODYNAMICS</i>
Extremal black holes (those with vanishing surface gravity $k=0$) have the minimum surface area.	A system at absolute zero ($T=0$) has the minimum entropy.



Sources:

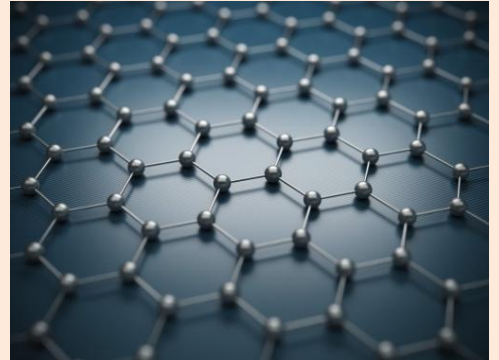
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An introduction to Graphene , a new nanocarbon

Nirupama Mitra, Indrani Ghosh, Mohima Chatterjee,
Taniya Sikdar, Bidisha Bag, Dewannshi Podder

Semester-VI

Graphene is a single layer of sp^2 bonded carbon atoms arranged in the form a two dimensional (2D) honeycomb lattice structure. Graphene is just a one atomic layer of graphite which is one of the naturally occurring allotrope of carbon. Graphene shows extraordinary thermal, electrical and mechanical properties and have become an interesting topic for research to explore it's properties and bring it into various applications.



Properties of graphene

Electrical properties: Graphene has a very high electrical conductivity due to it's remarkable electrical mobility. At room temperature the electron mobility is very high ($\sim 15,000 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$) compared to that in silicon ($\sim 1400 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$). Though it's not a metal it has very low resistivity ($\sim 1.0 \mu\Omega \text{ cm}$), which is much low in comparison to that of copper.

Mechanical properties: In graphene each carbon (C) atoms is connected to three adjacent C atoms by σ bonds. Graphene has a vey stable structure and the length of the C - C covalent bonds in graphene is only 0.142 nm which makes connection between each atom very strong. Breaking strength of graphene is very large ($\sim 40 \text{ N m}^{-1}$) which makes it stronger than diamond.

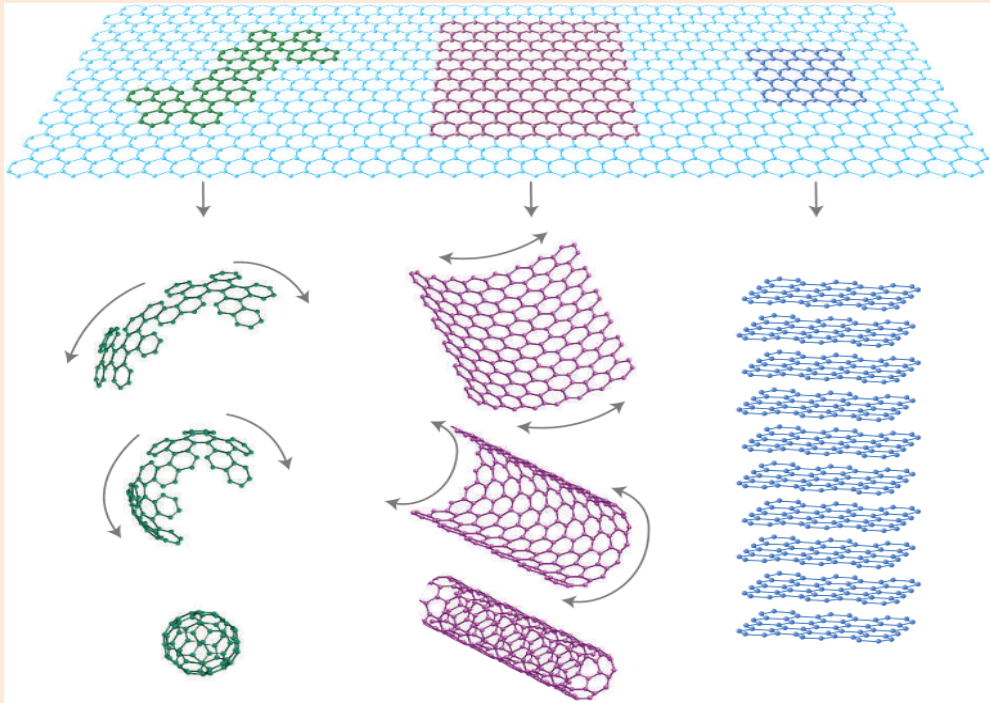
Optical properties: Depending on the number of the layers of graphene stacked together its optical properties changes. Each layer of graphene transmits 97.7% of light which is made to pass through it *i.e.* 2.3% of light is absorbed by each layer. Therefore in case of 2 layers stacked together the transmittance is around 95.4% of light and which shows that the transmittance decreases with layer number.

Thermal properties: Graphene has very high thermal conductivity which is about $\sim 4000 \text{ W m}^{-1} \text{ K}^{-1}$. For a suspended single layer graphene its thermal conductivity may change from 1500 to $2500 \text{ W m}^{-1} \text{ K}^{-1}$.

Synthesis techniques

- Exfoliation techniques which include using sonication, adhesive tape, electrochemical synthesis.
- Synthesis using chemical vapor deposition
- Electrochemical synthesis
- Epitaxial graphene growth on silicon carbide
- Laser induced production

Different forms of graphene



Graphene is a 2D building material for carbon materials of all other dimensionalities. It can be wrapped up into 0D Bucky balls, rolled into 1D nanotubes or stacked into 3D graphite (bulk).

Applications of graphene

- Due to graphene's unique properties, it can have ground breaking biomedical applications such as easy self testing kit, targeted drug delivery in the body, modern implants etc.
- Because of its high strength, light weight, flexibility and conductivity it can be used for coating purposes
- Generating next generation electronics for more modern electronic gadgets.
- Energy storage devices
- Ultra sensitive sensors

Conclusion

Nanomaterials have become an interesting topic of research in field of Interdisciplinary Sciences because of its exciting and peculiar behavior from its bulk forms. Among them graphene is one of most studied nanomaterial due its outstanding features. Studies are still going on for producing high quality large sized.

graphene layers and to have a detail information of its properties at different conditions and different forms. Graphene thus can offer a huge area of applications and therefore it holds a great potential for research in future.

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Time Travel

Theories, possibilities and paradoxes

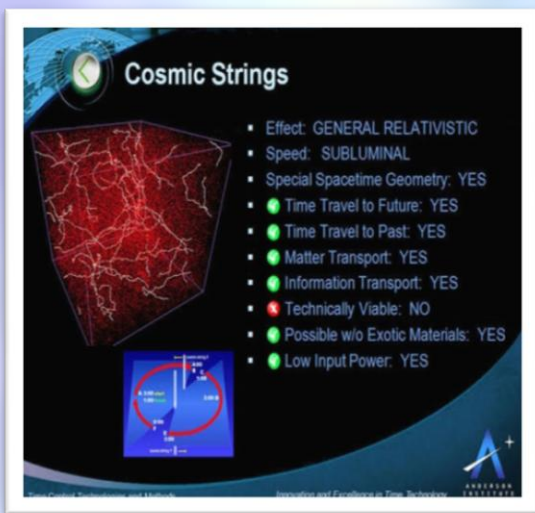
Debarati Maity, IVth Sem

Moving between different points in time is what we say as time travel. While most of the people think time to be a constant, but actually it is an illusion, which varies for different observers. Einstein's special theory of relativity says that time slows down or speeds up depending on how fast we move relative to certain things. General relativity provides scenarios that could allow travellers to go back and forth in time, but the equations are difficult to achieve physically, while some groups have proposed alternate solutions like to jump in Tipler cylinders, Alcubierre wrap drive, black holes, traversable wormholes or cosmic strings.

Talking of the idea of time and time travel a number of contradictions (logical or apparent) appears and the concepts of time travel paradoxes come into light.

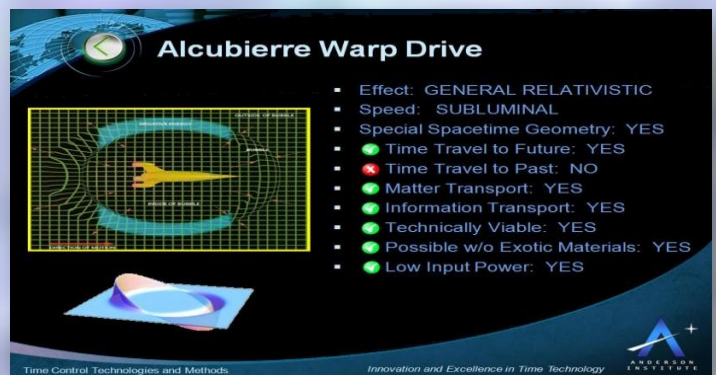
Possibilities for time travel

1. Cosmic Strings :



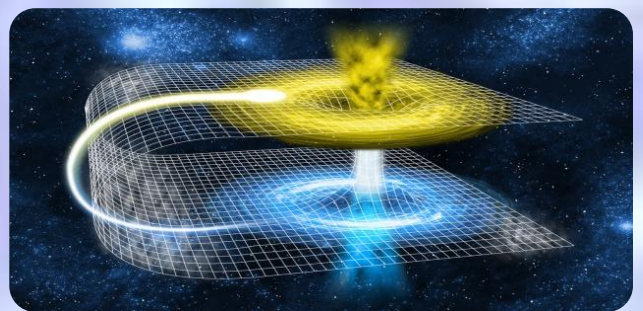
These are a kind of texture for the universe which carry huge amount of energy within them. According to the theory of special relativity, the fabric of space time can be warped that could give us a shortcut for superluminal speeds. Stretching the strings to such unfathomable size places them under lot of tension, for which they accelerate very close to space-time, warping it around into the shape of a cone. This gives rise to the gravitational lensing. With gravitational lensing, light from an object can take more than one path. If two cosmic strings approached and passed each other, the warping would be so great that a person moving around could take the shorter path travelling faster than the light and thus going back in time.

2. Alcubierre Wrap Drive

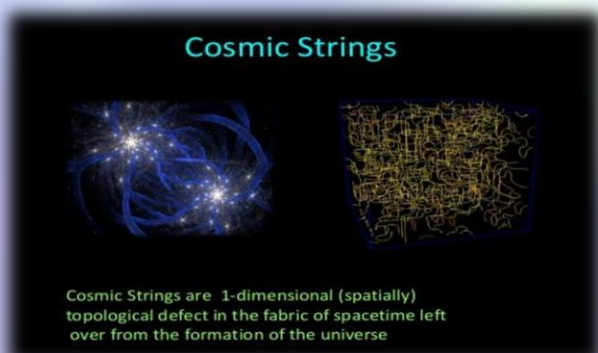


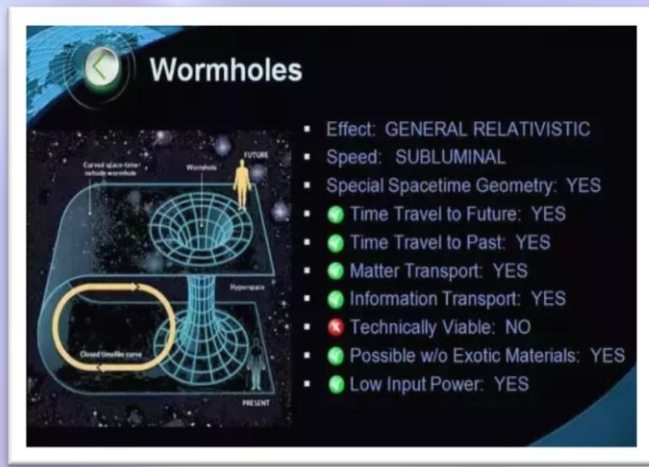
An Alcubierre wrap drive stretches space-time in a wave causing the fabric of space ahead of a spacecraft to contract and the space behind it to expand. The ship can ride the wave to accelerate to high speeds and time travel. It suggests only time travel to the future is possible not in the past.

3. Wormholes



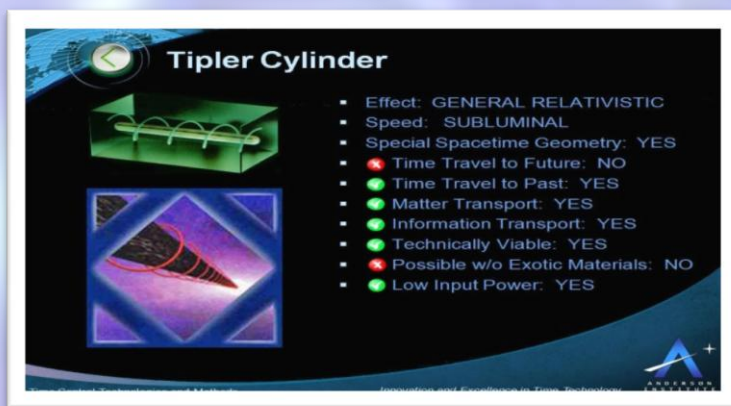
Travelling through time may be possible by travelling through a wormhole, the bipolar blackholes that link different regions of the universe. Wormholes are a hypothetical areas of warped spacetime with great energy that can create tunnels through spacetime. It is, however a purely theoretical model.





4. Triple Cylinder

A Triple Cylinder is a hypothetical object theorized to be a potential mode of time travel. It uses a massive and infinitely long cylinder spinning around its longitudinal axis. The rotation creates a frame dragging effect and the fields of closes time-like curves traversable in a way to achieve subluminal time travel to past. The frame dragging effects warps space time in such a way that the light cones of objects in the cylinder's proximity become tilted, so that the part of the light cone then points backwards along the time axis on a space time diagram. Therefore a spacecraft accelerating sufficiently in the appropriate direction can travel backwards through the time along a closed time like curve.



Time travel paradoxes

Besides the physical problems, time travel come with some unique, confusing and apparent contradicting situations called as paradoxes.

Few paradoxes are :

- A] Grandfather paradox
- B] Polchinski's paradox
- C] Bootstrap paradox
- D] Predestination paradox

A] **Grandfather paradox** : It says that if a traveler travels into the past and kills his grandparents then it would make their own birth impossible.

B] **Polchinski paradox** : It's just an another version of grandfather paradox where, a billiard ball is sent back into the past through wormhole in such a way as to collide with its former self, knocking it off course and preventing it from ever entering the wormhole in the first place.

C] **Bootstrap paradox**: It's a theoretical paradox of time travel that occurs when an object or piece of information is sent back in time becomes trapped within a infinite cause effect loop in which the time no longer has a discernible point of origin and is said to be uncaused or self created.

D] **Predestination paradox**: In this, a time loop in which a traveler has gone into the past causes an event that will encourage the original future version of the person to go back into the past.

Conclusion

If time travel is possible the visitors would have to be simply a passive observer, i.e., they can witness or participate in history but they cannot change any event ever.

If they (time traveler) aren't passive then they might loose their origin and can alter their actual time line. And it may result in the collision of two or more time lines or may cause collision of parallel universes.

In my opinion these paradoxes constitutes a proof that the time travel is utterly impossible but at the same time we can't certainly say it to be unreal.

RESOURCES:

- (a)Wikipedia
- (b)www.andersoninstitution.com
- (c)www.nasa.gov

THE MANHATTAN PROJECT

NAYEMA KHATUN, IVth Semester



What is the Manhattan project??

Physics is a subject which is too much related to our daily life by its laws and theorems. Though the discoveries related to physics are very much helpful to our daily life we can't ignore the bad impacts of it. The first thing that comes to our mind is the Manhattan project. Manhattan project is related to the formation of the first nuclear Weapon by United States. The project started on 13th August, 1942 under the direction of the Major General Leslie Groves. It was the largest and top-secret project. Research and production of atom bomb took place at more than thirty sites across the United States, among them the most important sites were Berkeley, Hanford, Chicago, Detroit, Columbia University, Los Alamos etc. Finally the first atom bomb was formed at the Los Alamos center. More than hundreds of scientists from all over the world participated in the project. The Manhattan project was filled with too much rules and regulations and all the scientists were not allowed to enter every sites of the project. But only ten to fifteen physicists were allowed to move every corner of the project and to collect information about the project.

The physicists who got special permission were Neumann, Szilard, Robinowitch, Feynman, Bethe, Frank, Weisskopf, Fermi, Chadwick, Bohr along with the head of the project physicist Oppenheimer. Finally the largest Manhattan project finished on 1946 after the successful formation of the first nuclear Weapon.

Motive of Manhattan project

The purpose of the Manhattan project can be divided into two parts. The scientists wanted to use the huge energy that formed in nuclear chain reaction for human welfare. But the government of United States wanted to use it as a powerful weapon. Finally they fulfilled their purpose and launched the atom bomb of Uranium at Hiroshima and bomb produced from Plutonium at Nagasaki and destroyed the population completely to prove United States as a powerful state.

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The Simulation hypothesis

Riya Chowdhury , IV th sem

Is reality really real? It sounds nonsense. Surprisingly, there is a weird but cool argument named “The Simulation hypothesis” which states that reality is nothing but an illusion. The word ‘simulation’ means a representative example or model of something. As per the hypothesis we, our planet, our solar system, our universe could all be an artificial simulation or model. Was the world created by a non-physical force which we can communicate with or possibly influence with our minds? Let’s find out what the hypothesis is and it’s acceptance in the scientific world.

Origin

There is a long philosophical and scientific history to the hypothesis. This can be traced back to antiquity, e.g. the “butterfly dream” of Zhuangzi, or the Indian philosophy of “maya” (brahma satya jagat mithya).

Abiding all these, it was first theorized as a part of long philosophical argument by René Descartes and later by Hans Moravec. A famous philosopher Nick Bostrom expanded this hypothesis considering the possibilities of our reality being an illusion in the year 2011.

The Anthropic Principle Computer Codes

Earth is perfect for life. Everything such as the distance between sun and earth, the gravity on earth, compositions of gasses in atmosphere, tilt of earth are nicely fit. Now, we are searching for exo-planet having life or with lively condition, But one fact is noticeable here. It is told that if the amount of dark energy would be slightly more strong, no life could ever be formed not only in earth but also in entire universe. The anthropic principle is a collection of principle which tries to explain why the fundamental physical constants are necessary to develop conscious life. It leads us to an important question ‘why’. Why is everything so perfect? Is it made perfect to accommodate life in this simulated world? Mathematics is the language of nature. We use mathematics to understand the mysteries of our nature or universe. And the other form of mathematics is computer code. Any mathematical expressions can be converted into codes. Hence it is possible to make simulation of each and every thing present in the universe. Sadly, we have not enough technology to create consciousness. Not today, but tomorrow may be possible. Then we can also say that any advance civilization has already done it with us. We are nothing but a character of a sophisticated video game. Are we ourselves composed off binary string of 0s and 1s ?



René Descartes



Hans Moravec



Nick Bostrom

Virtual And Augmented Reality Technique

Virtual reality is actually the use of computer modeling and simulation that enables a person to interact with an artificial three-dimensional visual or other sensory environment. On the other hand, augmented reality is an enhanced version of real physical world that is achieved through the use of digital visual elements, sound or other sensory stimuli delivered via technology.

Today we are already seeing in virtual reality that full immersion is possible. Anyone who has played a convincing VR game will realize that it is possible to forget about the real world and believe the world you are seeing is real. Also, as AR technology evolves to project onto the retina without needing external glass. It means that we could be see things around us that are not really there in a resolution that’s indistinguishable from the physical world. This brings up an idea that the world ‘out there’ could really be just a projection in our minds.

VISIBLE FLAWS

If our world is a simulated world, it might have some flaws.

- (1) Sometimes, unknown person or new places are seemed to be known. It is like “Visual Pareidolia” (a tendency for perception of visual stimulus as an object, pattern or meaning known to the observer).
- (2) The supernatural things like ghosts, spirits might be result of technical glitch. According to simulation hypothesis, these flaws arises due to the bugs present in simulation cord.

IS GOD A PROGRAMMER

If our world is a simulated one, then one might have written it. But who or what? All kinds of religion confirmly says that it is god-the almighty. Well, “God” might be the programmer who creates the universe by computer codes. But why? There is no definite answer. By trigerding our imagination skill, we can say that creator wants to know how a universe works and how a civilization develops. It is also suggested that humans have an innated mental connection to the universal programmer through subconscious. It reminds me of bauliastic ‘moner manush’.

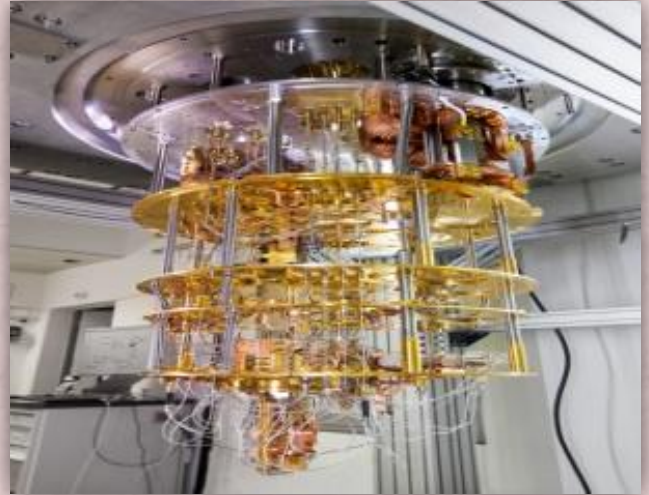
The simulation hypothesis In physics

A new branch of physics called quantum computation is actually an understanding the shift of universe from energy transformation to the information processing. Quantum evolution of a system is represented in quantum computation by a quantum circuit from quantum gates. From here, three views of universe is emerged.

- (1) Our universe is a quantum computer.
- (2) The system performing the simulation is distinct from its simulation (the universe).
- (3) Our universe is rendered on a pixerated screen for each observer.

Many physical aspects can support the hypothesis such as – No absolute frame of reference in relativity, measurement problem in quantum mechanics depends on observer, holographic principle etc.

In special theory of relativity, time dilation is actually framerate adaptation of moving object which needs more resources to render. Researchers also claims that time travel paradox, antimatter and many more have their individual interpretation in this hypothesis.



Quantum Computer

Conclusion

Today, we have enough technology that we are using even simulation. We use simulated model of planets, stars where we can not go physically. Gravity, energy, light – all are simulated there. Some history simulated games (e.g. Sid Meier’s Civilization) make us feel of being in older days. There are some simulation which are made to study the up gradation of human civilization. So, there is a high chance of creating simulation of a complex creature like human who can think off itself.

The simulation hypothesis is a thought provoking exploration of nature. Here lies another possibility. If our world is simulated, it may be possible that our creators are also simulated and this series goes on. This leads to an infinite order. Well, no one can either confirm it or deny it as no experiment is still there to say anything with accuracy.

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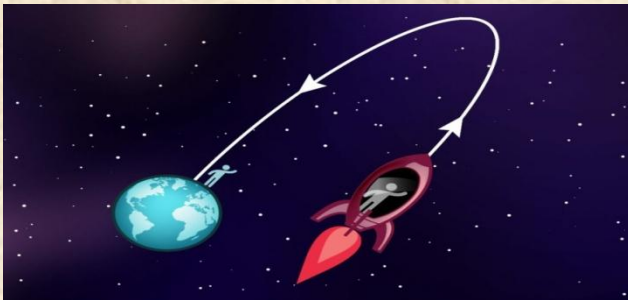
*“Reality is merely an illusion,
albeit a very persistent one.”*

---Albert Einstein

The Pseudo Paradox

Sima Dutta, Ivth Sem

Time is relative, the saying is not as famous as the saying “Time is money”. But the notion that time speeds up or slows down depending on how fast one object is travelling relative to another surely ranks as one of Albert Einstein’s most inspired insights. We are going to talk about arguably the most famous thought-experiment of relativity theory. Twin paradox, the idea completely lies in proper time. Proper time is operationally defined as the quantity measured by an ideal clock moving through space time as the passage of time itself is relative, the comparison of two clocks that travelled along different world lines, today’s clocks are based on atoms that can be in a superposition of different trajectories



Experiment

Now consider a pair of brothers, identical twins. One gets a job as an astronaut and rockets into space. The other gets a job as an astronaut too but on this occasion he decides to stay home. NASA did this experiment to find out. In March 2015, NASA astronaut Scott Kelly will join Cosmonaut Mikhail Kornienko on a one-year mission to the international space station. The interesting thing about Scott is he has a twin named Mark who is also an astronaut. While the test subject spends one year circling Earth at 17000 mp. Mark will remain behind as a control.

Results

The results from the ten research teams are summarized below.

The real power comes in combining them to form an integrated result.

Telomeres: The ends of each strand of DNA (also known as deoxyribonucleic acid; a nucleic acid in the cell’s chromosomes, containing the cell’s coded genetic instructions) have special features called telomeres.

Immunome: This study found that Scott’s body reacted appropriately to the vaccine.

Gene Expression: Samples taken before, during and after Scott’s mission in space revealed some changes in gene expression. Mark also experienced normal-range changes in gene expression on Earth, but not the same changes as Scott. Changes Scott experienced may have been associated with his lengthy stay in space.

Cognition: With few exceptions, Scott’s cognitive performance (such as mental alertness, spatial orientation, recognition of emotions) remained largely unchanged during his time in space, and relative to Mark on the ground.

Biochemical: Studying various elements in Scott found that his body mass decreased by seven percent during flight.

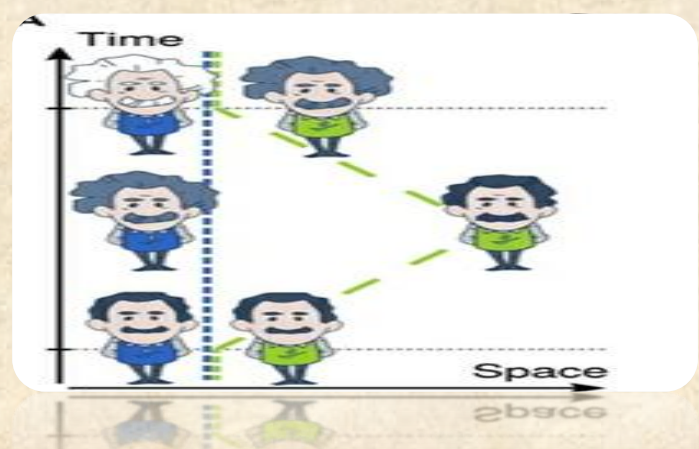
Microbiome: A highly diverse microbiome (bacteria in the gut) is generally associated with good health. Scott’s gut flora was found to be profoundly different during flight from preflight.

Proteomics: The proteomics team studied fluid shifts in the body, the structure of the eye, and proteins in urine to see if changes in protein pathways in response to fluid shifts might contribute to some astronauts’ vision problems. They found that a protein, AQP2, was elevated in Scott in space as compared to Mark on the ground. AQP2 regulates water reabsorption in the body and is a useful indicator of hydration or dehydration status.

Integrative Omics: Finally, the longitudinal integrated multi-omics analysis team examined all of the biomedical and molecular data collected from the other nine research teams to produce the single most comprehensive view of how the human body responds to spaceflight.

Data Courtesy-

NASA.gov.com
Youtube Videos



One Electron Universe :A Brief Description

Sweta Pal Majumder, IVth Sem

Conversation between great minds are always interesting. One such conversation was between two of very skilled physicists, John Wheeler proposed a hypothesis about One Electron Universe. Richard Feynman told that he received a telephone call at the graduate college at Princeton from Professor Wheeler where Wheeler told him that he knew the reason behind of all electrons having same charge and same mass. Feynman asked Wheeler, "Why?". John Wheeler replied, "Because, they are all same electron!"

Concept of One Electron Postulate

The one-electron universe postulate : "An electron and a positron are actually a single entity moving backward and forward in time." This idea is based on the principle that the *worldlines of electrons* are similar to those of positrons, with the directions in time reversed. In the fictitious four-dimensional space a curve that represents the history of a material point as it moves in time, is called a *world-line*.

"Why Does A Particle Travelling Back In time Acts Like Its Own Antiparticle?"

The answer of this question can be given from CPT-symmetry. CPT-symmetry is charge-parity-time symmetry. Charge is electronic charge of particle , it can be positive or negative. Parity is like reflecting the particle, flipping one of its space coordinates, like a mirror reflection. Generally, P-reversal reverses the 'spin'. The principle of CPT-transformation is that, if we reverse the charge, the parity, the time direction of a particle, we get the same particle. If we reverse the charge and parity of the particle (CP-transformation), we obtain a new particle. We need to reverse the time direction too and hence CP reversal and T-reversal can be considered equivalent. Now in the case of electron or positron parity reversal leaves the particle unchanged , they are symmetric under parity transformation.

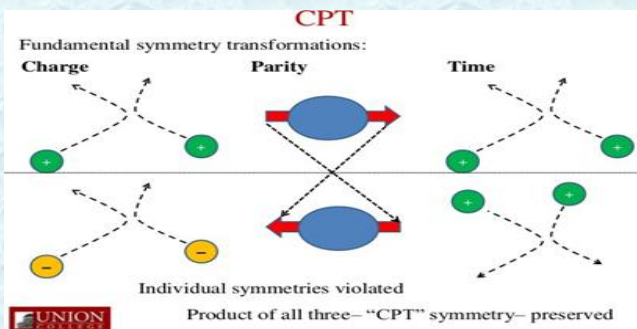


Figure 1: Depiction of the different transformation in the CPT-symmetry

So, now a CP-transformation just changed the sign of the charge of electron or positron. Thus it turns the electron into its antiparticle, i.e. positron. Hence the positron and electron differ in the direction in time they are travelling in. A T-transformation is equivalent to CP-transformation for them. Parity remains same as they are symmetric under P-reversal. This was the idea behind one-electron universe where all positrons and electrons, are the same electrons, travelling in time and space. In order to account for all the electrons in the universe, this one electron would have to move backward in time at least one time less than the number of electrons moving forward. Therefore there should be almost as many positrons in the universe as electrons, but there aren't.

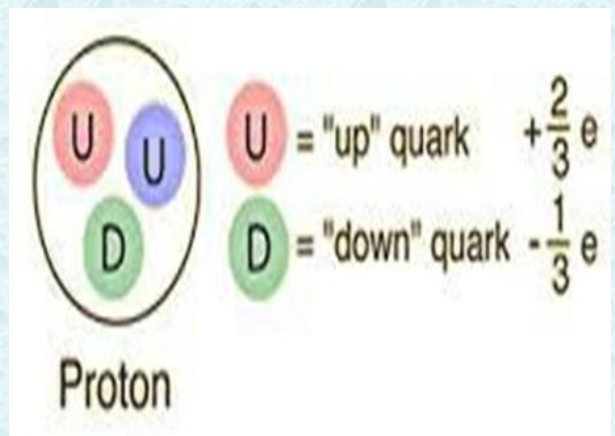


Figure 2: Quark Of Proton

Wheeler suggested that the missing positrons might be hidden within the protons. But this suggestion is inconsistent with the current theory that a proton consists of two up quarks, each with a charge of $+\frac{2}{3}$, and one down quark with a charge of $-\frac{1}{3}$. The quark theory leaves no place in the proton where a positron, with charge of $+1$, could hide. The one electron Universe idea is a classic example for the scenario that even though an idea might be wrong there might be some truth to it.

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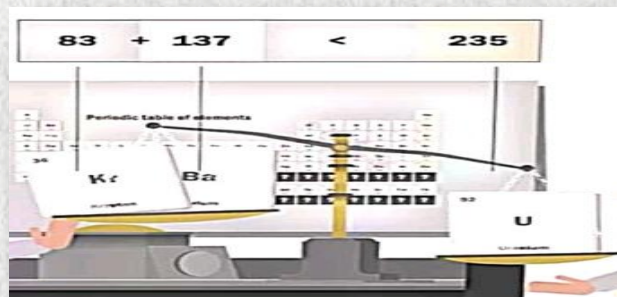
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Story Behind The Discovery Of Nuclear Fission

Ahana Dasgupta, IInd Sem

“Break an atom and you will get tremendous power”-

Atom bombs and nuclear plants are based on this idea by **Lise Meitner**. How did she make this discovery that changed human history?



Trying to explain these two mysteries, Meitner wondered : **WHAT IF THE NUCLEUS WAS LIQUID, AND NOT SOLID?** Then the neutron could hit the nucleus, elongate it and split it into two drops.



At the beginning of the twentieth century, the secrets of atoms were unravelled : first radioactivity; then the atom's nucleus , surrounded by electrons. Protons and neutrons were later found in the nucleus, thought to be a solid.

The more protons an atom had, the heavier the element was. Scientists filled the blanks in the periodic table as new elements were discovered, until they hit a limit, **URANIUM**. There was no heavier element in nature than Uranium. So scientists tried to create heavier atoms in the lab.

This was actually what **LISE MEITNER** was doing in 1938, together with **OTTO HAHN**. They made a really good team: she, a theoretical **PHYSICIST**; he, an experimental **CHEMIST**.

They bombarded Uranium atoms with neutrons, expecting two results : Either the neutron joined into the atom, producing a different and heavier element; or it would unbalance the atom, yielding another element, slightly lighter than Uranium.

And what about that disappearing mass?

Well, according to **EINSTEIN'S EQUATION**, $E= mc^2$ mass could be converted to energy. And as Meitner calculated using binding energy formula that fission would release a lot of energy.

$$E_B = a_V A - a_S A^{2/3} - a_C \frac{Z^2}{A^{1/3}} - a_A \frac{(N - Z)^2}{A} - \delta(A, Z)$$

Thus, she experimentally proved this nuclear fission that splits atoms was a powerful source of energy, the most powerful one ever.

Atomic energy became an everyday reality, for good and bad.

Thanks To These Scientists. **OTTO HAHN** Received the **NOBEL Prize** while **LISE MEITNER** joined the list of women who deserved a **NOBEL** and didn't get it.

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But the experimental results puzzled them : Hahn found none of these brand new expected elements, but two much lighter elements. Both were already well known and weighted about half of an Uranium atom. But summing them , a bit of the original Uranium atom's mass appeared to be lost.

THE CROCODILE MAN

SAYANI DAS, IInd Sem

It is surprising to think where science has reached today. A few years ago I read a story in the newspaper. Although, that is not a story at all, it is a fact. Let me summarise it and we'll see if you can believe it . The incident took place in a dense forest in the Sundarbans among some honey collectors. As they were returning home after collecting honey, the sun plunged on the western horizon creating a crimson glow. And in a few minutes it would be dark all around . This forest is not safe at all in the dark. There is the fear of tigers as well as many others besides that . On the way home, one has to cross the forest and a river. It is totally impossible to go so far in the dark. There are three men in the team. Karim, Akbar and Raibul. Everyone's face becomes pale in fear and panic. Their eyes wander around looking for a shelter. Suddenly Karim's eye caught a glimpse of something. He points his finger through the gaps between the trees, "Hey! Look...isn't that a house?" Everyone looks at the pointed direction, it's really a house. When they went closer, they realized that the house is very old. The house is broken in so many places.

Ignoring all that, they went into the house together. It was completely dark inside, one couldn't see anything. Raibul then wraps a towel around a branch of a tree he had already picked and makes some sort of a torch and it lights up the inside of the house. Some tools were scattered around there, all of which were unfamiliar to them . They also saw some pots filled with colourful liquids. Without bothering about what these things were, how this house came to be in this dense forest or who owned it, the three friends left the torch in a corner and fell asleep on the floor. It was quite late then. Suddenly a squeaky sound woke them up. The torch was burning brightly. They saw in that light that the door was slightly opened and a huge reptile was coming into the house through it. It was easy to discern it is a crocodile. They have never seen such a huge crocodile in their life.

The three men sit huddled in a corner. However, the crocodile does not attack them. It wandered around the room for a while and went out the way it had came in. After that, none of them could sleep well for the rest of the night.



As soon as it was morning, they left the house and reached home safely. Within a few days, the story of their amazing experience reached the city. About a week later, some high ranking people from the city went to the house again in the forest. There, they found an old man doing something. He smiled when he heard about three honey collectors' strange experience. In reply, he told a bizarre story. The old man said that he was a scientist. He was engaged in a secret research work in that forest, during the course of which he discovered a drug. With the help of that drug, which can induce genetic mutation, a human can become a crocodile of her own size. His research was completed few days ago. At first he applied the drug on himself. The crocodile that the honey collector team saw that night was the crocodile version of the scientist, Dr. Anilesh Sen.

ALL ABOUT A TIME MECHINE

Tanusri Santra, IInd Sem



Ashish had a craze for cricket. He played cricket with his friends the whole day. He loved his grandfather very much, who was a scientist and an inventor. But he was no more.

One day, Ashish was playing cricket and the ball went into his grandfather's room. He tried to find it, but while he was looking for it, he got hold of a box and a rolled paper. He decided to hide them from others. So, he kept it under his bed. That night, he unrolled the paper and realized that the box was a time machine!



He tried to operate it, but he pressed some button by mistake while fiddling with it and ended up in a place that seemed to be a forest. It echoed with the screeches of what had to be dinosaurs, so he realized that it was the Jurassic Age. As he got terribly scared, he opened the box again.

Photo courtesy: Internet

This time, he ended up travelling to the Mughal Age and met someone who he could recognize as one of his ancestors, since he found he resembled him. But at that moment, his box was stolen by a pick-pocket. His heart stopped in shock. He lost all hope of ever going back to his own time. He went to his ancestor for help, but he wouldn't believe him at first. Ho, he finally convinced him, not without many attempts at explanation.



Thankfully, he had an intuition who the thief could be. They went to the emperor who told his administration to do whatever was necessary to find him. Eventually, the soldiers caught with the box. Ashish saw a glimpse of hope at last. He had now got the box back and, expressing his heartiest gratitude to his ancestor and the emperor, he returned to his own time. And when he did, he realized that no more than one minute had passed while he was cavorting through eons. Even to this moment, he feels he's in some sort of delirium.