

DECEMBER, 2022

VOLUME 02

$\Phi 6$

PHYSICS MAGAZINE
PHYSICS SOCIETY
UNIVERSITY OF SRI JAYEWARDHENEPUA

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Physics Society committee members

Prof N G S S Gamage	Head of the Department	
Prof A R Kumarasinghe	Chair Professor	
Prof C P Abayaratne	Patron (Former)	
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Ms. Lakshmi Rasanjalee	Committee member	4 th year Extended
Mr. Nipuna Jayathilaka	Committee member	3 rd Year Special
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Ms. Irunika Imanshani	Committee member	2 nd Year General
Mr. Thilanka Perera	Committee member	2 nd Year General
Mr. Pasindu Viduranga	Committee member	1 st Year General
Mr. Mishan Navodya	Committee member	1 st Year General

Editorial Support

Dr. Wasanthi P De Silva

Dr. S. Kandeepan

Message from the Head- Department of Physics

Physics; the most sublime of all sciences. This might as well be the reason for Physics to be deemed as “the only science”. Hence, it is no surprise that physics is the foundation for most of the universe’s creations and inventions. In such a context, it is my great pleasure to extend a message to the “ $\phi 6$ ” magazine launched in the second consecutive year by the Physics Society of the University of Sri Jayewardenepura. My personal opinion is that, amidst many social issues, engaging in such extra-curricular activities whilst providing a great example to your fellow colleagues could indeed be considered as a great victory for you.

I must say that I too have a close relationship with the Physics Society of our university as I was one of the founding executive committee members when it was instated in 1993 under the guidance of the founder Professor P C B Fernando and Head of the Department Professor D A Tantrigoda. It brings me immense joy to recall the memories of the activities that I engaged when I was serving the Physics Society as an undergraduate student. Today, in 2022, I consider it to be a gift of destiny that I am able to extend my heartfelt wishes as the Head of the Department of Physics.

Physics is not a science that should be studied but a science that should be explored, investigated and experimented on. It is science which takes boundless theories and applies it to enhancement of the physical world. It is the reason why this “ $\phi 6$ ” magazine is very important. This magazine is a handbook for those who seek new knowledge. It is also an educational support which urges acquaintance with science. This magazine is also a few steps ahead of its predecessor back in 2021. It also realizes the university education expectations of the society. It is with great pride that I acknowledge the talents of our undergraduates and state that this magazine would definitely be a great challenge for the coming year’s magazines as well.

It is indeed commendable seeing articles not only from our students but also from the academic staff members. They are indeed of high quality and value. It is evident that great effort and determination have gone into the undertaken work. The immense success of the “ $\phi 6$ ” magazine can be recognized as a result of the collaboration made by the entire student body and the academic staff of the physics department. I strongly believe that this inspiration would motivate our students to write many journals and conference papers in the future as well.

I take this opportunity to thank the senior treasurer who was alongside the students throughout, guiding and directing them. This guidance is invaluable to these skillful and creative students.

This accomplishment by the office bearers and members of the Physics Society is highly commendable. I congratulate all the stakeholders who are launching the “ $\phi 6$ ” magazine today as a project of the Department of Physics.

Finally, I express my heartfelt wishes and success to the Physics Society in all its future endeavors.

Prof.N.G.S.Shantha Gamge,
Head of the Department,
Department of Physics,
University of Sri Jayewardenepura

Message from the Patron Physics Society

It is with pleasure that I write this message for the “ $\phi 6$ ” magazine which will be published for the second time by the Physics Society of the University of Sri Jayewardenepura. Producing the “ $\phi 6$ ” magazine is just one of the many activities carried out by the Physics Society throughout the year. It gives the students an opportunity to improve their writing skills which is an essential soft skill that should be developed by all graduates. I am happy to observe that most of the Physics students have excellent writing skills. Apart from writing skills, preparing a magazine involves time management, organizational and interpersonal skills as well, which too contribute to enhance the quality of a graduate. I take this opportunity to congratulate the Physics students, especially the executive committee members of the Physics Society for overcoming all obstacles and achieving the ultimate goal of successfully producing the magazine, showcasing the talents of the students. I wish the Physics Society all the best to carry forward the good practices of the past and to introduce new activities in the future.

Prof CP Abayaratne

Department of Physics

University of Sri Jayewardenepura

Message from the Senior Treasurer Physics Society

For the second time, I am honored to contribute a message as the Senior Treasurer of the Physics Society to “ $\phi 6$ ” Magazine. One of the more significant pieces of work produced by the Physics Society students is the “ $\phi 6$ ” magazine. I want to express my gratitude to the Editorial Board in particular for helping to make this a second time success. This time, the editorial board initiated an article-writing contest to draw attention to the Physics magazine among the Physics students in the Faculty of Applied Sciences. The students submitted their articles, and the winners will be recognized at the annual general meeting 2022 of the Physics Society.

It was particularly important to highlight the many committee members that contributed to the planning teams for several events. The Infinitum 2.0 quiz competition, Invenço, an innovative idea competition, and the valedictory talks for the two retired lecturers are the events that stand out.

I would like to thank former patron Prof CP Abayaratne, former department head Prof. A. R. Kumarasinghe, and current department head Prof. Shantha Gamage for their assistance in providing direction for the physics society activities. Also, the president, secretary, editors and committee members for working so hard to advance the physics society at a difficult time in Sri Lanka. Due to the pandemic scenario and the difficulty in organizing the event financially, there were restrictions on how people could engage physically. However, depending on the circumstances, they come up with innovative ideas to organize the activities. I would like to wish all of the winners of the competitions the best of luck in their future endeavors, as well as the members of the physics society.

Dr. (Mrs.) W. Wasanthi P De Silva

Senior Lecturer

Department of Physics

University of Sri Jayewardenepura

Editorial

Physics is one of the fundamental sciences that can help us understand about the universe, to see through time from past to present and into the future. There are many paths we can follow when it comes to a vast field such as Physics, and along these paths we find answers to most fundamental problems that we come across in our day-to-day lives. In this rapidly modernizing world where new technologies are introduced everyday it is a must to spark interest in students who are ready to carry the baton of scientific thinking to the next generation. This has been done over a period of 5 decades at the Department of Physics at the University of Sri Jayewardenepura by providing a suitable environment to produce quality graduates.

The University of Sri Jayewardenepura's physics society has been one of the most active societies in the university for over 25 years. It is helpful in preparing student-related initiatives in order to promote both curricular and extra-curricular experiences. To fit the current world of physics, the society aims to generate practical intellects and bring out the best in its members. Hence, it is with the greatest pride that we present to you the second issue of the annual Physics magazine " $\phi 6$ ", as one of the many contributions from the Department of Physics, with the hope of communicating scientific information in Sri Lanka.

On behalf of the Physics Society, we would like to extend our sincere gratitude to Dr. Wasanthi De Silva for her guidance and motivation through every step of the way. Also, we would like to thank Prof CP Abayaratna, Prof A R Kumarasinghe, Prof NGS Shantha Gamage and all other staff members for their continuous support. Further we thank all of the committee members and non-committee members who extended their support to make the second publication of " $\phi 6$ " a reality.

Editorial Board

Academic staff of the Department of Physics



Prof. N. G. S. Shantha Gamage

B.Sc.(USJ), M.Sc., Ph.D.(Tohoku), CPhys, FIP(SL).

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[Dr. W. K. I. L. Wanniarachchi](#)

B.Sc. (USJ.), M.Sc., Ph.D. (Wayne State)

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Research Interest: Embedded Systems, MachineVision, Computational Physics, Electronic Structure, Signal Processing



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Research Interest: Wireless Sensor networks, Embedded System Designing, FPGA – Development.





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Mr. Jeevan Jayasuriya

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Position : Probationary Lecturer (on study leave)

Research Interest: Control Systems, Robotics and Machine learning



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B.Sc. (UOK), M.Sc., Ph.D. (Georgia State)

Temporary Senior Lecturer

Research Interest: Atomic Photoionization, Two-dimensional electron systems, Graphene, Condensed matter physics, Theoretical Physics

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B.Sc. (USJ), M.Phil. (Ruhuna), Ph.D. (Kanazawa)

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Think like a Scientist!

Two days back I met one of my new neighbours with whom I started a conversation. At one point during that conversation, she asked me what my occupation was, to which I replied “I’m a scientist” sparing her with the details. Her immediate reaction was “Oh, you must be very smart!”. I simply smiled unsure of how to respond. Funnily enough, this is a sentiment that has been thrown at me many times before, across many parts of the world, and yet it’s one that I still struggle to find a short and simple answer to.

We often associate the words ‘smart’, ‘genius’, and ‘intelligent’ with the fields of sciences. That is why in high school, those who score the highest grades go on to follow their higher studies in science subjects, it is also why we commonly refer to the smartest people as Einstein. But what exactly makes a scientist smarter than non-scientists? Or are they really smart as people think they are?

Who is a Scientist?

A scientist is someone who follows the scientific method to understand the world around them. The scientific method is where you basically test, experiment, observe the outcome, collect data, analyse, and keep repeating this process until you can come up with a reasonable explanation to relate your findings. But it does not end there, and scientists are always on the lookout for any observation that might contradict an earlier explanation, so that they can go back to the drawing board and start it all over again. In today’s terms, this is sometimes called ‘fact-based learning’.

Although it sounds like tedious work, scientists know that this is a very exciting and natural thing to do. In fact, we humans are born scientists. If you remember how you explored your surroundings when you were a toddler, or if you have been around a 5-year-old kid for long enough, you would have undoubtedly had to face questions like “How can birds fly but we can’t?”, “Why is the sky blue?”, “Why can’t I climb up the wall like a gecko?” and “Why is it cold up in the mountains?”. Going back to my childhood, since nobody could give me a good enough answer to the first question, I can remember climbing up a mound of sand and flapping my hands vigorously to see how far the wind can carry me, and then feeling a bit disappointed when it didn’t work.

Although these are questions and experiments that might sound silly to most adult ears, this is exactly what science is about. And all four of the above questions carry valid scientific explanations. Yet, unfortunately, most of this childhood curiosity is suppressed and shut down as we grow into adulthood. Almost always it is suppressed through the ignorance of adults, be it parents, society, or teachers who are stuck in an institutionalized education system. But once in a while, there will be a kid who grows up while keeping their inner child alive, or another who would re-discover this childish sense at some point in their adult life; and then he/she is on the path to becoming a scientist.

Joy of Finding Things Out

Often when you realize the joy of finding things out, you tend to follow that passion. You choose to study science, physics, mathematics, biology, and whatever you are driven by. You might complete a degree in a scientific field, may pursue postgraduate research, engage in industry or academia, and at some point in this journey, you will feel that you can identify yourself as a scientist and take pride in it. You will feel proud not only because you have gathered a huge amount of knowledge, but also of your ability to handle that knowledge in a meaningful way. As Carl Sagan would say “Science is more than a body of knowledge. It’s a way of thinking”.

Science as a Way of Thinking

When science becomes a way of thinking, you are no longer restricted to the subject matter. It could be a profound theoretical problem in particle physics, it could be a mundane issue with how you cook your food, it could be some gossip that is currently going viral on social media, or it could be the latest legal bill put forward by a government; science equips you with the tools and techniques to sort through whatever information that you receive and figure out for yourself what the underlying truth is.

This is a skill. This is a skill that is sharpened through the challenges of scientific problems, experiments, data analysis, and mathematics. It is a skill that is needed today more than ever. With the internet and social media bombarding us with more information than needed, a scientist should be able to sort through the noise and extract what lies below, what is relevant, what is misinformation, and what action needs to be taken.

It is a skill that is needed at a time when mass media advocate superstition and pseudo-science for personal gain. We should be able to see through the lies and not sacrifice our lives simply because someone else is misled by their own illusions.

It is also a skill that we need as a society to understand how the legal, economic, and political framework of a nation should be laid out if we are to have a better chance at life. In fact, it is a skill that everyone should have, and not only those who qualify as a scientist.

If you show an everyday item such as an electric motor and ask an art graduate how it works, chances are they will reply that they don't know because they didn't follow science in school. It is exactly this attitude that put people in a place where they are vulnerable to manipulation. Sure, you can't know everything, and even a science graduate might have difficulty explaining how something works at first. And that is okay because the key is to be willing to find out. So, an answer like "I don't know, but please explain" or "I'd like to find out more about it" would be the attitude that a true scientist would carry, whether they studied science or not. Again, this brings us back to that childish sense of inquiry. If you showed something interesting to a child, chances are that they'll be fascinated, play around with it and figure it out, or completely destroy it in the process, but that's ok because they still learned something. They don't know whether it's categorized as science, mathematics, or arts. They are open to exploring the world.

Open Minds Make Everything Easy

When you are open to new knowledge, new skills, and new ideas, it makes things so much easier. You don't have to worry about not knowing something, you don't have to worry about your skills being redundant in the changing world and you don't even have to worry about making mistakes. Such a person can be called a life-long learner. It is an attribute that is in high demand in today's workplaces. With so much information, knowledge, and skills that can be grabbed simply through the internet, short courses, or degrees, the one thing that cannot be bought is the attitude to learn, to find out, and to do that in a meaningful and positive way. The path to becoming a scientist is paved with problems, materials, and mental exercises that challenge your thinking and sharpen your brain just like the path to becoming an athlete is paved with physical training and

exercise to tone your muscles. However, just as you don't have to be a professional athlete to keep fit, you don't have to be a science graduate to be a life-long learner either. In fact, if everyone was given the space to retain that childhood curiosity into adulthood everyone would have the capacity to think like a scientist. If that could be a reality, then the world would be a much better place for everyone to live in.

*Dr. Sasani Jayawardhana
Senior Lecturer (Former),
Department of Physics,
University of Sri Jayewardenepura.*

A remarkable 2D material like graphene

Since the discovery of the first 2D material in 2004, graphene, many researchers have been encouraged to find other 2D materials as they have unique electronic, magnetic, optical, and mechanical properties. As a result, scientists have developed more 2D materials such as silicene, stanene, germanene, phosphorene, etc. In 2011, Drexel University was able to synthesize a new 2D material called, “MXene”.

What is MXene?

MXene is considered the largest 2D material family that is existing up to today, and its nature is quite similar to graphene as well. It is an inorganic compound that is made of carbides, nitrides, and carbonitrides and its atomic structure formula is $M_{n+1}X_nT_x$, where M is an early transition metal such as Titanium (Ti), Vanadium (V), Chromium (Cr), Niobium (Nb), Tantalum (Ta), Tungsten (W), etc. and X is Carbon (C) or Nitrogen (N) where n is in the range from 1 to 4 ($n = 1,2,3,4$). The T_x is known as the surface terminations such as -F, -OH, -O. The first MXene material that was successfully synthesized in 2011 was $Ti_3C_2T_x$. With the inspiration of this discovery, scientists have achieved the synthesis of 30 different MXenes so far (Figure 1). Unlike the other 2D materials, MXene can be engineered to make composites with other materials, which enables the tuning of many practical applications.

How MXene is made?

MXene is generally produced by the top-down selective etching process from its precursor materials, such as MAX phases, by using etching solutions like hydrofluoric acid (HF) and ammonium bifluoride (NH_4HF_2). MAX phases are composed of transition metal carbides or nitrides layers with the general formula of $M_{n+1}AX_n$ (**MAX**), where n ranges from 1 to 3 ($n=1,2,3$) and A is an element from the periodic table of groups 13 or 14. Furthermore, this top-down etching method has shown no changes or alterations in the material properties when the batch size is enlarged.

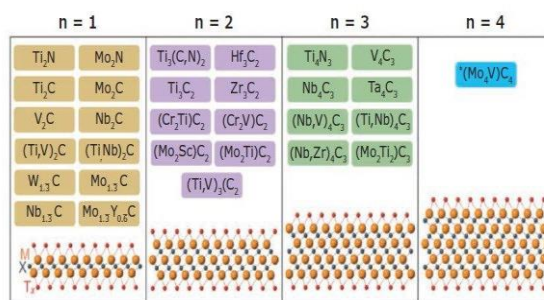


Figure 1- 30 MXene types as of today
<https://www.sigmaaldrich.com/LK/en/technical-documents/technical-article/materials-science-and-engineering/organic-electronics/mxenes>

MXene comes in several forms which are, **a)** Single metal element structures such as V_2CT_x , Ti_2CT_x , $Ti_3C_2T_x$, **b)** Ordered double transition metal MXenes such as $Cr_2TiC_2T_x$, $Mo_2TiC_2T_x$, $Mo_2Ti_2C_3T_x$, **c)** Solid-solution MXenes such as $Ti_{2-y}Nb_yCT_x$, $Mo_{4-y}V_yC_3T_x$, $Ti_{2-y}V_yCT_x$, **d)** Ordered divacancy MXenes such as $W_{1.33}CT_x$, $Mo_{1.33}CT_x$.

However, the main drawback of the top-down selective etching process method is that the hydrofluoric acid (HF) etching solution is an environmentally hazardous chemical. Therefore, scientists have been doing experiments to develop other possible options for synthesising MXene. As a result, many other possible alternatives have been suggested for making MXene. Such as,

- Urea glass route
- Chemical vapour deposition
- Molten salt etching
- Hydrothermal synthesis in aqueous NaOH solution
- Electrochemical synthesis at room temperature

Properties

MXene has extraordinary and exclusive properties that have a promising future in making many practical applications. It is a 2D nanomaterial with high metallic electronic conductivity and also has a higher possibility of producing transparent conductive films as well. Although scientists have made an effort to improve the conductivity, the first discovered material, $Ti_3C_2T_x$, remains the most conductive MXene material up to date. Since it is a nanomaterial, it has a high surface area and high functionalization.

Additionally, the surface functionalized MXene has been confirmed of acquiring the largest flexibility and can resist a larger strain than graphene. However, just like in graphene, most of the exposed MXenes are non-magnetic, which is restricted to spintronic applications. However, some MXenes are considered to be intrinsically magnetic. Considering the optical properties, the light adsorption of MXene is higher than carbon nanotubes (CNT). MXenes have optical transparency and effective photothermal conversion features. Additionally, MXene is a biologically compatible material with a high hydrophilicity ability that can be especially used in cleaning technology.

Applications

Due to the unique properties of MXene, there are many possible applications in energy storage, environment, biomedicine, wireless communications, and many other fields. MXene is known as the most effective electromagnetic interference shielding currently existing in the world, which can help to protect our electronic devices like smartphones from electromagnetic noise and to prevent credit card details from being stolen.

Energy storage and Antennas

Energy storage was the first application that developed right after the discovery of the first MXene material in 2011. MXene has been studied as the material of electrodes on lithium-ion batteries (LIB) and it has shown a higher specific capacity than graphene. Furthermore, MXene can be used not only in lithium-ion batteries but also in sodium-ion batteries and supercapacitors due to its high metallic conductivity property. Apart from energy storage, it has shown the possibility of antenna applications and, especially due to the flexibility property, printable 5G antennas and flexible antennas can be developed.

Biomedical applications

Mxene is currently under research for possible applications in the biomedical field. Its non-toxicity and biocompatibility of it have encouraged scientists to use it for antibacterial

safety, cancer treatments, tissue regeneration, biomedical imaging technology, and many other possible applications.

Catalysts

Catalysts have become significant in energy conversion technology due to the increase in global air pollution but the available traditional catalysts like precious metals are expensive. As a solution, precious metals can be replaced with MXenes and their composites due to the high hydrophilicity and conductivity features, which can be used to make electrocatalysts and photocatalysts to reduce CO₂ in the atmosphere since MXene is cost-effective in comparison with precious metals.

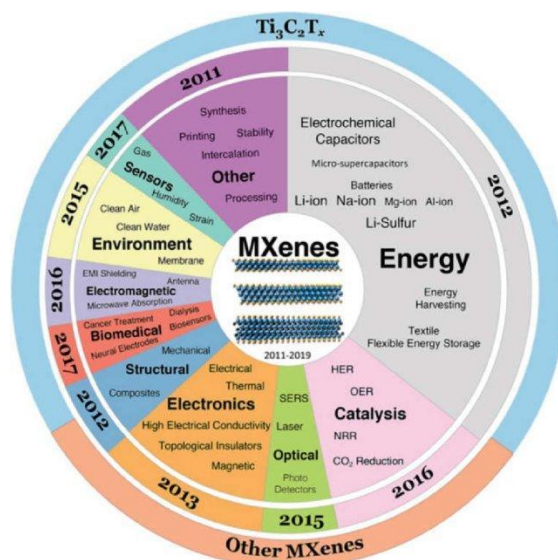


Figure 2 – MXene applications Credit:

<https://pubs.acs.org/doi/full/10.1021/acsnano.9b06394>

Optical devices

Considering the optical properties, MXene can be developed as electrochromic devices, photodiodes, transparent conductors and electrodes, etc. Moreover, it can be applied as a substrate in Surface-enhanced Raman Spectroscopy (SERS), which helps to develop biochemically enhanced sensing ability.

Additionally, MXene can be used in water purifiers, gas sensors, and biosensors, which had shown extraordinary performance results at the experimental level.

Unlike graphene, MXene is still in the premature stage of experiments and research. Hence, more challenges and potential of MXene have yet to be addressed. Nevertheless, since MXene possesses unique mechanical, optical, and chemical properties, and its easy synthesizing process, will surely revolutionize the future industrial and medical fields. Looking at the research progress and discoveries of MXene, more novel applications will be revealed soon, which will accelerate technology development in the world.

H. Nimna Sandali Peiris
4th Year Physics Special (2021)

Biometrics Systems for Personal Identification

Nowadays, Biometric systems have quickly grown in popularity as a secure user authentication technique, Because of the growing number of security threats and rapid developments in technology. Biometrics systems are simply described as system which automatically recognizes people based on their physiological and behavioural characteristics as shown in figure 01. Physiological biometrics are direct measurements derived from the human body, whereas behavioural biometrics are based on measurable patterns of human activities. Physiological biometrics, on the other hand, have been more popular in recent days than behavioural biometrics, because physiological characteristics are unique to each individual and cannot be stolen, copied, or 100% identical even among twins.

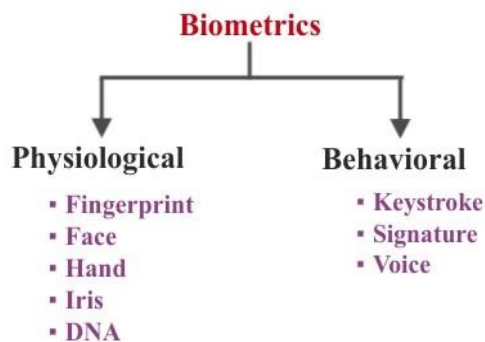


Figure 1: The biometric Classification

Fingerprint Biometrics

Fingerprint recognition is considered to be the oldest and most popular biometric solution for identifying individuals. There are different types of fingerprint scanning devices, such as optical, and capacitive, are now commercially available, with the process consisting of; 1) The fingerprint image or live image is captured and then digitally processed 2) Distinguishing features of the fingerprint are extracted,3) Fingerprint biometric template is generated, and 4) Finally, this generated template is stored and compared with the stored fingerprint templates.

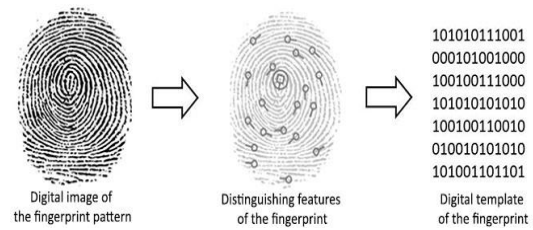


Figure 2: Process of fingerprint scanning devices (Image credit:

<https://www.bayometric.com/fingerprint-reader-technology-comparison/>)

Optical scanners, which utilize an LED to illuminate the finger, are the most prevalent fingerprint scanners. The fingerprint image is generated by the sensor detecting the light and dark areas created by the fingerprint ridges. If the image's brightness is too high or too low, the scanner processor rejects it. In such a case, the processor tries to scan the fingerprint again. If the generated image is in perfect condition, the scanner processor will compare it to the stored templates.

Capacitive scanning, which uses electrical current instead of light to sense the image, is another prevalent method of obtaining fingerprint images. In the capacitive scanning process, it captures the fingerprint images using an array of capacitor plates. The charge stored in the capacitor is changed when the ridges of the finger are laid over the conductive plates, but the charge on the capacitor is left unchanged in the valleys (gaps between the ridges). These fluctuations are detected by an operational amplifier integrator circuit, which is then recorded by an analogue-to-digital converter, which is then utilized to map the fingerprint.

This kind of scanner can be affected by electrical discharges such as shock, but it is not influenced by ambient lighting. Furthermore, capacitive-based fingerprint scanners are more sensitive to contamination issues than optical scanners. Using a high-quality fingerprint image rather than an actual finger to mislead this scanner is quite difficult. But on the other hand, using a mould of an individual's fingertip instead of the actual finger can be deceived by a Capacitive scanner.

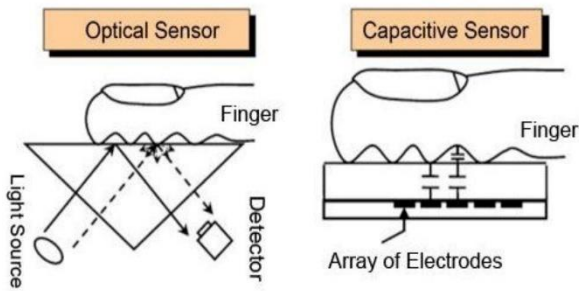


Figure 3: The schematic diagram for the optical sensor and capacitive sensor

(Image credit:

<https://semiengineering.com/fingerprint-sensor-technology-and-security-requirements/>

DNA

The nucleus of Each cell contains Deoxyribonucleic acid (DNA), which is thought to be the blueprint for the human body's design. The Genes, which are made up of exons and introns, are DNA segments that encode and regulate protein synthesis. Introns are generally where DNA markers can be located, and Individual human beings are frequently identified using these DNA markers. For example, STRs and SNPs, are DNA polymorphisms that provide more reliable personal identification and the sequence of DNA polymorphism analysis is shown in Figure 05. DNA segments having repeating units of less than 8 base pairs are known as short tandem repeats (STRs), while A single nucleotide polymorphism (SNP) is a single base variation in the DNA sequence at a particular location. STR markers have become popular DNA markers for human identification in the field of forensic science because they can vary widely between individuals. Compared to STRs, SNPs receive less attention for human identification, but to obtain the results provided by STRs, a large number of SNPs need to be analyzed. DNA biometrics have several advantages, including accuracy, rigidity, discriminatory power, and the ability to utilize the same analytical platform throughout the world. DNA biometrics, on the other hand, has some drawbacks, such as a long processing time, ethical concerns, expense, and the inability to distinguish monozygotic twins.

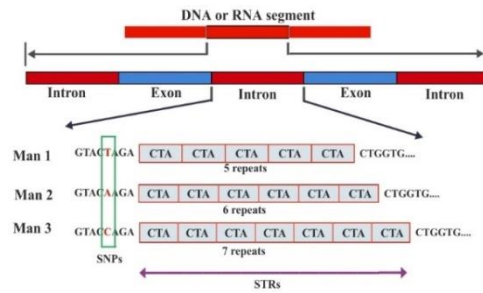


Figure 4: graphical representation of exon and introns of the gene, and examples for STRs and SNPs.

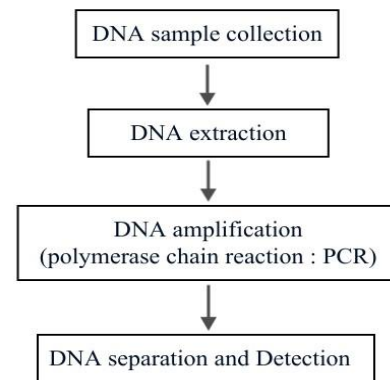


Figure 5: The sequence of DNA polymorphism analysis

Hand Geometry

Hand geometry biometrics is a technique that was prominent 10 years ago but is now rarely utilized. The human hand contains enough physiological features, such as finger length, width, and thickness, as well as palm thickness, to provide a personal identification mechanism. A light source, camera, mirrors, and a flat surface with or without pegs are the main components of the commercially available system. Pegs are used to assist hand placement on the device, and the mirror provides a side-view image of the hand to the camera. When a user places his or her hand on a scanner, the device captures two images: one on the top of the hand and the other on the side view of the hand, giving a partially three-dimensional image that can be used for measurements. The device compares the collected information against already stored patterns in the database. Hand scanners are widely used in offices and factories since the process is quick and effective.

However, hand geometry is not thought to be sufficiently distinctive to provide complete personal identification. Because it is time-sensitive and the shape of the hand can alter as a result of illness, ageing, or weight changing.

Iris Recognition

Iris is a thin, circular shape that surrounds the pupil of the eye and controls the size of the pupil. The complicated pattern of the iris has many distinctive features such as Furrows, Arching ligaments, Crypts, Rings, Zigzag collarets, and so on, and this pattern even differs between the left and right eyes of the same person. These features make it worthy of use as a biometric feature to identify individuals. Nowadays, this recognition technology is used in systems such as computer security, border crossing, secure electronic banking, etc.

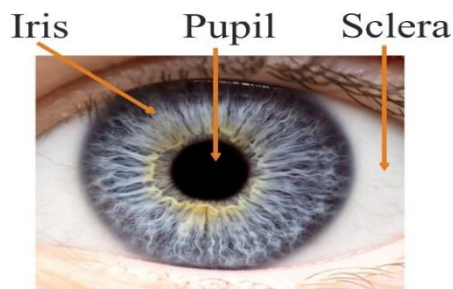


Figure 6: Structure of the eye

The iris recognition mechanism is made up of four steps, as illustrated in figure 07. Image acquisition is the first step in the iris recognition system done by highly sensitive scanners that illuminate the eye with invisible infrared light. For isolating the iris region from the captured image and reducing unwanted noises like brightness, image pre-processing is required in order to prepare the iris image for better feature extraction. In the feature extraction step, the pre-processed image's unique features will be extracted and stored as a biometric template. In the last step, a metric is required to compare two templates and find similarities and differences in order to decision.

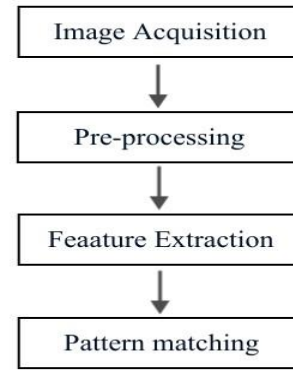


Figure 7: The flow of Iris recognition system

Menaka Madusanka
4th Year Physics Special (2021)

Can We Use Sunspot Cycle as a Predictor for Tropical Cyclones?

Tropical Cyclones (Hurricanes/Typhoons) are one of the devastating natural hazards that affect tropical countries and regions. These cyclones usually get formed over warm oceanic water bodies. This is because when oceans get warmer, the air particles just above the water layer absorb some heat from that and rise to higher altitudes. Because of that, colder and heavy air particles from higher latitudes come down to fill those air gaps. This process continues cyclically until it creates a void-like region in the atmosphere with a low air pressure above the ocean. That is when the air particles start to rush in to fill that void from far distances where the air pressure is comparatively high. As these air particles rush in at greater speeds, instead of filling the atmospheric gap where the air pressure is low, they start to rotate around it creating a spiral. As more air and clouds rush in, all those join this spiral to create a cyclone with a massive diameter. This is how a cyclone gets formed. The low-pressure centre of the cyclone is known as the eye.

As citizens of a tropical country, the devastating impacts of a cyclone are not strange to Sri Lankans. Therefore, I'm not going to discuss those in this article. Keeping that aside, the crystal-clear fact is that the warming of oceans is the major cause behind the formation of tropical cyclones. As the world is currently talking about global warming, it is possible to expect an increasing trend in tropical cyclone frequency as well. But the question I am going to address in this article is, whether there is a correlation between solar cycles and tropical cyclone frequency. To answer that, first let us discuss a bit about the active sun, sunspot number, and solar cycles.

The sun, which is the major energy source of the earth, is an active star. This can be observed through several activities of the sun including the rotation, sunspots, changes in magnetic poles, solar flares, etc. Some of these activities emit immense amounts of energy into our solar system and space. Among those, the solar cycle is one of the

major phenomena of the sun that affects the earth.

The solar cycle is a behaviour of the sun where it undergoes an approximately 11-year cycle in which the sun's magnetic field reverses continuously in a cyclic manner. Because of that, the sun's activities such as storms and many more vary between a minimum and a maximum along with this approximately 11-year cycle. Scientists identify this cyclic behaviour by observing the maximum and minimum sunspots on the sun's surface. Sunspots are regions with particularly strong magnetic fields and comparatively low temperatures. These sunspots appear comparatively darker when observed through telescopes because of this low temperature. The total number of sunspots reaches a maximum during a solar maximum, while it reaches a minimum during a solar minimum. Between two minimums or maximums, there is an approximate difference of 11 years. (Figure 1)

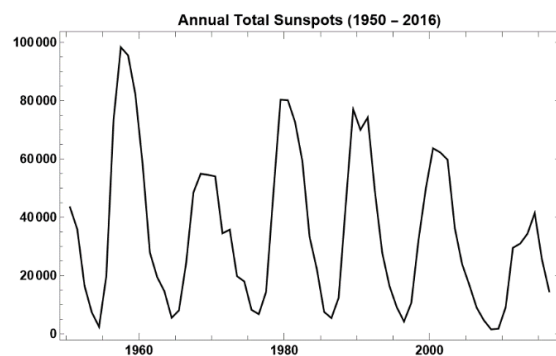


Figure 1: Annual total sunspots (1950 – 2016)

This phenomenon has several impacts on earth including the impacts on earth's magnetic field, telecommunication networks, climate systems, atmospheric stability, human health, environmental activities, etc. Among these, it is important to investigate whether there is a significant correlation between solar cycles and cyclone events in tropical regions. That allows the countries to prepare for possible extreme events and minimize the damage to the environment and society. This article is intended to discuss by comparing whether there is a correlation between solar cycles (Figure 1) and the historical cyclone activities in the Atlantic Ocean (Figure 2), which is the second-largest ocean in the world. Since the Atlantic Ocean is surrounded by many tropical countries in the American and African subcontinents. This comparison gives us a good understanding of the subject matter.

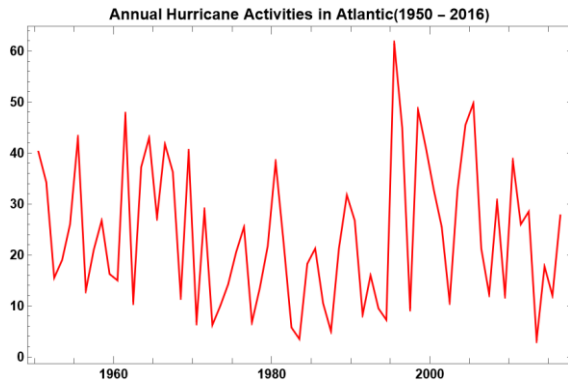


Figure 2: Annual Total number of cyclone activities in the Atlantic Ocean. (Data Source – NOAA)

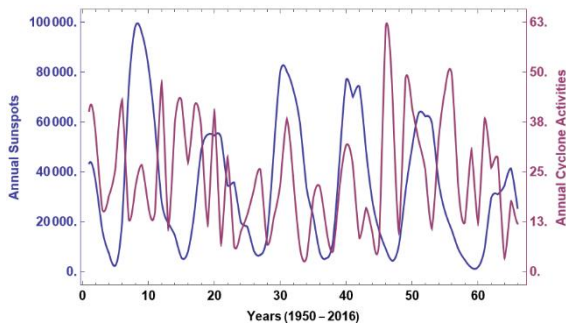


Figure 3: Comparison of annual sunspots Cycle and annual cyclone activities in the Atlantic Ocean.

The comparison between these two phenomena is displayed in Figure 3. As you can observe, there are not any strong evidence to state whether there is a correlation or an anti-correlation between the Atlantic Ocean and the solar cycles. Apart from a simple graphical analysis, similar results were observed in a study conducted back in 2018 using spectral analysis through the wavelet transform method in the Western North Pacific Ocean [1]. Another study conducted in 2013 using the North Atlantic tropical cyclone data has the same conclusion but it also states that there is a significant correlation between cyclone frequency and the years with sunspot maximums and minimums [2]. This significantly strong correlation between sunspot maximum or minimum and cyclone frequency can also observe in the Atlantic Ocean (Figure 3).

Therefore, the clear fact is that it is difficult to observe any clear correlation between solar cycles and tropical cyclone frequency. This means we cannot prepare for possible extreme cyclone events in tropical countries using solar cycle predictions. Yet, as stated earlier, there is a significantly strong correlation between these two phenomena during the years with sunspot maximums and minimums. So, it is possible to expect either an increase or a decrease in tropical cyclones during the years with sunspot maximums and minimums. Tropical countries can use this relationship to maintain a disaster response fund during such years as a precaution.

References:

- [1] K. B. Kim, J. H. Kim, and H. Y. Chang, “Do solar cycles share spectral properties with tropical cyclones that occur in the western North Pacific Ocean?” *J. Astron. Sp. Sci.*, vol. 35, no. 3, pp. 151–161, Sep. 2018, DOI: 10.5140/JASS.2018.35.3.151.
- [2] B. T. HUTTON, K. N. SCHEITLIN, and P. G. DIXON, “Solar Cycle Extremes as a Seasonal Predictor of Atlantic-Basin Tropical Cyclones,” *Southeast. Geogr.*, vol. 53, no. 1, pp. 50–60, Mar. 2013, [Online]. Available: <http://www.jstor.org/stable/26229047>.

Nirmal Kavindra Kularathne
4th Year Physics Special (2021)

Global Positioning System (GPS)

The Global Positioning System (GPS) is a satellite-based radio navigation system developed and administered by the United States Department of Defense. GPS, which was formerly solely accessible to the military, is now available to everyone. GPS technology is now highly integrated into our everyday lives as a result of its widespread usage.

History of GPS

GPS has its roots in the Cold War. The Sputnik I satellite, launched by the Soviet Union, signalled the commencement of the space race. What started as a way to study the Earth from space has evolved into a global technology used by practically every country. In February 1978, the first GPS satellite, the now disabled Block I advancement model, was launched, along with 11 test satellites. On July 17, 1995, the current system achieved full operating capability.

What is GPS

GPS is composed of three main components that work together to provide location information.

Satellites - a constellation of operational satellites transmitting navigation signals.

Ground control - comprises a network of ground stations, satellite control stations, and ground antennae that monitor and operate satellites in outer space.

User appliances – Watches, cellphones, and telematic devices include GPS receivers and transmitters.

Currently, it has a network of 32 operational satellites circling the globe. 24 of these are core satellites, with the remaining serving as reserves in case of others' failure. All the functional satellites orbit in 6 circular orbital planes at an elevation of around 20,000 km above the earth, providing precise position, velocity, and time synchronization for roadways, waterways, and airways anywhere in the world.

Only three satellites are required to provide an X and Y location on the surface of the earth. A fourth satellite is often needed to corroborate the information from the other three. If four satellite signals are available, it takes us into three dimensions, enabling us to compute the receiver's altitude. Data from four or more satellites can enhance the accuracy of the receiver's position even more.



Figure 1

Image credit: pixabay.com

How does GPS work

GPS drives through a mechanism called trilateration. Trilateration, which is used to calculate position, velocity, and altitude, collects data from satellites and provides precise location information. Trilateration is a more advanced variant of triangulation that does not use angle measurements in its computations.

The atomic clocks in the GPS satellites enable exceptionally accurate timekeeping. The time information is embedded in the transmitted codes of the satellite, allowing a receiver to trace the signal's broadcast time in real time. This unique signal contains its location, orbital data, and current time data needed to compute satellite locations and perform other modifications required for accurate positioning. In a precise orbit, GPS satellites circle the Earth twice a day. At regular intervals, each satellite broadcasts a unique signal which travels at the speed of light. Any GPS receiver can intercept these transmitted signals and decode and calculate the satellite's exact position.

Data from a single satellite offers a general position of a spot on the Earth's surface within a broad circular region. When data from a second satellite is added, the GPS can narrow down the precise position of a point to a zone where the two satellite data regions overlap. By combining data from a third satellite, the accurate location of the spot on the Earth's surface can be determined.

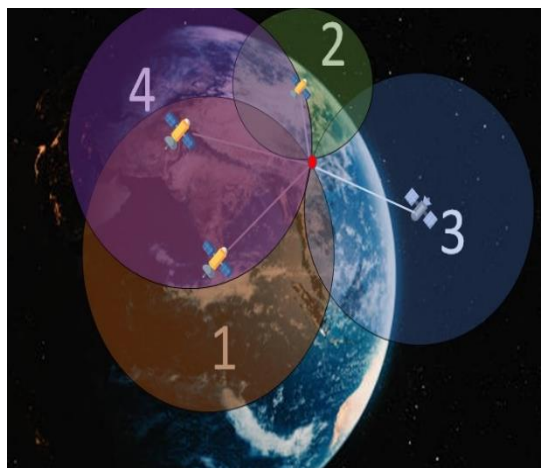


Figure 2-Trilateration with GPS satellites.

Since we are in a world with three dimensions, each satellite generates a sphere rather than a circle. When three spheres overlap, it yields two intersection points; the one closest to the Earth is picked. Four or more satellites improve the accuracy of the point's location even further. Distance to the satellite (radius) varies when a receiver device moves. New spheres are created as the radius alters, resulting in a new location.

Practical applications of GPS

The global information infrastructure would be incomplete without GPS. The free, open, versatile, and trustworthy nature of GPS has resulted in the growth of hundreds of applications that touch every part of present-day life in almost every industrial sector. Applications of GPS generally fall into 5 main divisions:

- 1) Location – identifying a position
- 2) Navigation – moving from one location to another
- 3) Tracking – observing personal movements or objects

- 4) Mapping – creating global maps
- 5) Timing – providing the world with exact precise timing

GPS has been critical in disaster relief operations worldwide in helping search and rescue operations. GPS is critical to the Next Generation Air Transportation System (NextGen), which will improve flight safety while expanding airspace capacity. GPS also enables researchers with weather forecasting, seismic monitoring, and environmental protection. Military operations are integrated heavily into GPS. From agriculture to marine, mining to aviation, recreation to military, GPS technology has a wide range of applications.

Accuracy of GPS

The accuracy of GPS depends on the number of accessible satellites, the ionosphere, physical constraints, GPS receiver precision, and other factors. Large bodies like buildings, mountains, and trees, as well as atmospheric disturbances such as atmospheric interference, Ionospheric propagation delay, and satellite clock errors, can all affect the position accuracy.

Global Navigation Satellite Systems (GNSS)

GPS is a Global Navigation Satellite System (GNSS), that covers the whole planet. The US navigation signal timing and ranging (NAVSTAR) GPS and Russia's Global Navigation Satellite System (GLONASS) are the two completely functional global navigation satellite systems. The most well-known and widely utilized system is the NAVSTAR GPS, consisting of 32 space satellites. There are 24 operational satellites in the GLONASS navigation system.

Latest advances

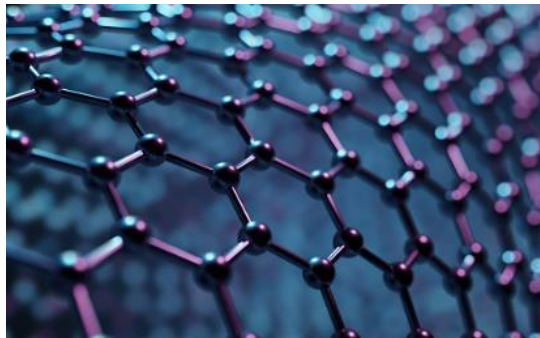
Countries continue developing and upgrading their GPS systems to enhance accuracy, durability, and capability. GNSS receivers are predicted to become smaller and improve accuracy and efficiency. The next generation of GPS satellites will have improved signal security and less susceptibility to jamming of signals. The Deep Space Atomic Clock of NASA will employ a strong onboard GPS satellite to offer improved time consistency for future humans on deep space missions. New GPS III satellites will be deployed as early as 2023, improving GPS accuracy of 1-3 meters, navigation functionalities, and component durability.

In the case of natural disasters, scientists and emergency crews are developing new methods to employ GPS technology in prevention and investigation. GPS monitoring is projected to become increasingly more precise and effective in the future, both for personal and professional use.

Dasun Prabathiya
4th Year Physics special (2021)

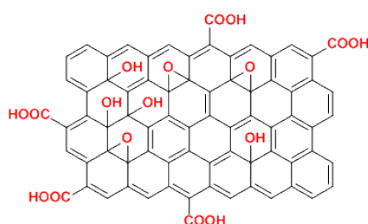
Graphene Oxide and Graphene Oxide membrane for water purification

Graphene



Graphene is a single layer of carbon atoms organized in a two-dimensional honeycomb crystal hexagon. It is the building unit of Graphite, and one millimeter of graphite has three million layers of graphene. There are many outstanding properties of graphene. Graphene is the strongest substance in the world which is 200 times stronger than steel but exceedingly lightweight is 20 times lighter than a feather. It is the thinnest 2D substance and is one million times thinner than the diameter of a single human hair. It has high electrical conductivity even 13 times better than copper and high thermal conductivity 2 times better than diamond. Due to these remarkable features, this wonder substance is becoming a vital component of our daily life and it has applications in numerous sectors. As graphene is costly and rather hard to generate, tremendous efforts are made to develop effective but economical techniques to make and utilize graphene derivatives or relative materials. Graphene oxide is one such material.

Graphene Oxide (GO) and Water Purification



It is a single-atomic layered material that is produced by the oxidation of graphite which is inexpensive and readily available. Graphene oxide is an oxidized form of graphene, and it can even be used to produce graphene.



Water is the most crucial and necessary component of life on earth and without water, life would not be possible. But water pollution is increasing day by day and it has become a huge problem all over the world. So, water treatment is an essential process to remove or reduce the contaminants in the water. Recently, GO has been used for water purification applications due to its unique properties such as being chemically stable in water, high water permeability, excellent dispersion in water, exceptional antifouling properties, anti-bacterial properties etc. In addition to them, GO contains a large number of carboxyl, carbonyl, hydroxyl, and epoxy groups, which are responsible for binding both organic and inorganic molecules and due to the presence of these oxygen-containing functional groups, graphene oxide is hydrophilic. In recent years, GO membranes have been used for water purification.

Synthesis of Graphene Oxide

GO membranes can be synthesized by various methods including Brodie, Staudenmaier or Hummer methods. The first two methods can be used to oxidize graphite by using nitric acid (HNO_3) and potassium chlorate (KClO_3). Hummer method can be used to oxidize graphite by using sodium nitrate (NaNO_3) and potassium permanganate (KMnO_4) and it is a rapid, safe, and more capable method because it is done in the absence of intense nitric acid.

Filtration mechanisms of GO membranes

GO membranes can obstruct liquid and gas molecules' flow while permitting the permeation of water vapours only.

This may be owing to the existence of space between the non-oxidizing sheets of graphene oxide, that is permeable to water vapours over low friction pathways. The many possible filtering mechanisms of GO membranes are as follows:

- **Size exclusion** - The bulky organic molecules are filtered by their size due to the presence of nanochannel in the membrane.
- **Donnan exclusion** - GO membrane can reject negatively charged organic species can be rejected because GO membrane becomes negatively charged.
- **Adsorption** - GO membrane can reject the small ionic species by strung adsorption via interaction with varying regions of graphene oxide sheets.

Preparation methods of Graphene Oxide Membrane

Vacuum filtration, spray coating, spin coating, dip coating and the layer-by-layer method are the main methods that can be used to prepare GO membranes.

1. **Vacuum filtration method** - This is the most often utilized technique for the preparation of GO membrane. The graphene solution was adjusted to a sufficient concentration before the fumed graphene dispersion was filtered, and then the GO was placed onto a membrane for vacuum filtering. During the filtering process, the graphene oxide will cover the whole membrane equally owing to the flowability of water. The resulting GO membrane has a uniform dispersibility, and the modulation of the dispersion concentration can modify the thickness of the graphene membrane.
2. **Spray coating method** - In this method spray the solution into the substrate evenly, and then the solvent is evaporated to achieve the required membrane. There are many advantages including ease to process, relatively high production efficiency and low cost. And it can prepare a large area and ability to spray on any substrate. But the homogeneity of the membrane is relatively low.

3. **Spin coating method** - This method is used to apply the graphene solution to the substrate, rotate the substrate and then regulate the rotation speed of the substrate. The solution is evenly spread across the surface of the substrate, and the substrate is dried to obtain an oxidized graphite film. During this process, the concentration of graphene solution and the speed are controlled to adjust the thickness of the film. Before applying the film, the substrate is initially rotated to allow the solution to be properly spread over the substrate. By increasing the speed of rotation, the thickness of the film can be decreased to get the desired film.
4. **Dip Coating Method** - The substrate is soaked in the solution of graphene oxide and removed the substrate after the immersion process. Then the excess solution is recovered. By using this method, the thickness of the film can be controlled by changing the temperature, concentration and pulling speed of the solution.
5. **Layer by Layer Method (LBL)** - The surface of the graphene oxide contains a substantial amount of oxygen-containing groups. So, they can be used to modify the surface of the GO with a negative charge. Layer by Layer Method is a method that can be used to form a multilayer film of polyelectrolyte by alternating deposition of the charged substrate in the opposite charge.

Research Progress of GO membrane in water purification

- **Modified GO membrane**
GO membrane can be modified to change the properties of the surface of GO by combining new functional groups and by changing the distance between the graphene sheets. As an example, the GO membrane was successfully modified by using fluorinated silica nanoparticles to reduce the surface energy and improve the surface adhesion, Ultra-thin GO films were prepared for filtration etc.
- **Hybrid GO membrane**
The preparation of a hybrid GO membrane can be used to obtain the advantages of organic films and nanoparticles while minimizing the defects in the GO membrane. By using this technique GO membrane can be developed for a specific purpose.

*W.D.Geethika Madhushani Senarathna
4th Year Physics Special (2021)*

How do computers see or understand the content of digital images?

What is computer vision?

Human vision is one of the most miraculous technology in nature. The major components of the human visual system are the brain and eyes. The eye works as an imaging sensor and the brain acts as an image-processing unit. These two components coordinate with each other to translate light beams into information. Then humans can manipulate this information to perceive the outside world. According to scientists, humans can identify around one million different colours and humans can recognize objects and even really think about them.

Studying the human vision system, scientists came up with an idea to develop a method for computers to see and understand digital images and videos. This new research area is known as computer vision (CV). Computer vision gives computers the ability to identify, understand, track, measure, detect and classify objects in digital images and videos as humans do. The main tasks of computer vision are image segmentation, pattern recognition, object classification, object tracking, and object detection.

When we look at a digital-coloured image of a flower, the brain can immediately identify it as a flower. But computers see it as a massive array of 8-bit numbers. These 8-bit numbers or pixel values are represented in binary because a computer can only understand them as 0s and 1s. Each of these pixel values represents different intensities of colour whose range is from 0 (black) to 255 (white).



(a)

0	3	2	5	4	7	6	9	8
3	0	1	2	3	4	5	6	7
2	1	0	3	2	5	4	7	6
5	2	3	0	1	2	3	4	5
4	3	2	1	0	3	2	5	4
7	4	5	2	3	0	1	2	3
6	5	4	3	2	1	0	3	2
9	6	7	4	5	2	3	0	1
8	7	6	5	4	3	2	1	0

(b)

Figure 1 (a): what humans see. (b): what computers see. (Source <https://medium.com/scapetechnologies>)

Computers use computer vision and machine learning algorithms to understand the meaning of these numbers. In this method, computers build machine learning models to identify unlabeled objects or scenarios they have never encountered before. However, this model may not work accurately with confusing images. Hence convolutional neural network (CNN) was developed to tackle this issue. CNN breaks an image into smaller parts of pixels called a filter. CNN does a series of calculations and analyzes these pixels. In the first layer of a CNN, it detects high-level patterns like edges and curves. As CNN performs more calculations, it will be able to predict special objects in an image. It uses an error function to detect and compare its prediction with the actual image. The first prediction may have less accuracy. Then CNN updates its filter values and starts the process again.

Usually, more iterations need to produce an accurate result.

Video is also a series of image frames. However, video analysis with CNN is a little bit complicated because the item that we are trying to identify can be changed over time. CNN can only take into spatial features, the visual data in an image, but can't handle time or temporal features. To fix this issue, we have to feed the output of CNN to another model. This model should be able to handle the temporal or time features of a video. This type of model is known as a recurrent neural network (RNN). RNN can handle many types of input and output data types. In each sequence, RNN uses an error function to compare its predicted output with the corrected label. Then it adjusts the weights and starts the process again and again until it reaches its best version. However, we need to feed a properly defined large amount of data with different colours and different angles to get better predictions.

Applications of computer vision?

These technologies use in different applications such as self-driving cars, facial recognition, augmented reality, medical imaging, intelligent video analytics, and optical character recognition (OCR).

- **Self-driving cars:** Some prominent automobile companies are conducting much research in this area to innovate semi-autonomous and completely autonomous cars. These automobiles are using computer vision techniques to detect lane lines, obstacle road signs, and steering angles.
- **Facial Recognition:** Facial recognition is one of the most dominant biometric security forms in the modern world. It identifies people in photos and real-time videos using facial recognition systems.
- **Augmented reality (AR):** This is a method of providing an interactive experience of real world surroundings by computer-generated digital information with the help of computer vision technologies.
- **Optical character recognition (OCR):** This technology allows us to extract printed or handwritten text from different media.

- **Medical imaging:** This technology creates a visualization of the body's interiors (organs or tissues) using images of X-rays and 3D scans like MRIs.
- **Intelligent Video Analytics:** This technology provides new information about the situation by analyzing the sequence of image frames. Here, convolutional neural networks use to compute pixel shifts between two image frames.

Limitations of computer vision

- The noises (random variation of brightness or colour information in images) of images make it difficult to identify.
- Computer vision needs a large sophisticated data set to provide an accurate prediction.

Lakshitha Dannoruwa
4th Year Special Batch (2021)

Is Time Travel Possible?

Time is one of the most amazing physical quantities you may get to deal with. Its mischievous, curious nature catches science lovers to observe its mischievousness more and more. One of the most famous questions of all time is whether time travel is possible or not.

And yet we don't know exactly the answer but up to date, there is no evidence to prove time travel has been done. In 2009, famous scientist Stephen Hawking tried out an experiment to prove time travelling is not possible where he held a party for time travellers but sent out invitations a year later. Of course, no one showed up, yet it is no strong proof to support time travel couldn't be done. As Hawking and some other scientists say, travelling to the past is impossible. But there might be a chance of travelling into the future.

According to scientists, there are a few methods to achieve the goal of time travelling but the drawback is the technology.

1. Reaching the speed of light

The most discussed method is moving faster than or closer to light. According to Einstein's special theory of relativity when an object moves at high speeds; closer to the speed of light time slows down relative to the outside world. So this theory suggests objects can travel to a time in the future relative to them as time moves faster in the outside world when they are moving at high speeds. When the speed is getting closer to the speed of light, the time-travelling effect is more prominent. But the time we can travel is limited here as the barrier of the speed of light couldn't be broken. As modern theories say when the speed of an object reaches closer to the speed of light its mass increases rapidly. Hence it needs an infinite amount of kinetic energy to reach the speed of light making it impossible to do so. The highest speed experimentally acquired so far has been reported at the Large Hadron Collider as 99.9999991% of the speed of light using protons. So time travelling to the future is possible by this method but it is limited.

2. Using the Gravity

This method is also inspired by the theory of relativity presented by Einstein. According to his theory of general relativity, when gravity is increasing time slows down. But the effect is very low. So very strong fields such as a field near a black hole may result in slowing time to an accountable level. But when considering the distance to the nearest black hole (about 3000 light-years), the effect of slowing time resulting from moving at high speeds to reach there is comparatively higher than the time slowing caused by the gravity of the black hole.

3. Suspended Animation

The third method is rather a biological method where slowing down or stopping the biological activities is done to slow the perception of time of that particular organism. This idea was inspired by the bacterial spores which survive millions of years inactively in a suspended animation state. When they got the suitable conditions metabolism starts again. In the case of humans, only a few hours of short-term hibernation state have been achieved so far which enables surviving emergency situations such as cardiac arrests where the patient can be kept alive until taken to the hospital. Various trials have been carried out in mice (by exposing them to minute doses of hydrogen sulfide) and in pigs (by replacing the blood with a cold saline solution) to achieve such states and currently, human trials are executed with the method used for pigs.

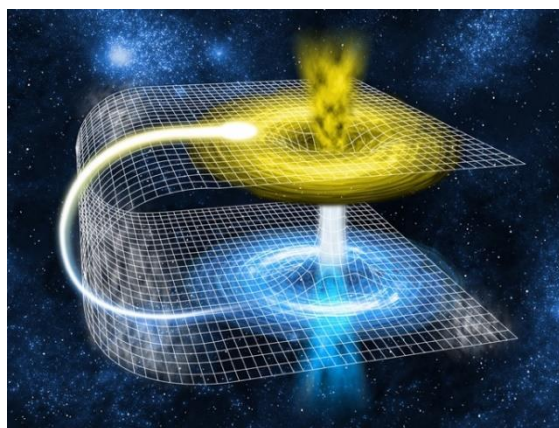


Figure 1-A wormhole. Image Credit: <http://www.shutterstock.com/gallery-138187p1.html>

4. Wormholes

A wormhole is a shortcut that connects two different points in time or space which may be sometimes separated by billion light years.

So time travelling could be done by travelling through a wormhole. But these doors are not stable on a macroscopic scale and only stable for a very short time on a quantum scale and these ideas are based on the theories yet. And to make a stable large-scale wormhole a huge amount of energy is needed and practically this idea couldn't be done due to the incompatibility of quantum mechanics and general relativity.

5. Light rotating cylinder

In 2000 American physicist Ron Mallet theorized time travelling can be done by using a light rotating space-time cylinder where space-time is twisted. Anything which travels inside the cylinder will be dragged around space-time, either towards the present or past as Ron Mallet states.

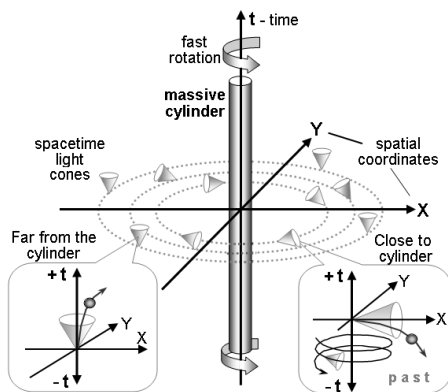


Figure 2-Light rotating cylinder, Image Credits:

<https://astronuclphysics.info/CestyCasem.htmits>

This cylinder should move around its longitudinal axis a few billion rotations per second after a huge mass is put inside it and the dimensions of the cylinder have to be enormous; the length should be infinite as scientists believe. So practically this idea is under research yet and most scientists believe this is not practical as it is based on a singularity.

But still, there are a few problems to face if we can do time travel which would lead to chaos. They are the paradoxes of time travel;

- Grandfather paradox- Killing the grandfather of the time traveller by himself before the conception of his father or mother which prevents the existence of the time traveller.
- Bootstrap paradox- Loop caused by time travel in which one event causes a second, which was the cause of the second.
- Butterfly effect- Happening big events in future by small changes which are caused by time travel to past

So, if time travel is possible, either these paradoxes will happen and lead to chaos may be resulting in multiple timelines or something will happen to prevent happening these paradoxes. As an example, in the grandfather paradox, something will always happen to stop the time traveller from killing his grandfather. But this won't happen when travelling into the future. So that leaves us some hope. Yet we all are time travellers as now you are in the future relative to the place in time where you begin to read this article!!!

Damitha Jayatissa
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Ocean Current

Have you ever had a bath in the sea? Have you ever noticed why water feels warmer on the surface and cooler as is deeper? Did you know that the Ocean current decides which part is warmer and cooler? Let's investigate more about this to clarify your problems.

Ocean currents are giant rivers/ streams of seawater that circulate within the oceans. Permanently or non-permanently horizontally moving of surface water. The movement of horizontal components varies its magnitude from a few centimeters per second to 4 meters per second. The intensity of the current drops off with the rise of depth. The vertical movement of current is called upwelling and downwelling.

Ocean current was firstly discovered by the well-known American Scientist Benjamin Franklin in the mid-1700s made a good observation on the currents on the East coast of the US. Later many tend to study more on the ocean current and its causes. Back in 1992, a cargo ship topples on the ocean due to a strong storm. All the cargo containers wash overboard and waves swept more than 28000 rubber ducks into the North Pacific. But surprisingly they didn't stick together. Later these ducks were found all over the world. This concept was used by researchers to study the path of ocean currents.

What causes Ocean Currents?

Circulation obeys the fundamental laws of mechanics which were developed by Sir Newton here it applies to the continuous volume of water. A plethora of forces that contribute are gravity, pressure gradient forces, *Coriolis forces, frictional force, and wind across the ocean. *Coriolis effect is the force that results due to the rotation of the Earth. Think of the Earth that didn't rotate. Will Ocean currents exist? Yes, but this will circulate between the equator and the poles in a pattern of back and forth. This is due to the low pressure at the equator to high pressure at the poles. But as the earth spins on its axis the air molecules deflect towards the eastwards and come back westwards.

This will occur in the northern hemisphere and the mirror image is seen in the southern hemisphere.

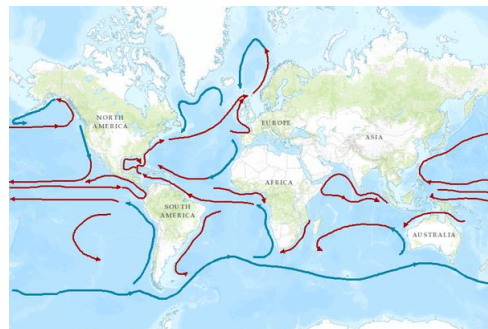


Figure 1: Red arrows indicate the Warm current and Blue arrows indicates the cold current marked on the world map

Therefore, loops of streams of winds are created in the ocean basins (figure 1).

Other than the forces Temperature, salinity, wind, density of water, and gravitational pulls of water down the hill against the pressure gradient are causes for the ocean current.

Types of Ocean Current

Ocean currents can be categorized in different aspects. Considering the depth factor; surface current and deep oceans. Surface current contributes the top 10% of the ocean water and the rest 90% mobilizes by the deep ocean current. Why does the water rise and falls on the seashore? This is due to the surface current which is driven by the wind and tides. When wind passes by it drags the top layer of water along with it this pulls the bottom layers too. A depth of about 400m is still affected by the winds on the ocean. When water moves to the north pole, it gets cooler. Since seawater has a high concentration of salt when it becomes icy it traps water and salt residuals leaving them behind. These residuals are denser, and they sink at the bottom. And the warmer surface water takes this place. Combination of deep water and wind on the surface current forms loops called Global Conveyor Belt (figure 2).

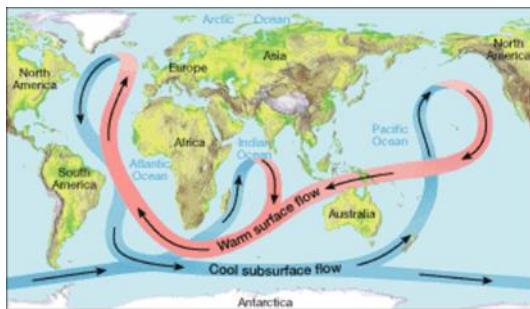


Figure 2: Global Conveyor Belt

It is said that the Global Conveyor belt is the longest current in the world. But this moves very slowly a few cm per second. Let's consider a drop of water, to travel the full trip it takes for about a thousand years. When considering the temperature gradient ocean current can be categorized as warm and cold ocean currents. Warm currents generate near the equator and travel towards the poles or too high latitudes. While cold currents are generated near the poles and travel towards the lower latitudes. Some examples of warmer currents are the Agulhas current and cold currents are Canary currents in the North Atlantic etc.

What are the effects of Ocean currents?

The Ocean is a factor that influences the climate on the land. Ocean current is the energy transportation that maintains the earth's climate Zones. The ocean absorbs twice the heat compared to the land they could store and move heat. The surface current carries this heat, and vapour, and redistributes it globally. Ocean currents affect rainfall, fog, and violent storms. The warm and cold current mixture helps to restock oxygen for the growth of Plankton (microscopic organisms found in the ocean) which is the main food of the fish population which helps in the fishing industry. Ocean currents can create deserts. The Namib desert in Southern Africa is a good example of the cold Benguela current. Since the cold current doesn't give moisture and no rainfall this region becomes desert. While warm currents make the coastline more humid and wetter.

“We live by the current plan by the tides and follow the sun” by Sandy Gingras

Importance of Ocean Current

- Dispersal of life forms – For instance lifecycle of the eel in the European region sustain by the ocean current
- Transportation by humans – currents help to sail easily along the ocean, additionally, this speeds up shipping lanes, keeps the ship safe, etc.
- Controls the climate – Currents are the main source of heat distribution from the equator to the poles and deduce to a balanced climate around the globe.
- Marine Life – Ocean currents create a balance in marine wildlife. Current carry nutrient and food organisms. This will be mostly fed by the organism that doesn't move. Current helps to carry reproductive cells to new places. For example, eggs laid by sea turtles in the sand on the shore are carried into the water by the current.

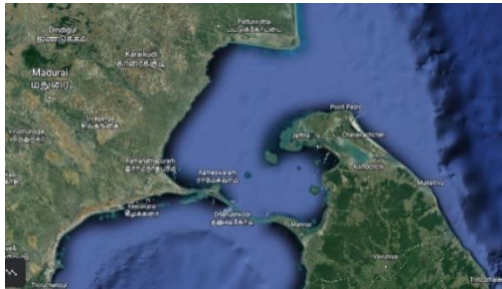


Figure 3: Baby turtle are carried out by ocean current into that habitat

Ocean current and their influence are studied by many geologists, geophysicists, and oceanographers. And these studies enhance how will ocean current contributes to global warming in the future.

Did You Know?

The Land shapes of some islands in the Maldives are modified by the nature. These sands are moved away and brought closer by the ocean current. And the Adam or Ram's Bridge in Sri Lanka also visible in some months of the year this is due to the fluctuation of ocean current within this region.



Images from Google Earth

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Optical properties of nanoparticles

Light is an electromagnetic wave and a form of energy. The wavelength of visible light ranges from 400-700 nm. Properties such as Reflection, Refraction, Total Internal Reflection, Absorption, and Diffraction can be seen in light. Nanoparticles are particles in the range of 1 to 100 nm. As the particle reaches the atomic scale the material properties change. In comparison to bulk materials, nanoparticles have a very large surface area to volume ratio. This feature factors for nanoparticles to possess optical properties, their small size allows them to confine their electrons and exhibit quantum effects. The nanomaterial size, arrangement, and composition provide an optical response.

A spectrum of colours can be seen when we step outside the concrete world. The Morpho butterfly has a vibrant blue colour and the chameleon can camouflage. These different colours can be observed in nature as a result of the optical properties of the nanoparticles.

Morpho Butterfly



Figure 1: Morpho Butterfly

Most butterflies gain their color through pigments while some gain their color through structural color which is a method where light is reflected and bent by the nano-sized elaborate shapes which result in the production of color. It occurs when light passes through a transparent, multilayered surface and the light gets reflected more than once. Multiple reflections bend one another and result in intensifying the colors.

As their wings have many layers for the light to pass through, this allows light to reflect and magnify each other.

Butterfly wings are made of microscopic scales broken into two or three layers – Lepidoptera, a Greek name for scales wings. Incoming light waves are diffracted as a result of the cross ribs that protrude from the sides of the ridges on the wing scale, which causes the waves to spread when they move through the spaces between the structures. When the diffracted light waves interfere, they form certain color wavelengths that cancel out, diffractive interference while the rest intensifies and gets reflected, constructive interference. [1]



Figure 2: Nano-sized shapes on the butterfly wing

Different heights of the wing scale ridges affect the interference in a way that the reflected colors are uniform when seen from a range of angles. The significant color that is reflected depends on the shape of the structure and the distance between them.

Chameleon

A Chameleon change its body color according to their mood. The reason the chameleon has the ability to camouflage when they see a deadly animal is because of their emotions. Chameleons use color to communicate and control their temperature. Chameleon's skin is made up of different types of cells that produce color. The uppermost layer consists of cells that contain the yellow pigment – Xanthophores. The red pigment cells – erythrophores which are present in the striped area. Iridophores lies under this layer, reflecting different wavelength of light depending on the way their packed and ordered.

Melanophores are contained in the last layer and have extensions that can reach the uppermost layer. [2]

When in a relaxed state, the nanocrystals in the skin become closer to each other and the shorter wavelengths are reflected – blue. In an excited state, the gap between the nanocrystals increases and longer wavelengths are reflected – red, orange, yellow. These colors can be seen in the striped band in the chameleon's body. As a result of green and blue wavelengths, chameleon's green color can be observed. Xanthophores give the yellow and blue can be seen because of Iridophores, which results in the color green. When the chameleon is in a neutral and relaxed state, the green is light and vibrant. In a suppressed mood, like in a case when it needs to hide darker shades can be observed. This is a result of the Melanophores that disperse the pigment to the upper layer using the extension.

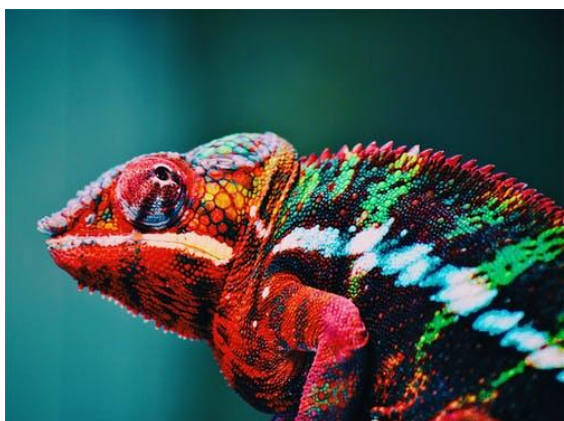


Figure 3: Chameleon

Chameleons change their color to control the temperature. If they are cold they will turn themselves into a darker color to absorb more heat and if they are hot they turn themselves to a lighter color to reflect more heat.

Plasmonic Nanoparticles

It is observed that by varying the size, shape and composition of the nanoparticles, the optical response can be tuned from the ultraviolet through the visible to the near-infrared region in the electromagnetic spectrum. Plasmonic nanoparticles are known to be strong absorbers and scatter of light. They are used in surface-enhanced spectroscopy, colour-changing sensors, lateral flow diagnostics and labelling.

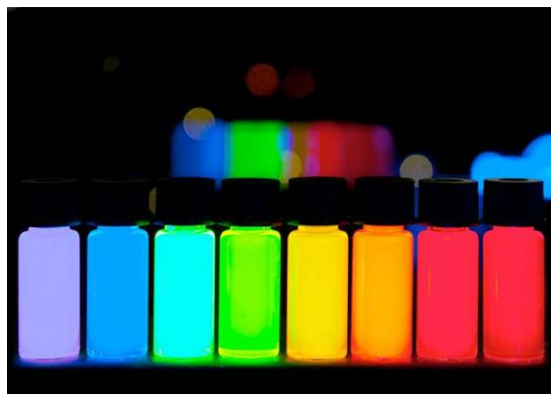


Figure 4: Plasmonic Nanoparticles

Metal nanoparticles such as gold, silver and aluminum support surface Plasmon modes where the material possesses free electrons that naturally resonate at a frequency that depends on the composition, size and shape of the particle. Strong absorption or scattering can be observed when the wavelength of the incident light matches the oscillation frequency which results in a strong colored particle.

Biomedical – These particles scatter light vigorously. Therefore they can be easily identified under dark field illumination and other sensing techniques. They can be used in vitro-biological applications. Gold and silver nanoparticles can be used as plasmonic biosensors for finding biomolecules and proteins.

Color-Engineering – Nanoparticle formulations are produced for absorbing and scattering wavelengths of light to generate a color. Biochromic color can be formed due to concurrent absorption and scattering of light of plasmonic nanoparticles.

Quantum Dots

Nanoparticles that are made of semiconductor materials absorb and emit light at different wavelengths depending on the particle size and shape as a result of quantum confinement effects. The size of the quantum dot has an inverse-proportional relationship with the bandgap energy level. When the dot is smaller, high energy is emitted which results in blue color. Similarly, when the size increases, low energy is emitted resulting in red color.

Quantum dots are advantageous as it is less prone to photobleaching under high intensity illumination, offer larger quantum yields than organic dyes, and can be excited to a much further emission peak giving an effective Stokes shift that allows more flexibility with imaging. They are used in Light-emitting diodes, photodetectors, medical imaging and television.

In conclusion, the optical properties of nanoparticles play a major role in the natural world as much as it does in the man-made world. By varying the particle size, shape and composition it is possible to exhibit different optical properties that serve numerous benefits.

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Study of Melting Glaciers in Poles

Imagine all the continents are submerged in water on earth. All the lands, all the properties, all of the manmade structures or things will be underwater memories if it happens. The only living beings that can be survived in that, would be aquatic species. Unfortunately, the truth is the path to that danger is already begun because of human activities on earth for several decades. What does cause such kind of a disaster? The answer is **“Rising the sea level on earth continuously”**. Why is that happening? What are the reasons for that? What can we do to prevent that? How can we do that? There will be a bunch of questions like that if you understand how serious this problem is, not only for humans but also for all the living beings who live on the ground continents.

Anyhow, the problem is, still humans do activities that can be caused to this natural disaster by pulling all the mankind into an edge. Even though the rules and regulations have been already implemented, there are a few unavoidable causes still going on such as the combustion of petroleum or burning fossil fuels which is directly connected to this “Inconvenient Truth”. As predicted by ecologists, if we let this sea level rise to continue, most of the islands will be submerged in water in a few years. As an example, the Maldives Islands will never be survived in the next 50 years if humans let this continue. **“It is not the sea that melts the glaciers in poles and rises itself. But if we let it, we will never be survived”**. Necessary steps should be made before it happens. In this article the general understanding of melting glaciers in poles, causes of that, and what can we do to prevent them will be discussed.

What is “Rising sea level”?

Simply sea level rising is the event that the water level in the oceans of the world goes high. The meaning of the words could be simply understandable but the process and the effects of it are not. When we consider the sea level rise, the main reason for that can be revealed as melting glaciers at the north pole as well as the south pole. Arctic and Antarctica.

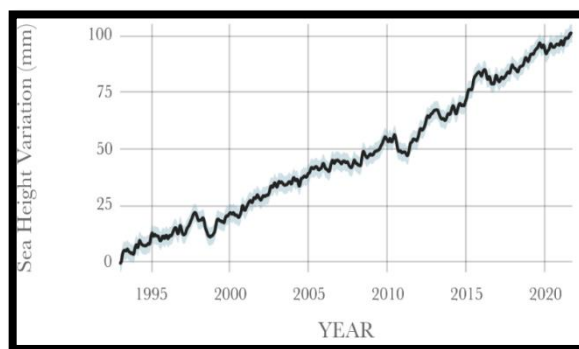


Figure 1: Satellite data: 1993-present Data source: Satellite Sea level observations. Credit: NASA's Goddard Space Flight Center

Melting glaciers not only affects the rising sea level but also affect people living in the poles, marine life, and Arctic and Antarctica climates as well.

Why is that happening?

The main reason for the sea level rising is the melting glaciers at the north pole as well as at the south pole. The Arctic and Antarctica are created with massive ice mountains, floating ice blocks, a cover of thick multilayer ice as well as thick ice caps. Recent studies claim that the ice caps in those areas have decreased causing a threat to the world. The main cause of these melting glaciers is **“Global Warming”**. Not only for that but also for many death effects have been caused by global warming. So, if we are going to stop melting glaciers in the poles ultimately, we should stop global warming. But global warming cannot be stopped because it is a phenomenon that is happening due to human activities as well as natural causes. Either way, global warming is directly related to melting glaciers in the poles.

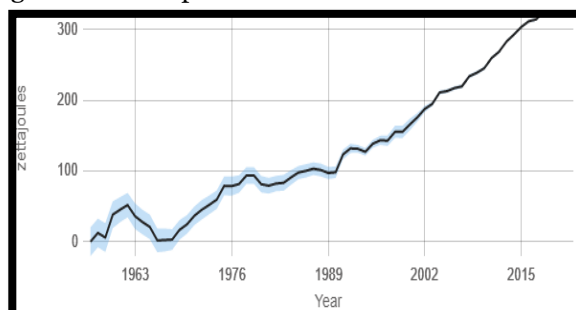
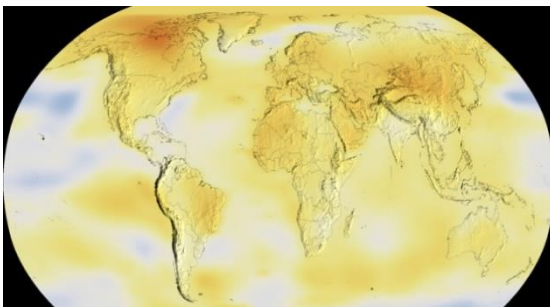


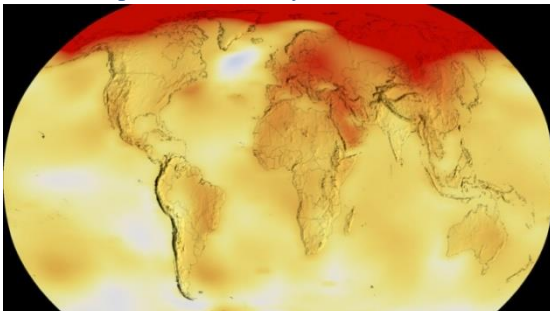
Figure 2: Ocean heat content changes, Data source: observations from various ocean measurement devices, including conductivity-temperature-depth instruments Argo profiling floats, and expendable bathythermographs, Credit: noaa/ncei world ocean database

How does global warming affect melting glaciers?

As figure 1 shows, the sea level is rising continuously. The rate of rising is 3.4 millimetres per year according to the NASA website of climate changes. Antarctica loses 152 billion metric tons of ice per year. The most shocking feature of recent changes in the poles (Arctic and Antarctica), particularly in sea ice, is how quickly it is warming or increasing the temperature, and ice is melting compared to changes that have been seen in the long-term climate records. Most of the research showed that if the temperature of the near equator increases by one degree of Celsius then the temperature of the poles will be increased by several degrees of Celsius. That is a huge problem when we consider the temperature increase in the poles.



The temperature anomaly in the world in 2000



The temperature anomaly in the world in 2021

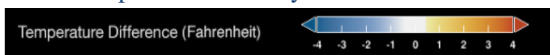
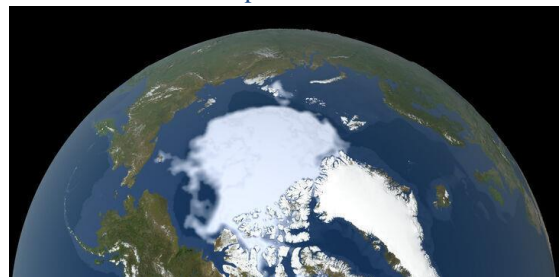


Figure 3: Temperature anomaly in Arctic pole compare 2000 and 2021, Data source: NASA/GISS Credit: [NASA's Scientific Visualization Studio](#)

Figure 3 clearly shows how the temperature increased at the poles. Anyway, that leads to melting down the ice cap coverage as well as the floating ice blocks on the water. If we consider the physics of the floating ice, that will not affect the sea-level rise. It is a simple idea that can be explained as follows. If we take two samples of the same volume of water and one is left to be frozen. And then if we check the density of the water and the ice cube, we can see that the ice cube has a lower density. But if we check further, the mass will be the same. Because of that, it is the same if ice is floated on the water or if it is inside the water as a liquid. So, that leads to a problem. Then how it does affect sea level rise? The answer is if the floating ice is melted, the up roof of the sea is exposed to solar radiation. That radiation is absorbed by the darker water surface as heat, resulting in further warming and melting of ice and snow. That means the ice caps reflect the solar radiation and that phenomenon is called temperature-ice albedo coupling. However, that increasing seawater temperature melts down the ice deposits inside the water. And that leads to rising sea levels. And as well as that, the increase in the temperature changes the climate of the poles. And also, melts the Ice Mountains which is also caused the sea level rise. From the above information, we can conclude that the sea level rising is mainly caused by global warming.



The Ice cap in Arctic in 1980



The Ice cap in Arctic in 2021

Figure 4: Arctic Sea ice content Data source: Satellite observations. Credit: NASA Scientific Visualization Studio

How can we prevent melting glaciers in the poles?

Since we know about melting glaciers, all the countries of the world agreed to so many regulations to prevent that. As we all know melting glaciers is directly caused by global warming. So, all rules and regulations that were implemented to reduce global warming can also be taken as rules and regulations for preventing glaciers from melting in the poles.

Intergovernmental Panel on Climate Change (IPCC), Natural Resources Defence Council (NRDC) and Glacier Protection Laws (GPL) are the foundations and laws which are implemented to reduce global warming and prevent melting glaciers. We cannot take direct reactions to decrease melting glaciers. But by helping to decrease global warming we can directly support preventing the glacier problem.

How we can reduce global warming (NRDC)

1. Reduce, Reuse, Recycle
2. Use Less Heat and Air Conditioning
3. Buy better bulbs (CFL, LED Bulbs)
4. Drive Less and Drive Smart
5. Power your home with renewable energy
6. Use Less Hot Water
7. Use the "Off" Switch and save energy
8. Plant a Tree
9. Reduce water waste
10. Invest in energy-efficient applications
11. Shrink your carbon profile

By encouraging the above steps, we can support to prevention of glacier melting in the poles as well as global warming and we can prevent the grave danger which we are about to experience.

As mentioned before, **“It is not the sea that melts the glaciers in poles and rises itself. But if we let it, we will never be survived”**. If we can follow up a successful method to decrease at least the rate of melting glaciers in the poles, we will be lucky to live on the surface of the earth in the future.

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Applications of superhydrophobic surfaces

Varying with the contact angle of a liquid, it can divide into different categories such as superhydrophobic, hydrophobic, hydrophilic and super hydrophilic surfaces. Lotus leaves are one of the natural examples of superhydrophobic surfaces. Superhydrophobic surfaces are very difficult to wet. They have a contact angle of more than 150°. Over the years researchers try to apply the properties of superhydrophobic to various objects' surfaces due to the non-wetting property of its.

Property	Hydrophobic surface	Hydrophilic surface
Contact angle	More than 90 degrees	Less than 90 degrees
Wettability	Poor	Good
Adhesiveness to water	Poor	Good
Solid surface free energy	Low	High

Table 1: properties of hydrophobic and hydrophilic

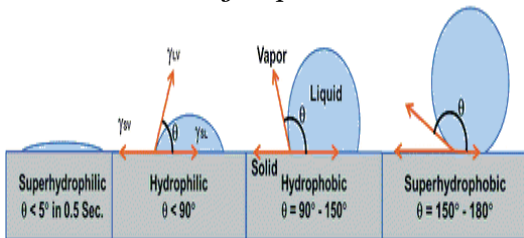


Figure 1: Contact angles of liquid at different surfaces source:

<https://journals.sagepub.com/doi/pdf/10.1177/2516598419836345>

Theory

The contact angle of a water drop is depending on the surface, the volume of the droplet and the gravitational force applied to the droplet. Using Young's equation, the contact angle θ of a drop can be calculated for a homogeneous solid surface.

$$\cos\theta = \frac{\gamma_{SV} - \gamma_{SL}}{\gamma_{LV}}$$

Where γ_{SV} is the solid-vapour interfacial energy, γ_{SL} is the solid-liquid interfacial energy and γ_{LV} is the liquid-vapour interfacial energy. Young's equations can apply only to flat surfaces only when the surface becomes rough young's equation is not suitable for the application. To obtain the contact angle of a rough surface Wenzel equation can be used. Wenzel equation can be used for homogeneous solid-liquid interfaces only.

$$\cos\theta_w = r\cos\theta$$

Where θ_w is the apparent contact angle, r is the ratio between the surface area over the projected area r value is 1 for a smooth plane surface and $r > 1$ for a rough surface and θ is the contact angle of the smooth surface obtained by young's equation.

When apply to a heterogeneous interface the Cassie – Baxter equation model can be used to calculate the contact angle of the superhydrophobic surface.

$$\cos\theta_{cb} = f(1 + \cos\theta_w) - 1$$

Where θ_w is the Wenzel contact angle for rough surfaces, θ_{cb} is the Cassie – Baxter contact angle for the rough surface. f is a parameter change with the surface. For a fully wetted surface (flat surface) $f = 1$ and for the liquids which do not touch the surface $f = 0$.

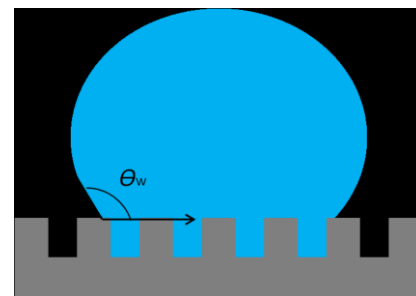


Figure 2: water drop on a rough surface.

Source:

<https://journals.sagepub.com/doi/pdf/10.1177/2516598419836345>

Modern applications

The superhydrophobic surfaces can be fabricated by different methods. Some methods are templating technique, etching nanograms, electrospinning of fibres, lithography, 3D printing, vapour deposition technique and plasma technique are some of them. Superhydrophobic surface applications can be found in different industries. Some of the applications are,

Protection coatings for electronic devices in a humid environment.

In a humid environment due to the water absorption of the sensor (figure print, gas sensor) the drift of the signal and surface conduction can be reduced. To get over this error by using a thin film of disposition by using the photochemical process on the sensor.

Anti-icing and desalination

The superhydrophobic surface of the anti-icing coating was tested using a nanoparticle-polymer composite by Lianglian Cao and his team. They experimentally prove that surface can prevent forming of ice on the aluminium surface. This is very useful in cleaning the areas of objects which are frequently covered with ice.

The reverse osmosis desalination process is the method mostly used to convert seawater into freshwater. But this process is much more expensive and complicated. One simplest method is evaporative desalination but in this process, salt is left as a residue. To prevent that a volumetric superhydrophobic coating can be used for evaporative desalination.

Antibiofouling

Biofouling is the buildup of small animals, plants, algae or microorganisms on a moist surface with a mechanical function, resulting in structural or functional problems on ships, submarine hulls, gates, ponds, medical etc. Using a chemical coating of nanotexture could help to reduce the biofouling on the surfaces but remove the biofouling effect anti-fouling property of the superhydrophobic can be used.

This coating helps to have long-lasting surfaces for medical and marine environments.

superhydrophobic coatings

When the coating on surfaces like mirrors, protective coating for solar cells, window glass and car windshields sensors, aerospace applications needed to be coated by using a transparent anti-reflective coating otherwise the purpose of the object could not be done. Kirill Isokav and his team experimentally proved an anti-reflective coating by using a glass-like alumina layer capped with plasma-deposited fluoropolymer. From that, they were able to get 94.5% average transmission with 173° advancing and 160° contact angle. Another method is chemical vapour-enhanced deposition (CVD) with a low-density polyethylene using double plasma.

Energy storage devices and microvalves

Lifton propose a method that modified the battery performance by silicon electrodes with superhydrophobic nanostructure properties. The method is the active electrode materials are separate from the liquid electrolytes. Then it acts as a storage bank creating a high capacitance.

Carbon nanoparticles trapped inside sol-gel binder can be used as a storage device and how the capacitance acts when the plasma treatment changes the surface properties and become super hydrophilicity was discussed by Bol et al.

In the microfluid, biochips like a lab on a chip have to face a problem like gathering protein on the surface of the chip and around the surface of the chip. To solve the problem, develop superhydrophobic microvalves which have a shape of a fishbone without usual valves. They can reduce the binding properties of the surface and low protein folding. Some superhydrophobic-type microvalves are used to control the flowing speed and pressure inside the microchannels.

Textile and oil-water separation

The resistance to absorbing water in the superhydrophobic surfaces is used by textile industries to manufacture superhydrophobic textiles. The simplest method to make a water-resistant surface is coating it with grease, oil or wax. In the textile industry, these are manufactured using cotton-based textiles modified with silica nanoparticle-based sol-gel.

Fabrics and fibres which have superhydrophobic properties are frequently used in the preparation of water from oil. In them, oil can easily penetrate through the fabric but water cannot penetrate due to less surface tension of the oil.

These are some applications where the properties of the superhydrophobic are applied. In the near future more applications will be discovered in this field due to the easiness which given by superhydrophobic surfaces in the different activities.

G.S.K.Gamage

4th Year Physics Special (2021)

Sustainable Material Innovations to promote a Circular Economy

Earlier, humans used to collect natural materials based on the materials' weight, strength, and hardness in structural applications. The essence of the selection criteria changed vividly when humans discovered that the properties of natural materials can be changed significantly by altering their structure. Notably, when humans learned to extract pure metals (iron) from natural oxides (iron oxide - rust) or to increase the strength of materials by mixing one element with another (alloys). This advancement in making novel structural and functional materials paved the way for the industrial revolution. Thus, it was a paradigm shift, where instead of gathering natural materials and depending on their original properties, the design and synthesis of artificial materials began. However, as a side effect of fabricating these artificial materials, their capability to degrade naturally within a short period was very low. Initially, this effect was ignored by society as they were fascinated by what these materials could do, but as the scales of production increased with population and consumption, pollution due to these materials has grown beyond a crucial point. Without discarding these materials, scientists have come up with an alternative solution to give additional efforts to create materials that can be used for their original function again. It will reduce material consumption as well as pollution.

Therefore, researchers are realizing new paradigms in sustainable materials by connecting the gap between basic material science and sustainable technologies. In this article, the focus is on some recent sustainable material science innovations that were invented to promote the circular economy.

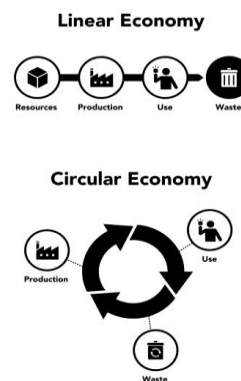


Figure 1 - Linear economy Vs. Circular economy
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What is Circular Economy in Materials?

A closed-loop system where the input resources and outputs such as energy, waste, and emissions are minimized by reducing the materials and energy loops is known as the circular economy in materials. Efforts have been given to find better ways to retrieve the products from waste and make them raw materials by converting the waste to its kind or other, by breaking and rearranging those bonds between elements.

What are the main areas focused on by researchers in sustainable material innovations?

Sustainability-related innovations can be seen in materials provision, processing, and applications in different areas. Among them, a lot of experiments are done on material innovations for energy-related challenges: renewable energy conversions, flexible power plants, electric grids, and energy storage. Moreover, research is done on how sustainable materials can be utilized for areas in transportation, electronics, smart materials, biotechnology, etc.



Figure 2 - Sustainable solutions for a circular economy
Image credit: <https://pixabay.com/>

Energy:

After the proceedings of the Paris Agreement on climate change in 2015, researchers have suggested different ways to accelerate the decarbonization of primary energy carriers such as the electricity grid and combustion of fossil fuels for vehicles. Some of the proposed ways to do this were by switching to renewable energy options (solar, wind), nuclear energy, energy storage for electricity and transportation and using CO₂ as feedstock for chemical fuel. Most of the industrialized countries are driving towards renewable energy. Low-dimensional micro and nanostructured materials and devices are being utilized for energy harvesting schemes of low-carbon photovoltaics and solar thermal power converters. The performance of chalcopyrite thin-film solar cells has been optimized by structuring the surface with nanotip arrays to enhance the efficiency and the plasmonic effects of photovoltaic cells. Using nuclear energy can be an ideal carbon-free solution, for that more sustainable and safe nuclear generators are being constructed. Novel materials and configurations to facilitate high-temperature operations of turbines for energy efficiency improvements have been made possible. Additionally, new bio-inspired processes based on nanocatalysts and artificial photosynthesis are being developed to increase energy efficiency.

Transportation:

The weight of seating materials in air and train transport has been reduced by replacing metal and wood with recyclable plastics. The use of new materials with high strength and durability for the aircraft parts and the engine can enhance its performance by improving thermodynamic efficiency, lowering gasoline consumption, and reducing the noise of motor operations. Graphene-integrated carbon fibres have been used to protect aircraft from weather-related disasters as they increase the conductivity and weigh less in comparison to traditional copper meshes. It can save fuel and enables a greater passenger load.

In addition to these new materials, new manufacturing methods for them have been assisted by extensive physics-based research integrated with computational materials engineering. Furthermore, electric vehicles too have offered an alternative to fuel-powered transportation. These innovations have caused lowering costs, increased safety and battery life, and reduced charging times. Due to these electric automobiles, the demand for Lithium, Cobalt, Nickel, and Platinum has increased as they are used for the cells that are employed in electric cars. Therefore, this has caused sustainable metal management where sustainable mining techniques are being practised.

Smart materials:

To optimize sustainability and develop new smart materials steadily, scientists have come up with innovative materials such as smart construction materials, smart non-construction materials, and smart structures. Construction materials like smart concrete, bricks and wrap can be used in fields of architecture to promote sustainable architectural concepts. Examples of smart non-construction materials which have been designed to promote sustainability are smart glasses that consist of light control properties and smart polymer composites. Electrically induced self-healing materials also have been successfully tested on materials like steel. These alloys were subjected to short pulses of electric current which caused them to transform or recrystallize spontaneously. Similar approaches are being taken to create such platforms for refractory ceramics, another promising material that can be used in sustainable applications.



Figure 3 - Windows using smart glass
Image credits: <https://pixabay.com/>

Electronics:

New fabrication techniques such as environment-friendly solution processing and low-temperature spin coating techniques which will save costs and give mass production are being employed to make transparent, flexible, and sustainable electronics. Among them are electronic displays and wearable devices. They are based on thin-film oxides, organic photovoltaics, and LEDs which are made from organic semiconductors and phosphorescent metal-containing polymers. In addition to new efficient energy solutions and advancements in innovative materials, the management of the world's resources has become an essential component of a sustainable circular economy. The 21st century has led to a phase of numerous global issues and continuous threats to the environment. Nevertheless, sustainable designs and technologies can give long-lasting solutions for resource conservation and enhance the living standards of people.

T.G.T.K. De Silva
4th Year Physics Special (2021)

Ultrasound Imaging Technology

Ultrasound imaging, also known as “Sonography”, is one of the key inventions in the medical diagnostics field. This has received a lot of recognition due to its ability to perform scanning without the use of radiation and making it completely safe and non-invasive and taking real-time images of inside the body such as the fetus of a pregnant woman.

As the name implies ultrasound technology uses ultrasound waves which lie in the 2 – 18 MHz frequency range. The fundamental idea is that the waves are sent to the body and are echoed back after hitting the tissues.

Piezoelectric transducer

The ultrasound wave is produced by a “transducer”, also known as the “probe” which is put on the body to perform the scanning. The front of the transducer has a layer of piezoelectric crystals. Quartz crystals, ceramic materials and lead zirconate titanate can be used for this. These crystals have unique electromechanical properties. When an electric current is applied to the crystals they start to vibrate and create sound waves in the ultrasound range. This is sent to the body. Afterwards, when the echoed ultrasound hits the transducer’s piezoelectric crystal layer it converts the ultrasound wave into electric current and sends it back to the machine. By stacking piezoelectric elements into layers in a transducer, it can convert electric energy to mechanical energy and vice versa more efficiently.

The transducer consists of several more components.

1. Acoustic lens
2. Matching layers
3. Piezoelectric crystal layer
4. Damping block
5. Acoustic insulator
6. Plastic housing
7. Transducer lead
8. Positive electrode
9. Ground electrode

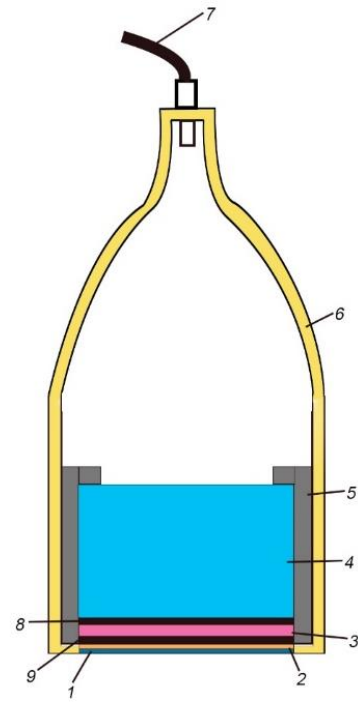


Figure 1: Piezoelectric transducer

Acoustic lens is made of hard rubber, and it focuses the waves and helps to reduce the scattering, which results in a better resolution of the image.

The matching layer reduces the impedance difference between the crystals and the skin the transducer is in contact with. Because of this layer, more soundwaves will penetrate the skin. Damping block is made from a very dense substance, it absorbs the energy that is emitted from the back of the crystal and monitors the vibrations.

An acoustic insulator ensures that no other sound interferes with the transducer.

Plastic housing provides electrical insulation.

The transducer lead sends the current signals into the computer.

Positive and negative electrodes allow the electrical connection.

A coupling medium (gel) must be used between the transducer and the skin. This is done to prevent trapping a layer of air between the transducer and skin interface. This gel can further help with a smooth scanning process.

Interactions with the tissues

The ultrasound waves that are sent to the body are absorbed, scattered, refracted, and reflected by the tissues.

The absorbed wave energy is converted into heat. High-frequency waves are absorbed faster than lower-frequency waves. Bones absorb the waves better than soft tissues and soft tissues better than fluid. Absorption will cause a reduction in signal strength. The amplitude of the reflected wave depends on the impedance of the medium and the incident angle. Therefore, to observe the sharpest images the transducer must be placed perpendicularly to the targeted area. If the surface is not smooth the wave will scatter in many directions instead of going back to the transducer, causing a reduction in the quality of the image generation. Waves that are not incident perpendicularly to the surface will undergo refraction, causing a reduction in the intensity of the reflected wave. Which will again reduce the quality of the image.

Images resolution

Characteristics of the wave such as their wavelength determine the resolution. There are two important resolution types, axial and lateral.

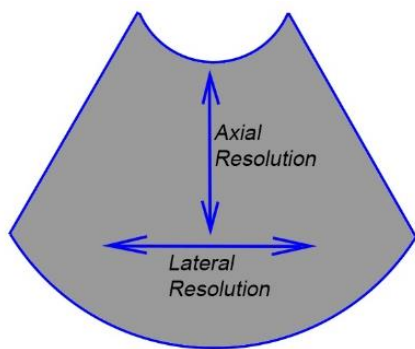


Figure 2: Axial and lateral resolutions

The axial resolution means how fine the pixels are from superficial to deep orientation. The shorter the wavelength i.e., the higher the frequency the better the axial frequency will be. From figure 3 we can see that if the wavelength is relatively shorter than the distance between two tissue surfaces the more we can discriminate between tissue surfaces. The lateral resolution on the other hand can be increased by a more focused beam.

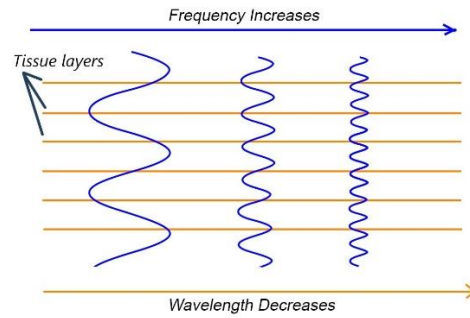


Figure 3: High-frequency vs low-frequency signals with axial resolution

Generating the images

The computer records the amplitude of the returning wave and the time it takes to return. The transducer sends the signal in a small fraction of the time and the rest of the time it spends on listening. Depending on the time the wave takes to return it can determine the depth of the reflecting surface. The amplitude of the echoed wave is converted into a brightness value on the grayscale.

The structures within the tissues can be differentiated with these grayscale measurements. Hyperechoic structures look light grey or white which produce high amplitude echoes (e.g., bones). Darker grey structures are known as hypoechoic (e.g., solid tumours). Solid black structures are categorized as anechoic (e.g., cysts). Structures that produce a similar echo to their surrounding area are known as isoechoic.



Figure 4: Hypoechoic, hyperechoic, and anechoic structures. Image credit: Das SK. Bedside ultrasound of the abdomen - Part 1. Curr Med Issues 2016;14:113-20

Doppler ultrasound

The Doppler Effect is used to determine the blood flow of vessels. The flow direction is dependent on whether the motion is toward or away from the transducer. The colours red and blue are selected according to the convention. Spots that appear red carry blood flow towards the transducer while blue indicates flow direction away from the transducer.

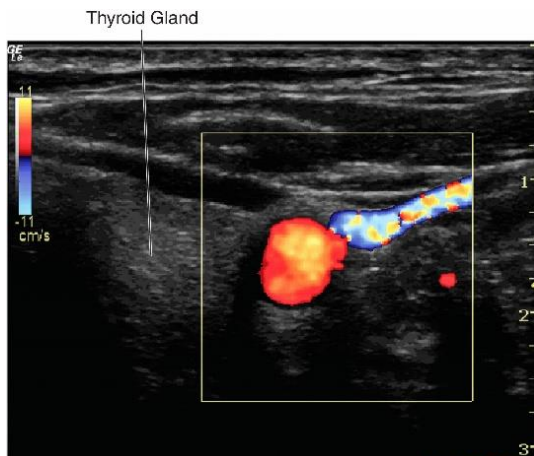


Figure 5: Doppler ultrasound with its colour convention. (Image credits: Hadzic A: Hadzic's Peripheral Nerve Blocks and Anatomy for Ultrasound-Guided Regional Anesthesia, 2nd ed. New York: McGraw-Hill, Inc; 2011)

Latest advances in Ultrasound Technology

Volumetric ultrasound gets this name because of its ability to produce images with more visual volume, and almost replicate the actual structures of organs making diagnosis easier for some instances.

Contrast-enhanced ultrasound also known as CEUS is very effective in tumor detection. With more advances this could replace MRI and CT scans to diagnose cancer and other medical issues.

*Sithumini Perera
4th Year Physics Special (2021)*

Beating Cyber Criminals with Quantum Solutions.

“The key to solve huge Cyber-criminals lies in the invisible quantum particles”

As hackers become more novel and intelligent in their cyber-crime efforts, modern technology users have to seek new technology to confirm that their systems are more secure and potentially unhackable. For some types of hacking, quantum physics can be used as the ultimate answer, where it provides a way to share information with absolute security. The ongoing quantum physics researches are focused on developing more sophisticated tools that will help to stop the cyber-crimes.

A secure Quantum Key

For example, if someone wants to send their credit card data to a friend through a network, then they can use an identical list of random numbers that are private to them as a secret key to encode and send uncrackable messages. But the problem is the shared key is made of ordinary bits of information which is possible to be intercepted, copied and then sent on without their knowledge. As a solution, a security key using quantum bits can be developed (qubits) instead of regular bits. These qubits are made from photons, which are individual particles of light.

Different from regular bits, photon qubits can have both 0 and 1-bit values at the same time according to Heisenberg's uncertainty principle. The photon qubits can also be made in ordinary 0 or 1 states as well as quantum superposition states, and choosing these states randomly can make the key more secure. Since photons obey Heisenberg's uncertainty principle, if the hacker measures data, the information carried will be altered and this alteration reveals the hack to users.

An (en)tangled web for criminals

Other than that, there is a potential for hacking their photon-measuring devices as well. This problem can be solved by using quantum entanglements which state that two entangled photons have quantum-linked states.

So, measuring the data stored in one photon tells about the data in the other even if the two photons are far apart. Measuring the first photon often yields a random result, particularly, a random bit 0 or 1. This means if the sender and the receiver perform the same measurement on separate photons from an entangled pair then they will have a random, but a shared number. By repeating this process on many entangled pairs, a secret key can be generated. Hence, if any hacker tries to measure one of the photons, will break the entanglement and will be able to detect it. So, if users can verify that they share the entanglement, the channel is proven trustworthy.

Quantum Readout

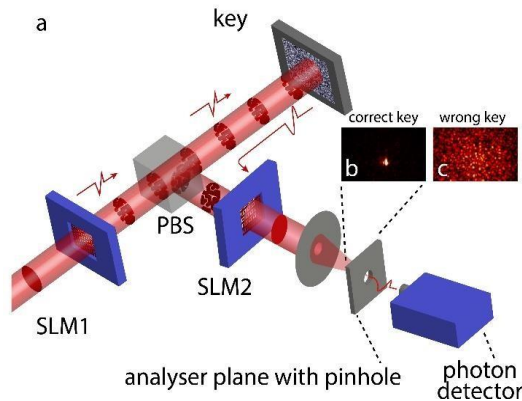
Other than these cyber-crimes, ATM (automated teller machine) card hacking has become an increasingly common crime. But a recent development called, Physical Unclonable Functions (PUFs) has made it possible to fight back against these ATM card hackings. The PUF is a white paint consisting of millions of nanoparticles that can firmly scatter any light beamed falls at it. When the light bounces around the PUF that generates a unique pattern that can be used for authentication. But there is a bigger risk for the authentication protocol by digital emulation where a PUF could be cloned precisely, or physically emulated exactly even though it is very difficult.

But using quantum physics in the PUF readout would take off the risk of digital emulation. So, using quantum physics the challenge would be an unpredictable quantum state, more specifically a single photon which then interacts with the PUF and yields a modified quantum state. Now the verifier is searching for a lone photon in a specific complex quantum state instead of a “classical” speckle pattern. Now according to Heisenberg's uncertainty principle, if a hacker tries to watch the photon, it collapses the quantum state and any attempt at measurement destroys most of the information.

Also, it is not possible to produce an identical copy of a quantum state according to the ‘No Cloning Theorem’ of quantum. But the verifier, on the other side, knows the expected response exactly and can compute if the coming-back photon is in the right state in contrast to the hacker. By using the quantum readout concept, people can secure themselves from ATM card hacking. According to the wave-particle duality, a photon is both a particle and a wave at the same time.

As photons are particles it has to be detected as a single chunk of energy. Since it is a wave, it generates a speckle pattern response by spreading and interfering with itself.

According to the researchers, a single-photon speckle pattern can be verified by a Spatial Light Modulator (SLM) which is a programmable device that changes the shape of the speckle pattern of photons. The SLM can be programmed such that the accurate response from an optical PUF gets concentrated and moves through a pinhole, where a photon detector detects the presence of the photon. However, an incorrect response is converted to a random speckle pattern that does not allow passing through the pinhole.



Weird World of Quantum Physics

Researchers have developed various entanglement-based techniques like quantum steering for safer communications with suspicious devices where the steering provides the security of the device in exchange for robustness against real-world imperfections (imperfect optical fibres) by programming it with additional photon qubits. Due to Heisenberg’s uncertainty principle, a hacked measurement device is not able to grab the data encoded in these extra programming photons, which consists of the information needed to scam the steering test. This means even though that device is implementing the program’s instructions, it is not able to learn everything about those instructions (sounds wired, but it works).

Commercial prototypes of simple quantum key distribution (QKD) systems already exist and have been used to secure channels in real-world tasks like bank branches. To execute this type of quantum communication security technology, users will need quantum links for exchanging entanglements, quantum repeaters (quantum signal-boosting devices) which will need longer or more complex quantum links and quantum computer networks which are under development.

L.S.P.Perera
4th Year Physics Special (2020)

Wireless Capsule Endoscopy

Technology is constantly changing and developing, so everything becoming faster, smaller, smarter, and more efficient. For example, the telephone has evolved its shape, add new functions and recently the phone is completely wireless. This isn't unique to telephones, we no longer require a physical connection and the wireless revolution has opened the way for new ideas and solutions. The endoscope is another piece of technology that is used to examine a person's digestive tract. This fibre-optic video endoscope needs to be manually pushed through the organ. Also, the endoscope requires a physical connection or umbilicus that transmits light to illuminate the stomach or large intestine and returns the video images to display on a screen. Due to these cables, the process of passing the endoscope is uncomfortable for the patient. What if we could bring endoscopy into the future by allowing patients to undergo an explorative procedure without all the cables and physical connections? This little device is called a wireless capsule endoscopy and represents the evolution of endoscopy.

The first capsule endoscopy was developed by electro-optical engineer Gavriel Iidan in Isreal. Now wireless capsule endoscopy (WCE) is widely used to examine Stomach pain, Ulcers, gastritis, or difficulty swallowing, Digestive tract bleeding, Changes in bowel habits (chronic constipation or diarrhoea), Polyps or growths in the colon and also use to take a biopsy (removal of tissue) to look for the presence of disease. In addition, WCE can be used to treat digestive tract disorders. For example, the endoscope not only detects active bleeding but even instruments that can avoid bleeding can travel through the endoscope.

It's about 24 - 30 mm in length, the diameter is about 11 mm and it is similar to the size of a vitamin capsule as in figure 1. The outer shell is made out of biocompatible material. It moves through the digestive tract naturally with the aid of the peristaltic activity of the intestinal muscles. Once swallowed the camera moves naturally through the digestive tract up to the rectum within 6-8 hours. This technology consists of three components. The wireless capsule, the data recorder belt which is worn close to the waist, and the RAPID (Reporting and Processing of Images and Data) workstation for image review and interpretation. The camera can capture two pictures every second and the antenna sends them to the data recorder. A minimum of 50,000 images are obtained in eight hours examine. Patients are not required to retrieve and return the video capsule to the physician.

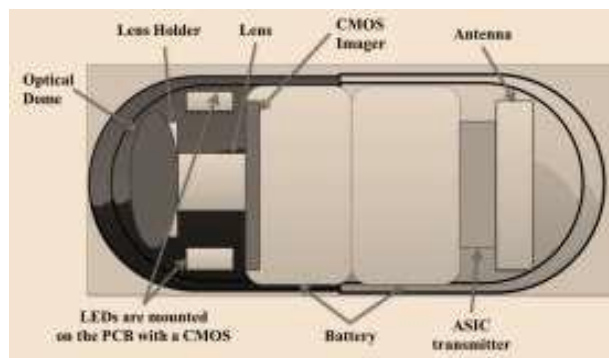


Figure 1 - Structure of wireless capsule Endoscopy

WCE contains an optical dome, lens holder, lens, illuminating LEDs, CMOS (Complementary metal-oxide-semiconductor) imager, battery, ASIC (Application-specific Integrated circuit) transmitter, and an Antenna. The optical dome is a non-conductive element of the capsule composed of two parallel curved surfaces and represents the front of the capsule shape. It contains light-receiving windows that are typically made out of BK7, UV-fused silica, and sapphire. Illuminating white LEDs are present near the lens and CMOS sensor which arrange in a doughnut shape. It provides evenly distributed illumination to the internal organs inside the digestive tract in dark. The number of LEDs varies with the manufacturer. The lens holder helps to accommodate the lens and avoids dislocation of the lens by tight-fitting. The lens is located behind the light-receiving windows.

So, light can easily fall on the lens through the windows and be transmitted to the image sensor.

A typical WCE consists of a CMOS (Complementary Metal-Oxide-Semiconductor) image sensor placed on one or both sides providing images with a typical resolution of 320×240 pixels (photosites). An array of the colour filter is placed over the pixel sensor array to capture the colour information. These photosites convert the incoming light into charge by exposing the pixels to the light for a certain amount of time. Then this charge is converted into voltage and voltage amplification is carried out by the pixels themselves using the CMOS transistor that switch to each pixel. An analogue-to-digital converter (ADC) is used to convert the voltage into a digital signal.

An improved image sensor allows a wider angle view, more natural colour turning (colour balance), and improved detailing.

A typical lens allows for wide-field acquisitions (170°) of the visible intestine area. There are two button-shaped 1.5V batteries arranged behind the CMOS image sensor. These Silver oxide batteries (Zinc/Alkaline Electrolyte/silver oxide) are used to supply 8 hours of continuous power for the device. It has an even discharge voltage doesn't harm the body and is disposable.

ASIC (Application-specific Integrated circuit) transmitter is arranged behind the batteries. Image data processing and transmitting were carried out by ASIC. The Human body is used as the transmission medium for transmitting data from inside to outside of the body. It contains two transmitting electrodes that are electrically isolated from each other. The antenna is arranged at the end of the capsule and it receives the processed data from the transmitter. An image recorder which is worn around the waist receives data from the antenna inside the capsule.

The data is finally downloaded to a computer workstation and continue the data processing to produce an informative video for the doctor. Depending on the application, WCE has different operating times, number of cameras, and the frequency of taking images. Some advantages of this capsule are as follows; the capsule is easily swallowed, it is painless and sedation free during the procedure, the patient can relax in comfort and walk, not necessary to stay at the hospital, exposure to potentially harmful radiation does not occur and simple procedure. The main drawbacks are it is impossible to control the behavior of the camera, it will stick if there is any obstruction in the intestine. This pill camera technology in future can be designed to sense temperature, viruses, and various diseases in the body. This capsule is a pioneering concept for medical science in the 21st century. So this Wireless Capsule Endoscopy is another giant step for mankind.

I.P.Liyanagunawardana
4th Year Physics Special (2020)

Generator for energy harvesting from water droplets

A team of scientists from the University of Twente and South China Normal University designed a novel electrical generator. The specialty of the generator is that it can harvest energy from water droplets which impact it and other sources of mechanical energy.

Renewable energy sources have higher demand at present because of the increasing environmental threats like the energy crisis and global warming. Rain droplets are a source of mechanical energy which can find in everywhere that can be converted into electrical energy.

There are other methods which have been proposed for harvesting energy from water movements. Reverse electrowetting, triboelectric Nanogenerators (TENG) and droplet-based electric generator (DEG) are some methods. But these methods were low efficiency, low stability and need external voltage. Reverse electrowetting needs external energy. TENG was the first invented method that has a low density and poor stability of surface charges on tribo-layers. The recent method DEG has better stability compared to TENG, but the energy harvesting efficiency is still limited because of the density and stability of charges.

It is a challenge to find high-efficiency nanogenerators for water-related applications. The new method, a charge Trapping based Electricity Generator (CTEG) has been proposed to achieve these challenges.

Generating a current

This CTEG is based on the Electrowetting-assisted Charge Injection (EWCI) phenomenon, a recently discovered phenomenon. The advantage of EWCI is that the trapped charges are highly stable and the density of negative charges does not degrade even in a water vapour environment. A new homogeneous electrowetting-assisted charge injection (h-EWCI) method was used in the CTEG for applying a high electric field on a large area of dielectric stacks. We can explain the electrical generator as a permanently charged capacitor and as an electret. The researchers used a novel method to charge this capacitor. The method is based on electrowetting and they have injected charges into an insulating layer of the capacitor. Electrowetting is the modification of the ability of water which is water contact with a solid surface with an electric field. The capacitor redistributed the induced counter charges when a droplet impact. Then the electric current is generated.

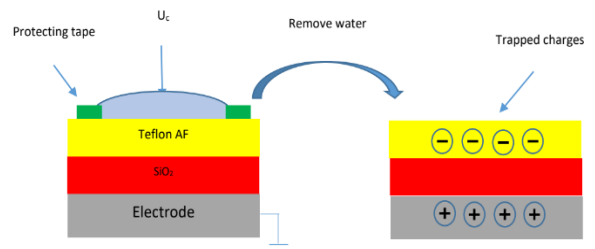
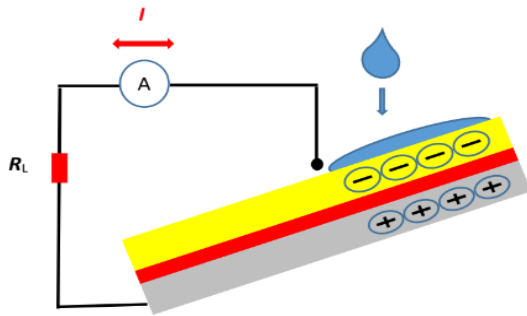


Figure 1 - h-EWCI method for generating surface charges.

The figure shows the h-EWCI method for generating surface charges. Bottom electrode-doped Si wafer, dielectric layer-thermally grew SiO₂, spin-coated a fluoropolymer (FP) film on top of the SiO₂ surface, charge area defines applying a mask of polypropylene (PP) and water placed on top of the FP. A charging voltage U_c is applied for 15 minutes and then remove water and voltage. The speciality is this charging procedure is applied only once and does not need to renew during operation. Now the surface charge density is homogenous throughout the charging area of the h-EWCI which is important for CTEG.

Next step, a Pt wire is the top electrode on the top of it and connect the wire to the bottom electrode with a load resistor R_L . Water droplets fell into the surface first impacting the FP surface and then spreading out. The droplet shows its maximum spreading and touches the Pt then a current peak generates. This current peak value is proportional to the surface charge density. This current value is higher than in previous research cases. The following figure will provide a clear image of these steps.



These steps will give you an idea about the electrostatic induction which is the basis of the current response in this method:

- (a) All counter charges induced by the trapped charges are located at the bottom electrode before a droplet touches the wire.
- (b) The counter-charges transfer from the bottom electrode to the top electrode when the spreading droplet touches the wire then an electric current signal is generated.
- (c) The counter-charges are again located at the bottom electrode after the droplet comes down and is ready to generate electricity from the next drop.

The current peak generated by droplets decreases with the increasing load resistance. It is no difference between the energy harvested from an individual droplet or a continuous stream of droplets.

Increasing the current

Current varies with the number of injected charges. They increased the number of charges by using composite samples which have high strength. They were able to occur more efficiently in charge redistribution in the generator because of the smart design of the electrodes. The percentage of converting the mechanical energy of an impacting droplet into electric energy is 11.8%. The researchers also stated that the energy harvesting efficiency does not degrade after 100 days and only 15 minutes of charging will be enough for long-term performance. Power density is higher than TENG and more than 3 times as high as DEG. The total energy harvested from a single drop is $0.35 \mu\text{J}$.

Performance and Applications

This CTEG device was tested using droplets of DI water, rainwater and seawater. CTEG shows that it is suitable for harvesting energy from drops of salty water. It also shows decreasing current signals with increasing droplet conductivity. These discoveries reveal that mechanism of CTEG is different from other nanogenerators. Therefore, CTEG has not limited to droplet-based energy harvesting. Niels Mendel, one of the authors says: "Our method can also be considered for other applications where mechanical energy needs to be converted into electrical energy, for example in wearables, from tidal waves, or for sensing".

More information:

Hao Wu et al., Charge Trapping-Based Electricity Generator (CTEG): An Ultrarobust and High Efficiency Nanogenerator for Energy Harvesting from Water Droplets, *Advanced Materials* (2020). DOI: 10.1002/adma.202001699

W. A. D. U. Ishadi
4th Year Physics Special (2020)

Can piezoelectric energy harvesting be used for military Purposes?

Today's life is more difficult without electronic power devices. A whole day, a whole week, a whole month, a whole year without an electrical power supply, we cannot imagine that day also. This implies how much our lives are bonded to the devices related to electricity. Due to the development of modern science, using wireless electronic devices is very popular today. For most of those devices, batteries are used. But in some cases using batteries is impracticable. Body sensor networks and inaccessible remote systems are examples of such cases. Finding an alternative or a solution to this recurring problem is the basis of the development of science and Technology. Energy harvesting is the best cure for this issue. Energy harvesting is the collection of a small amount of ambient energy present in the environment and using that energy to power wireless devices, especially in places where the usage of batteries is impracticable. And also, there is another risk in batteries when considering them at an environmental level.

There are various types of energy harvesting technologies. Out of this Piezoelectric energy has a higher position. The word 'Piezo' comes from the Greek word 'Piezein'. 'Piezein' means press or squeeze. So the piezoelectric effect converts the kinetic energy in the vibrations or kinetic energy in the shocks into electric energy. Piezoelectric energy is a reliable solution for wasting vibrating energy and that vibrating energy can be converted into valuable and usable electrical energy.

For the production of piezoelectric energy piezoelectric materials are used. The materials that can produce electrical energy from the applied mechanical stress are piezoelectric materials. Quartz, Polyvinyl Fluoride, Zinc oxide, and Aluminum Nitrite are some examples of piezoelectric materials. Lead Zirconate Titanate is the most common crystal used in piezoelectric generation.

The displacement of electric charges within a crystal structure creates the generation of the piezoelectric effect. External pressure or stress causes the displacement of electric charges. If there is no external mechanical stress, then the charge distribution is symmetrical and the net electric dipole moment becomes zero. Due to the applied external mechanical stress net polarization will be created. This is the piezoelectric effect.

There are various applications of this valuable Technology; the Piezoelectric effect. It is highly used in piezoelectric microphones, ultrasound imaging, sonar sensors, and piezoelectric transducers used in musical instruments. Besides those, this effect is used in the medical field also.

Can we use this technology for military purposes?

Piezoelectric energy harvesting can be used to supply the supplement power for dismounted soldiers. For this purpose piezoelectric material such as Lead Zirconate Tartanate is used. Piezoelectric material is applied to the heel of a combat boot. When the soldier is walking mechanical stress is generated. Then that mechanical stress is converted into electrical power due to this piezoelectric material.

When a soldier is walking, due to the generation of mechanical stress electrical charges in the crystal structure is aligned and creates a net electrical dipole moment. That electrical oscillation output can provide power. This power can be used in some applications such as global positioning systems, Dead reckoning systems and the army survival radio. Not only these but this piezoelectrical energy can also be used to power some consumer electronic devices such as cellular phones, two-way communicators and pagers. As the piezoelectric material Lead Zirconate Tartanate is used in the Heel strike generator because it has an adequate coupling coefficient and low dissipation.

There are two parts to the Heel strike system. They are Heel strike generation and power electronic circuits. Power electronic circuit is used to extract, store and regulate the electrical energy output. There are four phases of electric energy generation in the Heel strike generator.

AC voltage from each of those phases is taken by power electronics circuits and rectifiers to produce DC pulses that charge the storage capacitors. Then these storage capacitors can discharge the stored DC pulses as regulated 12V DC output pulses. The main advantage of this piezoelectric energy harvesting is, it is a renewable source of power and it does not require a dedicated effort. Due to the piezoelectric energy harvesting technology, all the useful and useless works can be turned into effective and powerful electrical energy.

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Chethana Lakshani Senevirathna

1st Year (2021)

A brief history of the Rockets

Since the beginning of civilisation, humans gazed upon the sky, observed it, and tried to interpret what they see as common knowledge. They tried to explore what is beyond their observations. As an animal filled with curiosity and fuelled by the eagerness to acquire knowledge, humans tried to conquer the sky and what is beyond it. These early attempts were done with crude technology but with great courage. The first successful flight attempt was done with a hot air balloon, but it wasn't until the development of the first self-propelled aeroplane by the Wright brothers that aviation was taken seriously by non-scientific humans. From that age onwards aeroplanes were developed radically and were used in many fields by humans. After conquering the sky, humans felt the need to explore space, which is beyond the limit of the aeroplanes that were developed simply because the atmosphere gets thinner as we move away from the earth and aeroplanes need air to fly. So, any of these aircraft couldn't be used to travel to space, hence the need for a new type of vehicle was felt strongly.

The most desired type of aircraft needed to fulfil this ambition ought to not rely on air or atmosphere to fly. These kinds of flying vehicles were conceptualised, and scientists of that day developed equations and methodologies that govern the flight of these newly idealised "Rockets". But it wasn't until the second world war, anyone was successful in manufacturing a rocket which had the required capabilities. In the late 1930s and early 1940s, during World War II, Wernher von Braun a German spacecraft engineer and his research team were able to develop the first useful rocket. It was named as V2 rocket and used as a weapon to attack the enemy states of the Nazis. Hence this rocket was as well the first ballistic missile ever made by mankind. It was the first spacecraft to reach the Karman line, which is the commonly agreed boundary of the earth's atmosphere. This was a breakthrough in the history of

mankind even if they were used as weapons of mass destruction causing the deaths of over 9 000 humans. By the end of the war, more than 3 000 V2 rockets were built by the Nazis and used in the war.

After the war, Wernher von Braun and his team of scientists and engineers surrendered to the Americans and the production facilities used to develop these rockets were acquired by the Soviets. From this point onward the space race as we know it, a part of the cold war between the USA and the USSR was started. The V2 rockets used a liquid propellant rocket engine which was the first of its kind used in a mainstream application. A 75% ethanol-water mixture was used as the rocket fuel, while liquid oxygen was used as the oxidizer. The single most significant advantage of these rocket engines over traditional internal combustion engines and jet engines is that they (rocket motors) don't require atmospheric oxygen to travel through space where there's no atmosphere. They use liquid fuel and an oxidizer to burn and exhaust mass at a high rate which in turn pushes the rocket body in the opposite direction according to the law of conservation of linear momentum.

In the early days, there was scepticism that these rockets won't perform in a vacuum since there was nothing to push against by the exhaust gases, and it was proven wrong by the scientific community because the exhaust gases don't need anything to push against as stated by Sir Isaac Newton centuries ahead. The rockets work entirely according to the law of conservation of linear momentum, and in fact, these rockets were more efficient in the vacuum of space than they were in the earth's atmosphere due to the exact reason of lack of air in the vacuum. The air causes aerodynamic drag on the rocket and creates friction which ultimately reduces the efficiency of the rockets by a significant amount.

After the development of this V2 rocket and the start of the space race between the USA and the USSR, the field of rocketry developed rapidly. These two nations developed their space programs independently and those two programs were the most prominent ones even though there were other space programs conducted by some other countries which were successful too.

The first significant event of the space race was the breaking of the sound barrier by the Americans using the Bell X-1 rocket, the first manned vehicle to break the sound barrier.

Meanwhile, the Soviet space program too had a genius engineer, Sergei Korolev who was the chief designer of the soviet space program. With the help of captured German technicians, the soviets developed their rockets which led to the development of the first ICBM (Inter Continental Ballistic Missile) the R-7. And Soviets successfully launched the first artificial satellite (Sputnik-1) into the earth's orbit using the R-7 rocket platform. Then they sent the first man to space, Yuri Gagarin, using this rocket platform and it is still in use today. The main prominent feature of this soviet rocket platform is modularity. The rocket can eject the solid boosters and other stages after they have been used for the desired task so the mass of the rocket reduces and the energy needed to ascend is reduced.

Soon this modular feature was widely embraced by the rocket industry. Compared to soviet rockets, the US rockets were usually larger and their tasks were different from each other, the notable US rockets of this time were Atlas and Titan. With the start of the cold war, the space programs were funded largely by both camps. The soviets manufactured several expendable modular rockets such as Vostok, Proton and the legendary Soyuz. While the US manufactured notable rockets such as the X-15 and the well-known Saturn V. During this time manned spaceflight was gaining a lot of interest and with the apollo program the Americans were able to send the first man to the moon this was the groundbreaking event for the humankind. Then again, the Americans made a significant event by manufacturing a partially reusable spacecraft known as the Space Shuttle. This was a highly successful rocket design which led to the manufacture of multiple space shuttles by the US and led to the Soviet development of their version called Buran Energia. From this, the idea of reusability in the rocket industry was established but seemed too ambitious for the time.

Currently, the reusability in rockets has been a major development factor and innovative companies notably SpaceX have developed technologies which allow the rocket boosters to be reused by landing them vertically on the ground. Also, the cost of spaceflights has been brought down massively by these innovations. And space tourism is being promoted by some other companies like virgin galactic. Compared to the start of the rocketry field, the current development is slow because the industry has been developed to a high standard and since there was no war between major powers during the last few decades, the requirement of new ICBMs is low and current rockets systems are more than capable enough for the applications.

What started as a weapon of mass destruction was developed into a tool which could fulfil the curiosity of the human mind through exploration of space, and still, there's a long way for the rockets to ascend. These beautiful machines are true marvels of human imagination, and I hope there will be innovations and developments in this field to improve our understanding of the universe even more through space exploration.

Dumindu Sasanka
2nd Year (2021)

Fractal structures in the profile of physics

'In the mind's eye, a fractal is a way of seeing infinity' (James Gleick)

The world of physics is full of many semi-similar structures. Most of the time, those types of structures have coincided with Mandelbrot sets that the most famous object in modern mathematics. Furthermore, Mandelbrot's set is one of the essential tools to study the influence of fractal geometry on physical systems. In that way, a lot of fractal patterns can be seen in so many aspects of physics.

The relationship between fractals and quantum physics can be seen in many profiles. Imaginary time - Brownian motion and Zig-Zag paths of propagation in quantum mechanics (Feynman's path integral) provide evidence for the applications in fractals behaviour in quantum physics. The self-similarity of paths occurring in the path integral is considered the first example of fractal geometry in quantum mechanics. This was presented by R. P. Feynman and A.R.Hibbs. Fractional quantum mechanics has been built up with the new fractional path integrals approach. Schrodinger equation has been discovered as the generalization of fractal theory. Based on that, a new relationship between the energy and the momentum of the nonrelativistic fractional quantum-mechanical particle has been established and the Levy wave packet has been introduced into quantum mechanics. Not only those things but also, the equation of fractional plane wave function, Fox's H-function to derive a free particle quantum-mechanical kernel and a fractional generalization of the Heisenberg uncertainty relation are other related aspects which say us the relationship between fractals and physics., A free particle in a square infinite potential well, the fractional 'Bohr atom' and the development of a new fractional approach to the QCD problem of quarkonium are some applications of fractional quantum mechanics.

Also, Fractal-like patterns can be seen in a quantum material exhibiting strange electronic or magnetic behaviour, as a result of quantum, atomic-scale effects. This is a way in which fractal geometry is combined with quantum physical structures.

Cantor set is another representation of fractals. Microphysics reveals the fractal behaviours in soft materials and matter distribution in the universe. Fractional Maxwell's equations describe the fractal distribution of charged particles. Recent theories of quantum gravity pave the way to think about a fractal structure for spacetime and the dimensionality of space evolves with time. Here the reality is revealed as the Planck scale in 2D and that spacetime gradually becomes 4D at larger scales. Fractals are related to the infinite universe. Astrophysicists have an opinion that the forming of stars in their position in the universe is related to the fractal nature of interstellar gas.

In this way, beautiful structures of fractals can be seen in physical systems. Fractal shapes out of electrons, Particles of abstract fractal formation, and fractals in Metallic glasses. Complex systems in statistical mechanics and fractal time structures are identified as fractal structures in physics. Thus, fractals are built into physics in incredible ways. Because of that, it has been able to add extra beauty to physical structures. Hence the study of fractals with physics exists fascinatingly. However, fractal patterns and physical structures pave the way to see the world with curious eyes and identify infinity.

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Gangulali Gunasekara
3rd Year (2021)

The longstanding misery-Black Holes

Something so fascinating, yet unseen, unrecorded by man, and undetected by technology for decades, black holes prevail as one of the universe's greatest phenomena. A black hole, also known as a singularity, is known for its tremendous gravitational field and compelling mystery and it continues to be perplexing and inexplicable to everyone who strives to fathom it. A black hole is defined as an area of space with a gravitational field so intense that no matter or light can escape.

Humanity does not fully comprehend them, although there are some aspects of their origins that scientists are well aware of, such as how they came to be. The formation of a black hole can be triggered in a variety of ways, one of which is when a significant amount of matter gathers in a small region. "It's like heaping more and more books into a library, the shelves will eventually give way, and the library will become a black hole" Hawking remarks. Another way black holes are formed is when two stars collide in a binary system. A black hole is formed when two black holes combine. When a star runs out of energy and its mass becomes too great to hold, the star will shrink and its content will be compacted into an infinitely small, infinitely dense point called a singularity, which is the centre of a black hole. Given that some black holes are formed from the remains of dead stars, you might be wondering how they die. To put it another way, how can something that has already died... end up dying? Hawking radiation is responsible for this. There are always matter and antimatter particles combining and transforming into energy on the event horizon of a black hole. As a result, if an antimatter particle falls into the black hole's singularity, it will combine with a matter particle within the black hole's singularity, and "antimatter destroys matter" As a result, the black hole would decrease, but the difference would be negligible because "the greater the black hole, the shorter the lifespan"

Secondly, it's vital to understand how black holes function and to examine some of the hypotheses that are still unknown to the general public. One of these hypotheses was proposed by Albert Einstein, who stated that if an astronaut approached a black hole, he or she would not notice it and would ultimately pass through the black hole's event horizon (the place of no return). It is impossible to escape once you have crossed the event horizon. According to this theory, the black hole would ultimately tear the astronaut apart, destroying him. The paradox is known as the Firewall. Another explanation, known as the holographic theory, is causing a lot of debate, but it is the one that experts are leaning towards. When matter travels over the event horizon, the black hole transforms everything into information, according to this concept. Everything is made up of information, which is the arrangement of particles. If you organize the particles one way, you'll get a mango; if you arrange them differently, you'll get a smartphone; and if you add more and more particles in other patterns, you'll obtain a person. As a result, all substances that pass across the event horizon are converted to information and transformed from 3D to a 2D state.

However, the data would be shown as a hologram that appeared to be three-dimensional but was not. If the object that fell into the black hole was a human, he would be unaware that his physical condition had altered. Stephen Hawking devised the last theory, which likewise has to do with the information. He believes that once within the black hole, all matter transforms into information, but what happens when the black hole vanishes? All information would be destroyed, therefore the particles that emerge from the black hole would be meaningless and "bear no resemblance to what fell in."

If this is true, we would have no past since we would have no knowledge of our origins and hence no identity if all information was destroyed. Hawking, on the other hand, has presented a thesis that could explain what happens to the information. He claims that because information is preserved, a black hole is not what people thought it was, and that it is not a prison with no exit. "This tells us whether it is possible to fall into a black hole and emerge in another universe," Hawking says. Information would be stored but would not be accessible.

The death of a star generates the formation of a black hole; however, this only occurs if the star dies with a mass more than 2.8 times that of the sun; at that point, no force will be able to stop the collapse.

It's also worth noting that black holes warp our perceptions of space and time. When approaching a huge body, a curvature of space-time is formed, which means that if a human were to be orbiting on the edge and avoid falling into the event horizon, time would slow down for that individual. For example, suppose you spend a week orbiting a black hole and then return to Earth to discover that ten years have passed but you have only aged a week. Near the event horizon, time slows down, so the week you spent there would fly by, but time back home would remain constant, and if the black hole is large enough, that week might be the equivalent of billions of years on planet Earth.

As a result, what has been discussed so far may be perplexing and difficult to comprehend at times. Nonetheless, this is an enthralling subject, with a theory that will continue to enthrall humanity. Scientists will continue to learn more about black holes, and some new hypotheses will be confirmed true while others will not. In this sector, research will continue in the hopes of making them less confusing to the human brain in the future. Instead, they'll be something that's both transparent and terrifying for the entire culture.

Panchanie Karunaratne
2nd Year (2021)

Physics and Truth

Physics has in the last two centuries pushed humanity to its absolute limits of knowledge and comprehension. The bizarre world of our quantum universe with its continuous relativity is truly astounding. It begs the question of what exactly it is that physics captures, the mysteries of our physical world or the marvel of being able to observe and experiment on such a spacetime. In this article, we shall ask ourselves what this Physics truly is. To which the answers thereof shall be left for the discerning reader.

As a start, this Physics has paved the way for us to be able to consider “Precision Physics”. While the astute Engineer might deem it feasible to consider 5-8 decimal places of accuracy, the modern physicist remains ever hungrier for more than 14 decimal points of accuracy. This first fact reveals that our search is certainly something that goes beyond the practical and feasible, and reaches deep into the soul in opening up questions about who it is each of us are, and what it means for us to live in such a beautiful and intelligible universe.

The second fact to consider is how in this search for self-realization we are shouldered by a broken crutch. Ever since Kurt Gödel presented his incompleteness theorems in 1931, it has been evident that there is a hole at the very foundations of mathematics, the language and logic that we use to talk about our universe. It is believed by many that the scientific method too may have to be adjusted for us to move forward. That is, in our search for Truth, we may never find the end of this human project that is Physics.

The Classical Popperian scientific method that is still in use today is recursive in its presentation of facts. In conducting research under this method, the key motivation is to continue to produce testable experiments for any and all current or new theorems that are held with esteem. This means that the theory of General Relativity for example is only as true as having passed all of the experiments we have been able to test it against by our own imagination of experimental design.

To which end, we can never say that GR or QCD are true theories, as that would be going against the Philosophy of Karl Popper.

In this, it is evident, that this search for Truth began in its fundamental philosophy to be an incomplete means to an end. But what is fascinating to many is how irrelevant this has been in the eyes of the sciences. Physics is known as the King of the Sciences, to which I can say no more than to regard the honourable title, but in this at least it is fair to say that Physics has allowed us to chip away at the Truth that lies forever hidden from us under Popper.

It does not mean, that we like all those who have gone before us should lose hope. I wish to ask an even deeper question in this context, why is it that Truth is so important to humans? The truth that is absolute, as written in the form of an equation is so strange when humans really ought to be pattern-seeking creatures in how we have been shaped through evolutionary history. Unintuitive, given how even in the context of modern physics, we seem to study particles and behaviours that seem very fittingly describable as arcane.

From leading physicists questioning if we should stick to Popperian logic, to the delayed choice quantum eraser experiment where subatomic particles seemingly go back in time and destroy all of causality. From questioning the notion of Physicality itself because of the existence of virtual particles to seeing physicists delve into the realms of philosophy and understanding. This article stands as exhibit A of that motivation.

Why then study physics?

Studying physics to me is all about the metaphysical power and reach that physics is able to touch. And in that fascination to transform lives to think of themselves objectively, realistically, and to be united in the smallness we are in this universe. If indeed we find a different method of scientific inquiry than what popper has suggested: we stand to see the universe with fresh eyes and a longing heart.

Physics is a new assurance, that even if powers and dictatorships might destroy Truth as it stands, even if Truth becomes a whisper of a doubt. That we may know, that this universe will always be singing a song that whoever listens may hear and that we can be proud commentators of that wonderful song.

So while philosophy stands in the middle of questions asked and answers given, Physics stands between the physical and metaphysical realities of our existence unfolding. It trains us to be Brave to ask questions and humbles us to accept whichever answer we might receive. It perseveres us to seek the truths of our natural world and the problems of human existence objectively, that in searching we might learn that Truth is always worth persevering for.

Rahul Vishmith Silva
2nd Year (2021)

A Massive Flight: under the Feathers of Bald Eagles

As a daydreamer looking at the sky every day, intentionally or unintentionally we may have perceived the birds were flying all over the sky. Nevertheless, have we ever wondered how they fly and what branch of science is hidden behind their movements of wings? Well, your answer may be “No” but there might have been enthusiasts who rarely would like diving into this sort of aerodynamical topic.

Moreover, remember that not every bird that still exists on this planet uses the same techniques or follows the way to change its wingspans. Their movements vary from species to species and from situation to situation. This makes them unique and very exquisite. Of all birds we may have or haven't yet perceived, Bald Eagles are comparably as significant as their other counterparts who fall under the categorization of species related to the **Birds Of Prey**. Being the national bird of the United States of America and having the scientific name **Haliaeetus leucocephalus**, the Bald Eagle is naturally gifted with a more prominent body structure. Its wings, body mass, and skeleton structure are a few components, which make it capable of taking a notable place among aviation of birds.



Figure 1: Bald Eagle (*Haliaeetus leucocephalus*)

According to the calculated estimations, its wingspan is ranging from 1.8 – 2.3 meters. Usually, for many research purposes, the wingspan is measured by extending the specimen bird's wings to a possible maximum and obtaining the length between wingtips while a few ornithological methods are to obtain twice the length measured from

the middle of the bird's back to the tip of the fully extended wing. With lightweight form, long wings weigh less than 900 grams because of overlapping feathers with air spaces between them. In addition, wide and long feathery wings result in these wonderful flyers using the main flight techniques, soaring and gliding with less effort as well as, providing them with an extra lift when they have to carry their prey.

Soaring: As for this technique, Bald Eagles make use of two types of rising air currents depending on the situation namely thermal updraft and slope updraft. In the first, as the heating air near the Earth's surface rises the eagle engages in a circular motion within rising air and then glides out of the air currents to move further. The second one is advantageous when the wind blows into structures such as mountains, hills, or ridges. Such a scenario itself is helpful for the eagle to go along. So, every time an eagle soars in the blue sky, it gives a very small effort in its flight.



Figure 2: Soaring through Slope updraft



Figure 3: Soaring through Thermal updraft

Gliding: This is not only limited to Bald Eagles but also Storks, Albatrosses, Vultures, and Frigatebirds. To glide through the air birds' wings come in handy and the technique is based on Bernoulli's Principle. Wings shape is one of the main determinants affect in gliding. The upper surface of the wing is more curved than the undersurface and as the fast airflow patterns move over the upper surface, pressure in there is reduced. But the pressure in the undersurface is relatively higher than the upward and then finally, this pressure difference causes the wing to be lifted by a net force.

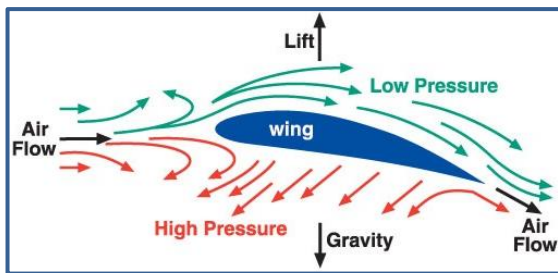


Figure 4: Flow of the air in upper surface and undersurface of the wing causing a lift force

Apart from the aforementioned flying strategies, Bald Eagles can control their speed on their own. Turning the front edges of the wings is the way it increases its speed when needed and to slow down, it turns the wide surface into the wing thus decreasing its speed. Other than strong wings being a vital part of aviation, its feathers, tail, body mass are the other factors behind the vigorous flight and thus enhancing the movement through the air and against the gravitational pull towards the earth.

Approximately a Bald Eagle has more than 7000 feathers altogether and weighs less than 586 grams and this indicates that the feathers are more lightweight. And on the other end, those feathers are strong. Scientists have classified wing feathers into a few groups. One of the kinds makes the wings thicker on the front side to speed up the airflow over the top of the wings. Secondly, the other kind can be spread to reduce drag.

The third type is to increase drag by moving downward and to reduce drag by moving upwards. These flight feathers cover a large area without giving additional weight.

Another key thing to remember is what is to be learned by perceiving the full functionality of Bald Eagles' aviation is limitless and extremely in value. The way these birds use natural forces to fly with less effort and control their speed properly and precisely when in need could be admirable attributes for an aeronautical engineer to design a unique aircraft like never before. Back then humanity could build up so many creative and innovative ideas through imagination beyond traditions. However, we still have to take a few steps far to expand the future of aircraft for humans' necessities. Until then let us observe how the massive flights with light feathers roam all over our skies, hoping to witness another day for another flight.

*Sachith Gomes
2nd Year (2021)*

Activities of the Physics Society 2021-2022

1. **Infinitum 1.0** – A general physics quiz contest for the 1st and 2nd year students in the Faculty of Applied Science. This contest consists of 2 rounds. 1st round consist of more than 18 groups over 160 participants participated in the competition. Out of them best 5 teams were selected for the round 2. A quiz session and a Presentation on the relevant topic was given to each team. The best 3 teams were selected. Maxwell’s Demons, Gravity Gang, Lab Rats won the competition. All the participants and Winner are provided with a valuable e-certificate .The event is organized by 3rd year Special Batch 2020.
 - Date:- 30th December 2020 to 13th January 2021
 - Venue:- Zoom platform
2. **“An Introduction to CERN”**-Webinar presented by the Physics Society with an Engineer Markuxx Joos and Ms Margherita Boselli from CERN which is the world largest particle physics laboratory. More than 50 curious minds were participated to know about CERN and activities they follow. Organized by Kalhara Perera, Achini Ovitigala, Yashan Hettiarachchi, Areshi Karunarathne.
 - Date:- 24th February 2021
 - Venue:- Zoom Platform
 - Time:- 5.00pm
3. **“Vidya Aurudu Udana”** – A virtual New Year festival organized by the Physics Society in the month of April for all the students in the faculty. This event consist of different new year games Tug or War, “Jana Gee”, “ Segaunu Amuththa “ and many. Winners of the competition are awarded with valuable gift. Kavindu Sellahewa, Sithumini Perera, Yashan Hettiarachchi and Areshi Karunarathne are the main organizers of this event.
 - Date:- 13th April 2021
 - Venue:- Facebook
 - Time:- 8.30 pm onwards
4. **Farewell and the Valedictory lecture** of Dr. C L Ranathunaga who was a senior Lecturer in the Physics Department for the service and contribution for more than 30 years. More than 70 participants including past students, Lectures and other delegates participants to thank him and wish Sir for the future. Topic of this lecture was “ *Research toward Development*” which is organized by Yashan Hettiarchchi , Kalhara Perera , Kavindu Sellahewa and Areshi Karunarathne.
 - Date:- 18th May 2021
 - Venue:- Zoom Platform
 - Time:- 6.00 pm
5. Physics Society collaborated with the Sri Lanka Association for the advancement of Science Section E1 organized a Webinar with Dr. N P Liyanawaduge who is a Senior Lecturer in Physics in Faculty of Technology University of Sabaragamuwa. The topic for the webinar was **“Measurement Error and Evaluation of Uncertainty”**. Enthusiasm Students of university of Sri Jayewardenepura and Sabaragamuwa along with the lectures participated. Over 80 participants joined to enhance their knowledge. Organized by Kalhara Perera, Achini Ovitigala.
 - Date:- 26th August 2021
 - Venue:- Zoom Platform
 - Time:- 5.00 pm

6. **End Semester Relaxation Party** – An entertainment event organized by the physics society to open the path for the students to enhance their soft skills and Aesthetic skills. The main purpose of this event is to provide entertainment and relaxation admits their busy schedules. The event consists of songs, Dramas and dancing items from our beloved students. Two guest artist “Samare and Samare” and Sandaru Sathsara” featured the event with their fabulous items where all the participants had much fun. Over 390 participants join to embrace the happiness. Organized by Damith Jayathissa, Thiloka De Silva, Yashan Hettiarachchi and Areshi Karunarathne.
 - Date:-18th September 2021
 - Venue:- Zoom Platform
 - Time :- 6.30 pm

7. **“The power of Supercapacitors and Postgraduate opportunities in New Zealand”**- Webinar presented by the Physics Society with Dr. Dulsha Kularatna Abeywardana from Department of Electrical, computer and Software Engineering, University of Auckland. More than 40 curious minds were participated.
 - Date:- 20th January 2022
 - Venue:- Zoom Platform
 - Time:- 6.00pm

8. Launch of the premium official **YouTube channel** – “ *Physics Society - USJ* ” by the physics society. In this channel society will update all the webinars, upcoming videos and other educational physics related videos. Created by Yashan Hettiarachchi..

9. **“Research Collaboration opportunities: Physics - USJ with Nanoscience Technology-WUSL ”**-Webinar presented by the Physics Society with Prof. C A N Fernando Senior Professor Head, Department of Nanoscience Technology WUSL . Yashan Hettiarachchi and Areshi Karunarathne are the main organizers of this event.
 - Date:- 11th February 2022
 - Venue:- Zoom Platform
 - Time:- 6.30pm

10. **“Article Writing competition”** – A competition which was organized by the physics society to all the undergraduates who follow physics as a subject. Selected articles were published in the annual physics magazine 2022. This event was organized by Sithumini Perera, Naduni Ranaweera, Heshaki Peries, Areshi Karunarathne and Yashan Hettiarachchi. The first place was won by Panchanie Karunaratne on the topic of “*The long standing misery- Black holes*”, second place goes to Rahul Silva on the topic of “ *Physics and Truth*” and “ *Can piezoelectric energy harvesting be used in military purposes*” was the topic of Chethana Senevirathna who won the third place in the competition.

11. **Invenção** - an innovative idea competition has been organized by the Physics Society of the University of Sri Jayewardenepura in collaboration with the *Sri Lanka Inventors Commission*. The competition was open to all the undergraduates in the Faculty of Applied Sciences and was intended to encourage and establish an innovative culture among the undergraduate students by providing a road map for a positive change in society. Along with the competition a webinar series was held to via zoom to encourage undergraduates for the competition with the participation of our beloved lectures from different departments . The webinar series was conducted for 3 days,

Day 1

- Prof. N M S Sirimuth presented on the topic of “ Role of Inventor commission to promote innovation”
- Mr. Trishan Perera spoke on the topic of “Developing commercially viable innovation”

Day 02

Prof. Laleen Karunanayake presented on the topic of “ Path to innovation” while,

Prof. Upul Subasinghe spoke about “ Innovation: concept to Product”,

Prof. S B Navarathne -“Product Development process in the perspective of physics during post covid pandemic situation” ,

Prof. Duleepa Pitigala presented on the topic of “ Path to Innovation”,

Dr. Nalin Ganegoda – “ Automate Decision Making a support from Mathematics” fianally,

Day 03

Prof. Hiran Amarasekera on the topic of “ Science,Technology, creativity and innovation” ,

Prof.Nilwala Kottegoda on the topic of “Shattering the glass ceiling” ,

Dr. Indika Wanniararchchi presented on the topic of “ Path to successful Innovation”,

Dr. Thiyanga S Talagala – “ Data Science: A game changer for Science & Innovation” and

Mr. Adhisha Gammappila – “ Innovation & Creative mind”.

This event was organized by Nimna Peries, Menaka Madusanka, Yashan Hettiarchchi, and Areshi Karunarathne. Due to the prevailing pandemic situation in the country the society was unable to provide funding for the projects, however all the enthusiastic participants received a valuable certificate. Mainly 5 groups participated D J De silva proposed on the topic of “**The preparation of 2D piezoresistive sensor using Carbon Nanotube based polymer composite**” , Team 2 Nuwanthika Herath with the topic of “ **To build aseptic environment inside a glass box**”. Thus, Wanitha Desilva, U A D P Bhagya, P P Kodikara proposed on the topic of “**innovative idea for a life filled with safety of the children and easy, time-saving and favorable modern technological asset for parents**” Team 4 K L Dhanajaya presented on the topic of “**Smart robot car chassis**” Finlay team 5, S C R Fernando, F H S Romenia Silva, and D R M Maduranga proposed on the new concept of “ **NeuroX: The device of identifying neurological disorders by using line drawing technique and modularizing platform for diagnosing various neurological diseases.**”

- Date:- 01st February 2022 – 20th April 2022
- Venue:- Zoom Platform

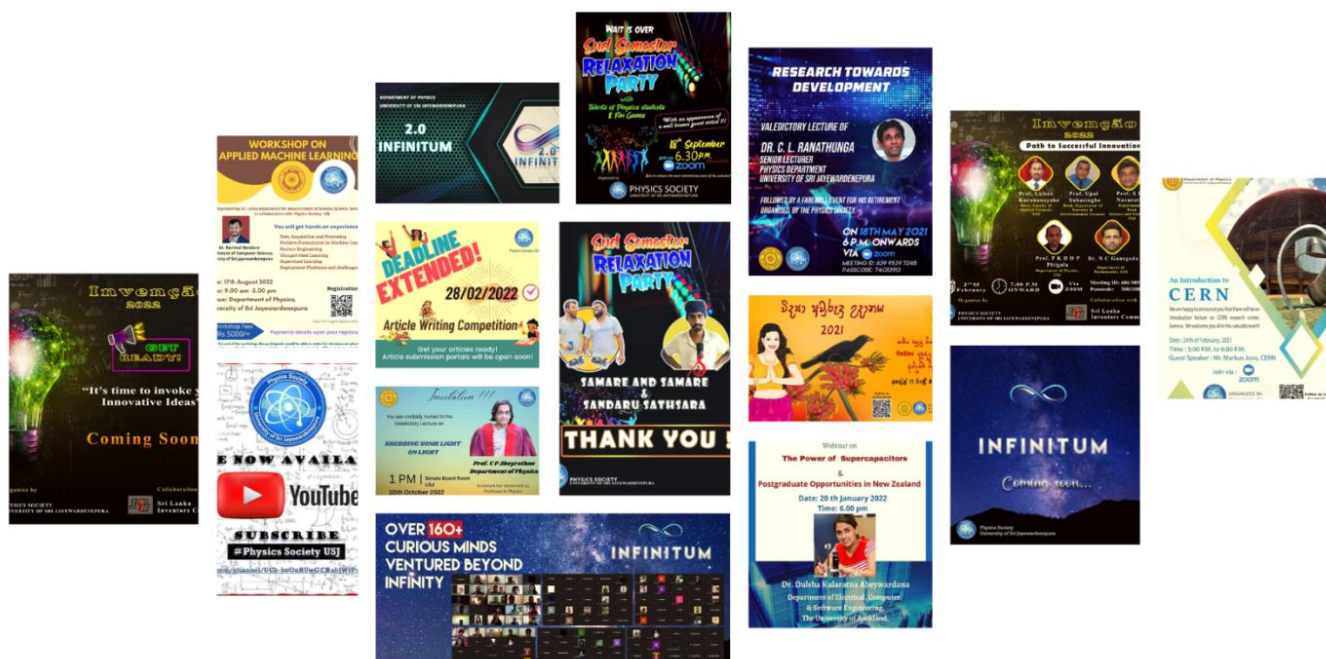
12. An invite talk on “**General Overview of Sri Lanka Atomic Energy Board**” organized by the Sri Lanka Association for the Advancement of Science (SLAAS)-Section E1 and Physics Society of University of Sri Jayewardenepura in collaboration with Sri Lanka Atomic Energy Board by Mrs. Uththara Perera Scientific Officer via Zoom.
 - Date:- 03rd March 2022
 - Venue:- Zoom Platform
 - Time:- 12.00 noon

13. **Infinitum 2.0** – A general physics quiz contest for the 1st and 2nd year students in the Faculty of Applied Science. This contest consists of 2 rounds. 1st round consist of 12 groups over 60 participants participated in the competition. Out of them best performing 6 teams were selected for the round 2. A quiz session and a Presentation on the relevant topic was given to each team. The best 3 teams were selected. Family Joules won the competition. All the participants and Winners are provided with a valuable certificate. The main organizers of this event are Randula Wijeyasundara and Udara De Seram.
 - Date:-12th March 2022 to 21st 2022
 - Venue:- Zoom platform

14. A guest talk “**Generalized Ising Model Applied to Model an Auditory Stimulated Brian Under Altered States of Consciousness**” was jointly organized by the Sri Lanka Association for the Advancement of Science (SLAAS)-Section E1 and Physics Society of University of Sri Jayewardenepura with the participation Dr.S Kandeepan via Zoom with approximately 30 participants.
 - Date:- 08th April 2022
 - Venue:- Zoom Platform
 - Time:- 6.30 pm

15. An online forum on “**Learn and Earn from E-waste**” was jointly organized by the Sri Lanka Association for the Advancement of Science (SLAAS)-Section E1 and Physics Society of University of Sri Jayewardenepura with the guest speaker Dr.Jehan Seneviratne via Zoom with approximately 50 participants.
 - Date:- 22nd September 2022
 - Venue:- Zoom Platform
 - Time:- 6.30 pm

16. The Valedictory lecture of Prof.C P Abeyathne who was a Professor in Physics, patron of the physics society in the Physics Department for the service and contribution for more than 42 years. More than 70 participants including past students, Lectures, and other delegates participants on lecturer on the topic of “Shedding some light on light”
 - Date:- 10th October2022
 - Venue:- Senet Board Room
 - Time:- 1.00 pm

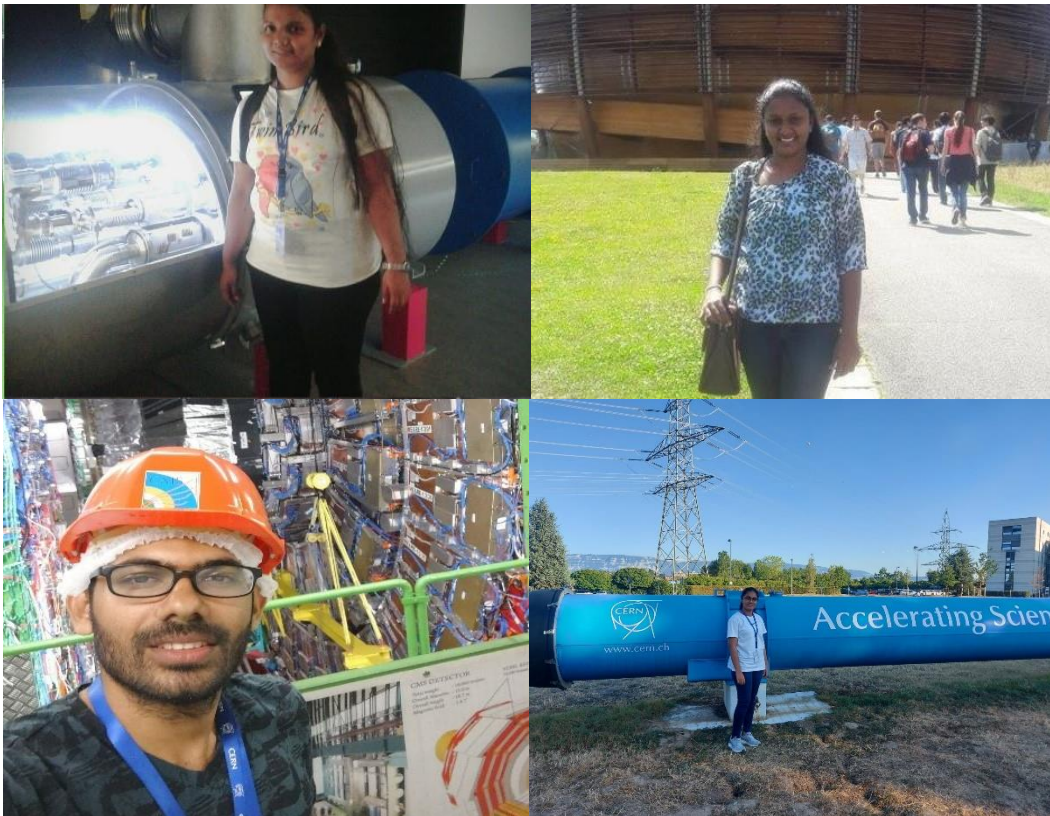


CERN Internship

Every year four students from Sri Lanka get the opportunity to participate in the summer student Programme at CERN, Geneva, Switzerland-the most prominent particle physics research institute in the world. Starting from 2017 continuously each year one student from the Department of Physics, University of Sri Jayewardenepura was selected to participate in the programme. Chamini Pathiraja in 2017, Harshani Srikanthi in 2018, Channa Hatharasinghe in 2019 and most recently in 2022, Nimna Sandali Peries were able to participate in the programme.

Nimna was able to get selected for the summer student programme and she was the only student selected from Sri Lanka that year. She participated in this summer internship for 8 weeks, from 4th July to 26th August 2022. She worked on a project based on the ATLAS, where she studied the efficiency of semi visible Jet reconstruction.

In addition to taking part on this project she was also able to participate in well organized lecture series conducted by CERN. She was also able to visit the ATLAS, the largest particle accelerator in the world.



Annual publications and conference proceedings 2021-2022

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- K K D A C Karunarathne, , D.D.T.S Chandrasiri, , S.S.Kumarawadu, N.G.S.S.Gamage. (2022). Locating Earthquakes Occurring in Sri Lanka. *Proceedings of the Technical Sessions, 38 Institute of Physics – Sri Lanka* , 55-61.
- B.V.N. Sewwandi, A.R. Kumarasinghe, D. Thushara, H.D.W.M.A.M. Wijesingha, C.H. Manathunga,, V.S.P. Perera, R. Weerasooriya. (2021). Fabrication of size-tunable graphitized carbon spheres with hierarchical surface morphology on p-Si (100) by chemical vapour deposition. *Sri Lankan Journal of Physics*, 80-99.
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- Hiroharu Kawanaka Isanka Diddeniya, Indika Wanniarachchi, Hansi Gunasinghe, Chinthaka Premachandra. (2022). Human-Robot Communication System for an Isolated Environment. *IEEE Access*, 63258-63269.
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- NL Adihetty, MLC Attygalle, NS Narayan, PK Jha. (2021). A study of the performance of organometal trihalide perovskite solar cell due to defects in bulk CH₃NH₃PbI₃ (MAPI) perovskite layer. *International Journal of Multidisciplinary Studies*, 101-112.
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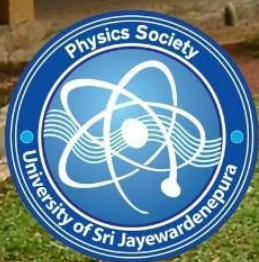
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