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Φ6

ANNUAL PHYSICS MAGAZINE
PHYSICS SOCIETY
UNIVERSITY OF SRI JAYEWARDENEPURA

Contents

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Message from the Head- Department of Physics

It is my great pleasure for being able to send this message as the Head of the Department to the physics society, in particular, at a time when the committee members of the Society are taking every possible effort to achieve the formidable task of getting published the Journal, the first of this kind, despite the prevailing ill-disposed health condition in the Country. This is a clear proof for the unrelenting determination of the members of the physics society to fulfill the responsibilities on their shoulders in the face of the obstacles placed by the pandemic situation. Therefore, first I wish to extend my appreciations to every single effort made by the Physics Society as a team to make this endeavor a success.

A journal or a magazine in any discipline is considered to be a modus operandi for the dissemination of knowledge in that discipline. Physics is no exception from this and sharing information and widening the access to acquire it ultimately broaden the horizon of each individual's knowledge. This process has been taking place throughout the history of human civilization and has radically transformed the way of our thinking. Physics, on the other hand, is subtle, yet simple. The fundamental laws of physics encompass a large variety of physical, technological and natural phenomena. Physics influences our material well-being as well as our philosophical outlook. Physics is therefore rightly regarded as a natural philosophy. Communicating physics and initiating such accomplishments are therefore very important and require a talented group of people working with a single mind.

We observe that the first magazine contains articles written by staff members as well as physics society members on various interesting topics. It also includes activities carried out by the physics society throughout this year and research publications/conference proceedings of staff member and students. Participating in such endeavors undoubtedly develop students' skills in various different educational (cognitive, psychomotor and affirmative) domains and is an integral part of the experience which is expected from the University education. It is my sincere hope that the experience gathered by taking part in these activities would usher them in their future activities too.

Last but not least, I would like to take this opportunity to thank the Patron, especially the Senior Treasurer for giving the necessary guidance and encouragement to the executive committee members of the physics society to make this venture a success.

I wish every success to all activities of the physics society and the new magazine.

Prof. A. R. Kumarasinghe,

Head of the Department,

Department of Physics,

University of Sri Jayewardenepura.

History of the Department - The Patron Physics Society

Reminiscences of the past....

I write this at the invitation of Dr. Wasanthi de Silva who is not only an alumnus of the Association of Physics Special Degree Alumni of the University of Sri Jayewardenepura and present Senior Treasurer of the Physics Society but also a Senior Lecturer in the Department of Physics. Wasanthi requested me to write an article for the online magazine the Physics Society is planning to launch in October 2020. It is with pleasure and nostalgic memories that I pen these words reminiscing the past in compliance with her request.

Whenever I turn back to get a glimpse down the memory lane, the first figure that comes to my mind is Late Emeritus Professor P.C.B. Fernando, the Founder and Chair Professor of the Department of Physics. He is the key figure who laid the foundation for all academic activities directly and indirectly and who stands behind all achievements of our alumni even though most of our young graduates of the 21st century may never have met him. From the meticulous planning of the curricula, to well-planned buildings and other infrastructure facilities, most of which are still in use, he has manifested his far-sight and vision for the future. The department which was founded in the late nineteen sixties and shifted to the present building in 1974 with a few students at that time, now accommodates about 250 new undergraduate students annually.

Recalling nostalgic memories, I well remember the day I met Prof Fernando, together with my three batch mates Champa, Gnanathilake and Kulawansa after being selected to follow the Special Degree Course in Physics which was at that time done after completing the three-year General Degree. We were given a lengthy lecture by Prof Fernando trying to convey to us the serious nature of our choice to continue studies in Physics. He also told us to consider ourselves as being robed as monks; he seemed to think that learning Physics was a sacred task. Among numerous other duties in campus as well as outside, he had time to supervise the final year projects of all four of us. When we were recruited as Temporary Assistant Lecturers after successfully completing the Physics Special Degree, he told us with equal seriousness to consider our new appointment as a 24-hour appointment and that we should strive hard to fulfill our duties.

Prof. Fernando's lectures were different from other lecturers' lectures. They never were coherent lectures with a beginning and an end, but he discussed anything, and everything related to physics giving us a broad general knowledge in the subject area. We had to do a lot of independent studying to catch up with the lectures. I am extremely grateful to him for the training he gave in the Optics laboratory which enabled me to work with confidence.

Although Professor Fernando retired in 1995, he used to come to the department once a week, usually on Thursdays and I used to look forward to meeting him. Most of the time one of us lecturers was there sitting in front of him chatting, getting advice, discussing our problems be they academic or personal. Professor Fernando who appeared to me as a person to be respected but not to get close enough to discuss personal matters seemed to have changed or my perception of him seemed to have changed in later years. It would not be a disrespect to say that he was like a father advising his children. I am forever grateful to him for all the achievements I made academically and professionally.

In the forward march of the department, the next Chair Professor of Physics, Prof D.A. Tantrigoda has played a vital role in updating curricula to be on par with the ever-changing field of Electronics and other branches of Physics where changes were in demand. Prof Tantrigoda has carried forward the baton handed over to him by Prof Fernando, preserving the friendly atmosphere of the department, peaceful coexistence with nonacademic staff and work ethics established since its very beginning until his retirement half a decade ago. I must mention that he continued to carry out his academic responsibilities including the supervision of many final year projects when the necessity arose until his retirement, taking part in all activities of the department setting an example for the junior staff to follow.

I am indebted to him for enhancing my knowledge on teaching and learning especially during the period from 2009-2012 when I was the Head of the Department. What I learned from endless discussions paved the way for many achievements I made then and afterwards in improving the quality of teaching and learning activities in the Department of Physics.

Before I finish, I must at least mention the names of a few other academics, who inspired me as a student and a young lecturer. Prof. Ronald Stoner who served as a Fulbright Professor for one year in the early 1980's taught me many courses in Theoretical Physics and helped many Sri Lankan students to find opportunities for higher studies in USA and won the hearts of all of us. Dr. Ranjith Divigalpitiya stays in my mind as an inspiring lecturer who taught me Thermodynamics and Special Theory of Relativity. Statistical Physics introduced by Dr. Gamini Godamanna, Space Physics taught by Mr. Chithrananda Peiris, practical and tutorial classes conducted by Prof Dayakanthi Kaluarachchi and Pulse Circuits taught by Dr. Ariyasinghe also contributed to enhance my interest to continue higher studies in Physics. Dr. Kithsiri Jayananda who was a colleague in the 1990's deserves mentioning for his tireless efforts in upgrading the course contents in Digital Electronics and Microprocessors which I consider a giant step in the progress of the department in recent times.

Finally, I would like to thank the Physics Society for coming up with the idea of launching a magazine and the reunion of the alumni in Physics. I wish the executive committee of the Physics Society all the best to keep the society active and to make use of the reunion to enhance opportunities available to the generations of students to learn Physics in the future.

Prof CP Abayaratne

Department of Physics

University of Sri Jayewardenepura

Message from the Senior Treasurer Physics Society

The Physics Society of the University of Sri Jayewardenepura was established in the year 1994, under the guidance of Prof. P.C.B. Fernando. The physics society helps to create a bridge between the students and the academics to enhance the soft skills of our students. The students who come from different areas in the country have contributed to make the Physics Society one of the most active student societies in the Faculty of Applied Sciences. Among the different activities organized by the society throughout the year, the first-year welcome ceremony, the Wesak festival, A/L practical sessions for school students, fundraising events, and guest talks are to be highlighted. In addition, to show their true colors in academic activities, most of the students find a platform to display their hidden talents through these events. The activities organized by the physics society and the involvement of the students in the activities and the skills they develop through these activities, manifest the quality of the physics graduates produced by the department of physics, who are dedicated and responsible persons rather than just being scientists.

This is the first time the society takes a step forward to publish a magazine, "ϕ**6**" with scientific articles, department news, and society activities throughout the year. This is the best starting point for dissemination of knowledge. The continuation of this magazine will also keep records for future students in the long term. I would take this opportunity to thank all the academics, students, and sponsor who helped to make this magazine successful.

I am extremely happy to have guided the team to success fully launch this inaugural magazine as an Alumni member and the senior treasurer of the Physics society.

I wish success to the Physics society and the newly introduced magazine to continue for a long time.

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

Senior Lecturer

Department of Physics

University of Sri Jayewardenepura

Editorial

"Physics is a creative activity of human mind. Studying Physics provides you with a delightful and a rewarding experience that will make you suitable for any future career."

Physics is the study of the world around us. From the microscopic level of particles to the macroscopic level of space, physics has changed our understanding of the universe and, in doing so, has changed our philosophy and way of life. In recent years physics has slowly but steadily grown to become an important field in the country. Over a period of 5 decades the Department of Physics at the University of Sri Jayewardenepura has supported that initiative by providing a suitable environment to produce quality graduates.

With a history of more than 25 years, the physics society of the University of Sri Jayewardenepura has been one of the most active societies in the university. It is instrumental in organizing student-related activities to promote both curricular and extra-curricular events. The society aims to generate practical minds and bring out the best out of its members, to suit the current world of physics.

Hence, it is with the greatest pride that we present to you the first issue of the annual Physics magazine "ϕ**6**", as one of the many contributions from the Department of Physics, with the hope of communicating scientific information in Sri Lanka. "ϕ**6**" is a Greek letter and pronounced as "fee-six" and ϕ and **6** together is pronounced as physics.

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 C P Abayaratne, Prof A R Kumarasinghe 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 first publication of "ϕ**6**" a reality.

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Wisdom and Relativity

Knowledge and wisdom:

Initially if I ask you what knowledge is, each of you will answer with different angles. As I personally see, knowledge is something that we have built after imagination of our past experiences or within the culture we live in. This is sometimes stored in the mind or else sometimes in thoughts. However, this knowledge varies from person to person. There is one thing that a person can understand while studying over and over again. That is, at the end, the person realizes that he knows nothing about that matter. This is because the amount of unknowns is infinite compared to what the person knows in that particular field. Realizing this thing can only be understood by wisdom. I know that not everyone understands this point. Therefore, we can identify true educators by the humble way they live in and accepting that they do not know everything.

The other is that the person who studies any subject continuously understands it to some extent. So we meet scholars in the world who say the same thing in different ways. For example, if you study the philosophy of the Arabic philosopher Khalil Gibran, you will realize that it also portrays some parts of the Lord Buddha's philosophy. He has conveyed the same message in a different way. This can be interpreted in two possible ways. The first is that Gibran is abducted by Lord Buddha's vision. The second is that although the Lord Buddha and Gibran live in different locations of the world, at some point, having wisdom will enable them to understand the same vision. I believe the latter because I am not rural (rustic) enough to think the first to be true. Although there are many more examples of this type I will only mention a few of them. The philosophies of Sigmund Freud, Jacques Derrida, Bertrand Russell, Albert Einstein, Jesus Christ, Osho, ..., etc. are somewhat close to Lord Buddha's philosophy. Therefore, there is something I believe. Although degrees such as B.Sc, B.A, M.B.B.S., B.Com., ... are conferred for Bachelor's Programs in different fields, at the end of any field, the common degree awarded for all the respective fields is the "Darsanasuri" or doctorate (Ph. D). This is because after researching in a specific field, a person awarded with the doctoral degree will realize "emptiness" and understands that, at last, all the fields converge together conveying the same message. This may be the reason why doctorate is considered the highest degree that you can eventually achieve in any field. But nowadays there are persons who have still not reached this level although they have doctorates.

In addition, some people who obtained doctorates think that they know everything. I do not know exactly where the problem is. Some people in our country are conferred doctorates just due to their political powers. I see it as a real punishment for those people, because it seems to be a joke to everyone, as these doctorates do not have any knowledge on their relevant fields. Finally, I would like to emphasize that, although nowadays some people inappropriately use this doctorate as a jewel to cover up their weakness, wise people use their doctorates in a proper way to live a respectable life and enhancing the quality of others' lives.

Creation of Relativity, the Lord Buddha's? or Einstein's?

Relativity was first introduced to the world by the Lord Buddha who lived 2550 years ago. Unfortunately, the relativism presented by the Lord Buddha cannot be tested using western scientific methods like experiments, observations and conclusions. Oriental thinking is built almost entirely on understanding, not on experiments or observations. He pushed relativism for everything. That is, there is nothing in the world that is incompatible with his relativism.

He has said that everything in the world is impermanent. He showed the whole world that all the things are changing, or all relatable. These philosophies are all taught in Buddhism. According to Buddhism, there is only one permanent thing, which is the enlightenment (“nirvana”). This is something that can be attained by only a person who understands the impermanence of the teachings of Supreme Buddha.

Albert Einstein, who lived nearly 100 years ago pointed out that certain things are relative. To put it simply, "When a time period is measured, the time depends on the measuring frame, or the time interval measured changes from frame to frame". The difference of relativism presented by the Einstein's theory with respect to Lord Buddha is that he had presented only for the physical parameters.

Later scientists were able to measure them scientifically. Hence, the relativity offered by Einstein was popularized in western philosophy. Einstein's relativity is well-known in our country too because many scholars in our country are obsessed with western culture. But anyone with a free mind can thoroughly distinguish these two relativities.

You can realize that the relativity of the Lord Buddha is true for everything in the world. But Einstein's relativity is true only for physical parameters like length, time, mass, energy, momentum... etc. Also, the causality (“හේතුඵලවාදය”) presented by the Lord Buddha provided strong evidence to strengthen Einstein's special theory of relativity in the beginning of the nineteenth century.

Dr. Madhuranga Fernando
Senior Lecturer,
Department of Physics,
University of Sri Jayewardenepura.

Dear physics department ,

We met under your shelter.

We grew up together with your love and affection.

The physics family was the best thing that we ever had in our lives.

There is nothing on this earth more to be prized than true friendship.

Both good and bad times were there,

But we could fly through all these times without being tired.

The support from lecturers, staff was priceless,

Here is our heartiest blessings for them.

Finally ,

Best of luck for your future endeavors,

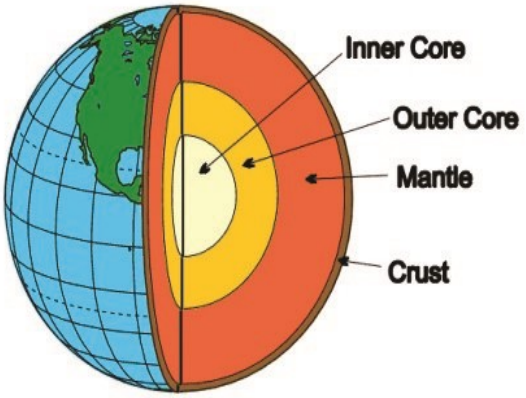
We will always be there for you.

Special Batch 2012/2013

Geothermal energy trapping the Earth's internal heat

As a result of the gradual increased potential use of renewable energy sources, geothermal energy is also identified as green energy in many countries even though it is novel to Sri Lanka. This article presents the method of using geothermal energy from early days to today.

It is believed that Earth was formed 4.5 billion years ago. Its core is still at an extremely higher temperature. The energy that is obtained from this is known as Geothermal energy. This energy is derived from the core of the Earth, which contains hot magma i:e: located 6500 km



Internal structure of the Earth

beneath the surface. Due to the slow decay of the radioactive particles, the temperature of the Earth's core is hotter than the Sun's surface. This is evident as you can observe the increase in the temperature when we go deeper by digging a hole straight down into the Earth.

History of geothermal energy

The first incident to be reported on usage is in 1904 in Larderello, Italy, where they used natural steam erupting from the Earth to power a turbine generator.

Geothermal Reservoirs

Geothermal reservoirs are formed by rising hot water & steam trapped in permeable porous rocks. Such reservoirs are discovered by texting the soil and analyzing the underground temperature. Some visible features of geothermal energy are,

- Volcanoes
- Hot springs
- Geysers
- Fumaroles

Most of the resources are not visible as they are situated deep underground.

Ring of Fires

The Pacific Ocean border is the area that has most of the geothermal activities called the "ring of fire".

Uses

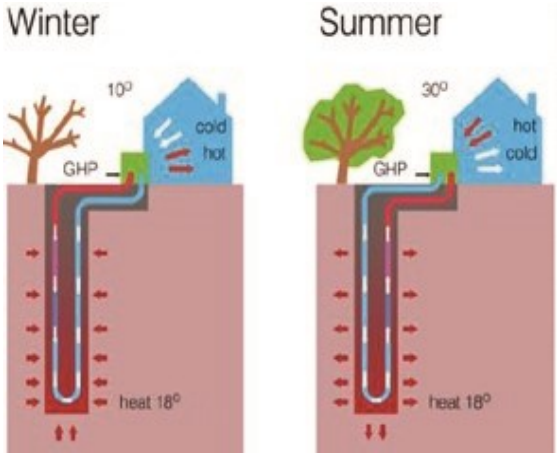
Direct use: Geothermal heating and heating umps.

Heat is extracted from a low-temperature source <150 ^{o}C and is directly used as given in the following examples:

- Hot springs are used as spas.
- Heating water at fish farms.
- Provide heat for buildings.
- Raising plants in greenhouses, drying crops. Provides heat to industrial processes.

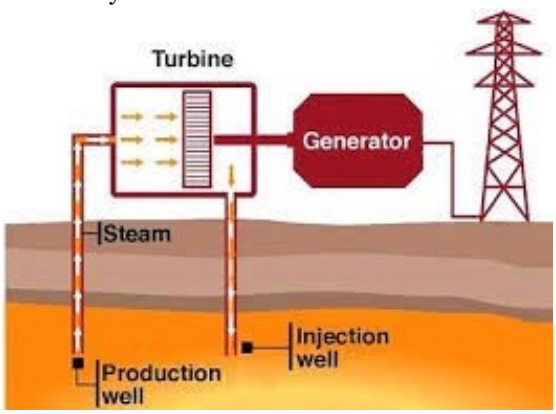
How is it used?

In order to generate electricity and heat and cool buildings directly, underground reservoirs of steam and hot water can be trapped. The constant temperature of the upper ten feet (three meters) of the Earth's surface can be utilized to heat a home in the winter by the geothermal heat pump. Simultaneously, extracting heat from the building and transferring it back to the relatively cooler ground in the summer. It can be used for space heating, industrial processes, drying crops, hot water supply and melting snow.



Indirect use: Electricity production

Source temperature is higher than 150 °C. Deep wells are drilled, and the steam from the reservoir is used to drive turbines and produce electricity.



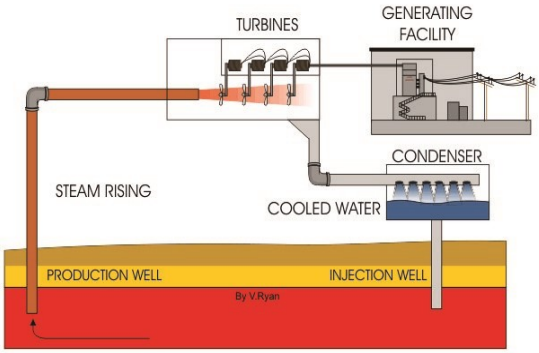
Geothermal power plants

Geothermal energy can also be used for producing power. Geothermal power plants produce renewable energy using steam or hot water created by natural sub-surface heat to drive turbines that generate electricity. In order to pump steam or hot water to the surface, wells are drilled 1 or 2 miles deep into the Earth at a geothermal power plant.

There are several types of geothermal power plants.

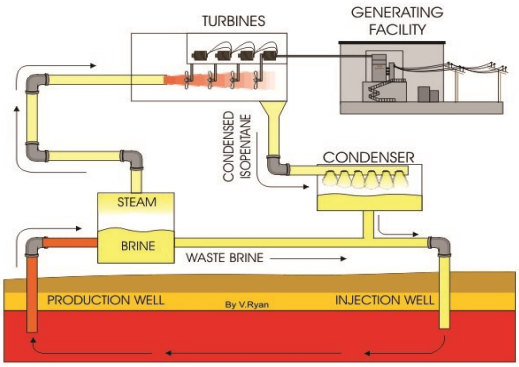
Dry Steam

After passing steam through an apparatus where the steam goes directly through the turbine, then into a condenser where the steam is condensed into water. This is known as dry steam. This steam can be released into the atmosphere or pumped back underground.



Flash Steam

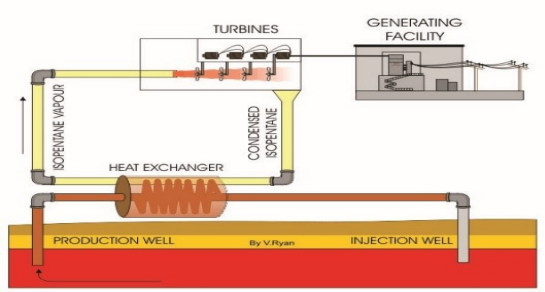
In order to drive the generator turbines, high pressure hot water is taken from deep inside the Earth and is converted. The water that is obtained through condensation of steam is injected into the Earth to be used repeatedly. Most geothermal plants are flash steam plants.



Binary Cycle

Binary power plants pump pressurized hot water as flash steam plants do. However, the tube that pumps the pressurized water is

connected to another tube that contains low-pressure water. When the hot, pressurized water flows into the second tube, it heats the water in the second tube, boiling it and driving the turbine. The water from the first tube then gets pumped back to the underground power plant.



Flash steam power plant

Hybrid Power Plant

Both boiling water and steam are used in this. Steam is directly used as in a flashed steam plant. At the same time the energy of hot water is used through secondary liquid as in a Binary system.

Future of Geothermal energy

- Geothermal energy has the potential to play a vital role in the world in establishing a cleaner, more sustainable energy systems.
- Fossil fuels, one of the renewable energy technologies, can supply continuous baseload power.
- The costs for electricity from geothermal facilities are also declining. Some geothermal facilities have realized at least 50 percent reductions in the price of electricity since 1980.
- There is also a bright future for the direct use of geothermal resources as a heating source for homes and businesses in any location.

Iceland's Nesjavellir geothermal power

Geothermal Power Plants and the Environment

- Geothermal power plants do not burn fuel to generate electricity, so their emission levels are very low.
- Release less than 1% of carbon dioxide emissions from a fossil fuel plant.
- Use scrubber systems to clean the air of hydrogen sulfide.

M.A.D. Hansani Yashomala
4th Year Physics Special (2019)

Environmentally friendly alternative fiber material for asbestos roofing sheets in Sri Lanka

Asbestos is a natural fiber material and is used for roofing material, ceiling sheets, gaskets, brake lining, water supply lines, and pads for automobiles. Asbestos is used for the above because of its resistance to chemical attack, excellent tensile strength, poor heat conduction and its durability. It is also used for boilers, turbines, valves, pumps, and ovens which are subject to high temperatures.

Asbestos is a popular material among contractors and industrialists because of its fire resistance, temperature resistance, chemical resistance, durability, flexibility, and other characteristics.

Due to the scarcity of timber, tile, clay, and other construction material Asbestos became a popular alternative in Sri Lanka. According to statistics, Sri Lanka has imported White Asbestos (Chrysotile) for more than 60 years. Though there are varieties in Asbestos, Sri Lanka imports only chrysotile (white Asbestos).

In producing asbestos roofing sheets and ceiling sheets, Asbestos makes a mixture with cements and these cements works as a bond that controls the breaking up of Asbestos fibers.

As it has been scientifically proven that Blue Asbestos (Crocidolite) fiber and Brown Asbestos (Amosite) fiber cause cancer, it is suggested that it is better to test whether White Asbestos (Chrysotile) is also harmful to the human health.

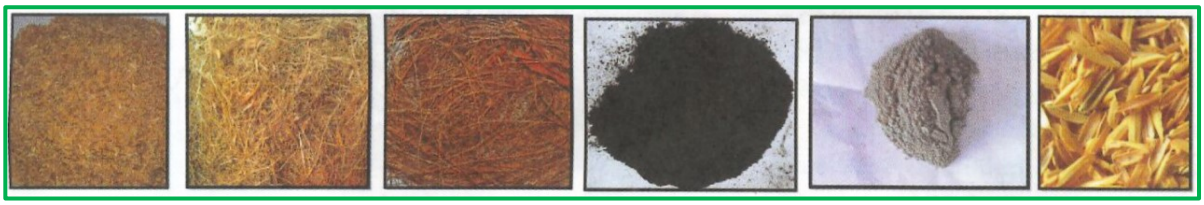
Asbestos is a term used to allude six naturally occurring minerals of silicates. All fibers are composed of long and thin fibrous crystals, and each fiber, is composed of many microscopic fibrils that can be released into the atmosphere by abrasion.

The six minerals commonly known as Asbestos are grouped into two categories, namely serpentine and amphibole families. The six minerals – Amosite (Brown asbestos), Tremolite, Actinolite, Crocidolite (Blue asbestos), Anthophyllite, and Chrysotile (White asbestos). As Asbestos has lots of excellent qualities it has been used for over 3,000 products.

World Health Organization (WHO) and the International Programme for Chemical Safety (IPCA – 2011) in the year 2011, revealed that Asbestos is a threat to health. According to the WHO, 107,000 people die each year from Malignant Mesothelioma and Asbestosis.

People engaged in asbestos-related projects, such as construction and building trade, (carpenters, and store workers) Asbestos factories, belong to the high-risk category. Health Ministry along with IPCA, is working on bringing up laws and regulations to upgrade the health of workers who are engaged in asbestos-related industries. More than 50 countries have banned the use of Asbestos materials.

The 1992 Basel Convention has reduced the movement of hazardous waste between nations. Accordingly, Asbestos has been listed as a hazardous waste. One hundred sixty-two countries signed the Agreement convened by ILO on the use of Asbestos safely in 1986.



/www.slsi.lk/images/downloads/draft_standards/dsls533.pdf

Only 36 countries ratified and implemented the Agreement.

According to the International Agency for Research on Cancer (IARC), Asbestos was categorized as group one carcinogenicity in humans in 2006. The Ministry of Health, New Zealand in 2014 revealed that the more you are exposed to Asbestos and who are exposed more frequently over a long time, are more at risk.

People at risk of developing Asbestos-related sicknesses in Sri Lanka

Those working at:

1. Asbestos producing factories.

2.Carpenters engaged in Asbestos roofing and ceiling work.

3.Brakes and clutch manufacturing companies

4. Breaking of roof and ceiling

5. Those who live in Asbestos roofing houses.

Though blue asbestos (Crocidolite) was banned in Sri Lanka in 1997, white asbestos (Chrysotile) is mainly used for roofing and ceiling in Sri Lanka.

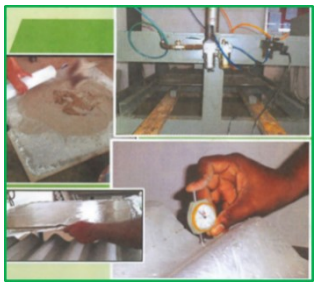
Sri Lanka signed the Rotterdam Convention in 2006, and the Government of Sri Lanka officially announced that it would reduce the import of Asbestos fibers by 2018. As users of Asbestos roofing and those engaged in Asbestos-related produce have encountered many health problems, Sri Lanka must reduce the use of these products to safeguard the future of Sri Lanka. In order to achieve this, we have to find an alternative.

As the Government of Sri Lanka has controlled the Asbestos use, it is time to find an environmentally friendly alternative for the same.

From recent studies:

Recognizing ecofriendly fibers to replace Asbestos fibers.

A study was done to find out an environmentally friendly alternative fiber material available in Sri Lanka for the manufacture of non-asbestos roofing sheets. During the study, asbestos fibers were replaced by cellulose fiber material found in Sri Lanka, such as rice husk, paper pulp, coir fiber, and coconut charcoal. These materials are found abundantly in Sri Lanka but disposed to the environment as waste. According to the study, rice husk can be used as an alternative to Asbestos fiber. An experiment done using rice husk compiled with Sri Lanka Standard (SLS) International Standard (ISO 10904:2014), and Indian Standard (IS 1471:2000).



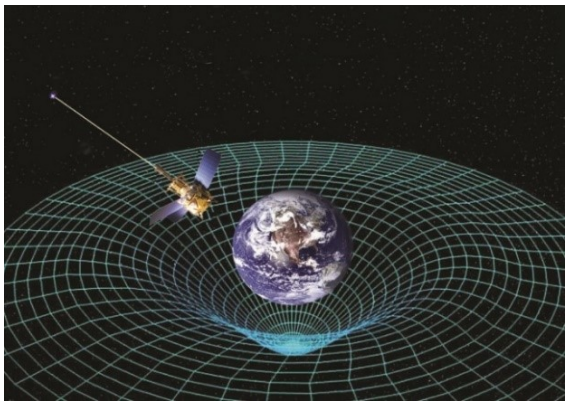
Paper pulp, the second alternative, was also in compliance with all other samples except the breaking load test and other standards, ISO 10904:2011 and Indian Standard 1471:2000.

Tharaka Dissanayake
4th Year Physics Special (2019)

Gravitational wave detection from collision of black holes…

What is a Gravitational wave?

Ripple in space time caused by some of the most violent and energetic processes of the universe is considered as a "***Gravitational wave***". In 1916, According to the general theory of relativity Albert Einstein predicted gravitational waves. He showed that the 'waves' of distorted space would radiate from the source such as massive, accelerated objects (such as black holes or neutron stars orbiting each other) disordering the space time. Furthermore, these ripples carry information about their cataclysmic origins and clues to the nature of gravity which would travel at the speed of light through the universe.



Two- dimensional illustration of how massive bodies in the Universe distorts space- *time Image Credit: NASA*

The most substantial gravitational waves are produced by colliding black holes, coalescing neutron stars or white dwarf stars, the slightly wobbly notation stars that are not perfect spheres, and remaining gravitational radiation created by possibly the birth of the Universe.

Though Einstein predicted gravitational waves in 1916, the first evidence of existence was not discovered until 1974, 20 years after his death. Einstein's prediction was tested in many ways. In that year, two astronomers using the Arecibo radio observatory in Puerto Rico discovered a binary pulsar, exactly the type of system, according to general relativity. After eight years of observation of measuring how the orbits of stars are changed over time, it finally determined that the stars were getting closer to each other at exactly the rate predicted by general relativity; if they were emitting gravitational waves (Gravitational waves remove energy from the system causing them to move nearer together as they orbit each other).

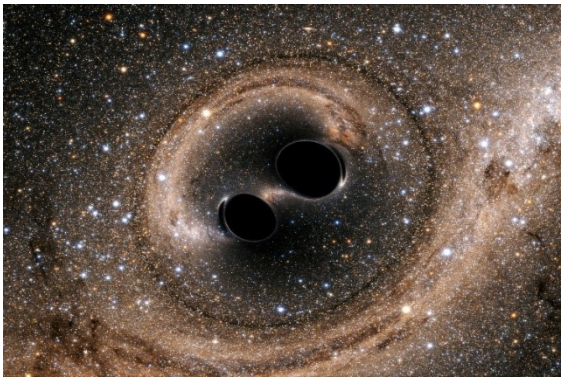
As further confirmation of gravitational waves, many astrophysicists had studied pulsar radio-emissions. However, these confirmations were always coming from a mathematical theorem and not a 'physical' theorem.

First detection of Gravitational wave.

For the fourth time a gravitational wave was detected from the collision of two black holes and the shape of their waves, which were sent through space-time for the first time. The announcement was made at a meeting of the G7 Ministry of Science in Italy after laboratories in Pisa and the United States identified teeny vibrations.

The findings provide astrophysicists with an extra dimension of detail on the warping that occurs when two giants of the universe collide and create the gravitational waves that helped forward the theory of general relativity introduced by Albert Einstein. According to Einstein's theory, massive bodies are bent in spacetime, the single continuum which binds the three dimensions of space to time.

When two massive objects collide, this curvature can be altered as a wave or sparking ripples moving out across galaxies.



Two merging black holes
Image Credit: SXS, the Simulating extreme Spacetimes (SXS) project

These gravitational waves are minuscule by the time they arrive on Earth, For the first time this wave was recorded by detectors and it was sensitive enough to be picked up. The newest ripple recorded by the Laser Interferometer Gravitational Wave Observatory (LIGO) in Washington and Louisiana and the vigor detector in Pisa on August 14 was triggered 1.8 billion years ago by two black holes that struck to produce one 53 times the mass of the sun. Scientists had discovered the 3-dimensional model of the ripple's path of the gravitational wave in first time using the Virgo interferometer.

Further evidence of Einstein's theory and gravitational waves were first observed in September 2015 and the second detection occurred three months later. The third detection, which the astrophysicists labeled **GW170104**, was made on 4.01.2017. The discovery is widely expected to win the Nobel Prize in physics.

Scientists hope gravitational waves will point out a completely different view of the universe, allowing them to study events hidden from radio telescopes and traditional optical telescopes.

"It is wonderful to understand a first gravitational-wave signal in our brand-new Advanced Virgo detector."
Said by: Jo van den Brand, Virgo spokesperson and professor at Vrije Amsterdam University.

DID YOU KNOW THAT…

LIGO consists of two huge laser interferometers thousands of kilometers apart and examines the physical properties of light and space itself to detect the origins of gravitational waves and get an idea of them.

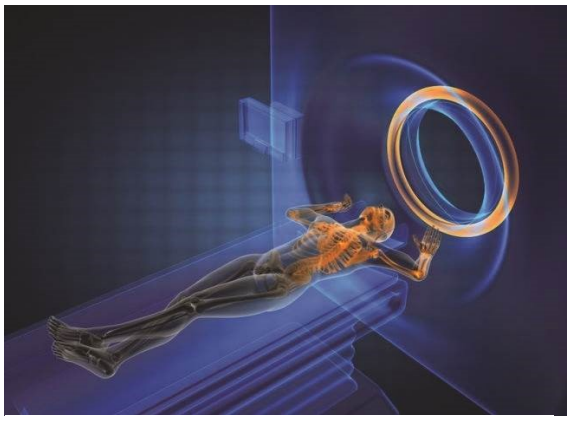
Virgo interferometer near Pisa, Italy. *Image Credit: The Virgo collaboration/CCO 1.0*

Udara Niroshan
4th Year Physics Special (2019)

MRI to explore the human body

In today's world, technology has an impact on every field of life. Healthcare is undeniably one of the top industries that technology plays a central role. The invention and development of novel medical devices and equipment in medical technology has permitted physicians to diagnose and treat their patients, enhancing medical services. Thanks to the continuous development of technology, uncountable lives have been saved. These novel technologies undoubtedly improve the overall quality of life providing the patients with better medical experience. Out of all the inventions from small to big, MRI technology is worth discussing**.**

What is an MRI?



MRIs are medical imaging systems used to diagnose health conditions. *Image Credit: MRI scan via Shutter-stock*

In order to diagnose certain medical conditions, scanning the organs might be crucial. Magnetic resonance imaging (MRI) is one such scanning technique available for generating detailed images of our human body. In this technique, a strong magnetic field and radio waves are used to produce images of the parts of the body that cannot be seen even with X-rays, CT scans or ultrasound. The doctors are widely using this method to see inside joints, ligaments, cartilage, tendons, and muscles, making it much useful for detecting various sports injuries. This technique allows examining internal body structures and diagnoses a range of illnesses, including strokes, tumors, spinal cord injuries, and eye or inner ear problems. It is also widely used in research work.

How does MRI work?

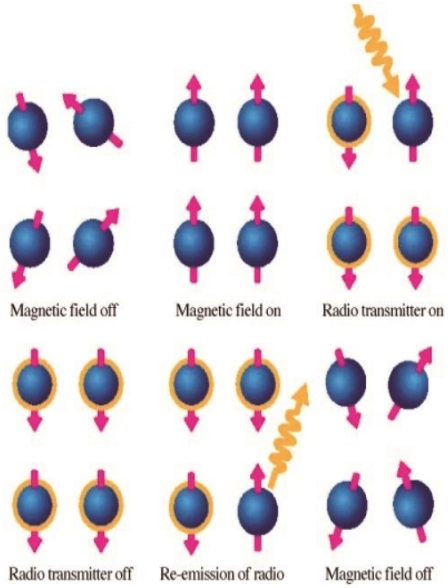
The MRI scanner can resembled a giant magnet. MRI measures how much water is present in different tissues of the body using magnetic fields and radio waves. Eventually, the water locations are mapped and then this information is used to generate a detailed image. Our bodies are made up of around 65% water (H_2O). The hydrogen (H) atoms make water interesting for MRI, and therefore it is the hydrogen atom that we use to measure the signal from the body, when we do MRI scan. We know that the H has a central nucleus containing a single positive charge (proton). Each spinning hydrogen (H) proton is just like a tiny magnet spinning around its axis. Once the patient enter an MRI scanner, the axes of H protons align along the direction of the magnetic field (B_o), some parallel and some anti-parallel, while still spinning around on their axes. Apart from this alignment, there is no physical movement of H protons within the body.

Due to the wonderful laws of quantum physics, there are always just slightly more "parallel" protons than "anti-parallel." The net magnetic field generated from the hydrogen protons collectively, is almost cancelled out, leaving the residual magnetic field, generating the tiny proportion of extra "parallel" protons. In fact, it is this small amount of magnetic field that is measured using MRI. The field (B_o) not only affects the hydrogen proton's alignment but also affects how fast those protons spin called precessional frequency. The precessional frequency depends on the strength of the magnetic field (B_o).

How do we detect the magnetic field?

A radio frequency (RF) pulse is used to disturb or flip all the protons, simultaneously, out of alignment from the scanners magnetic field. The frequency of the

RF pulse must be the same as the frequency of the spinning hydrogen protons, to show resonance with each other. Resonance enables the protons to absorb enough energy from the RF pulse to rotate their axes away from the B0 magnetic field, so that the MRI scanner can measure it. In the example shown in the Figure, a second magnetic field, B1, is applied.

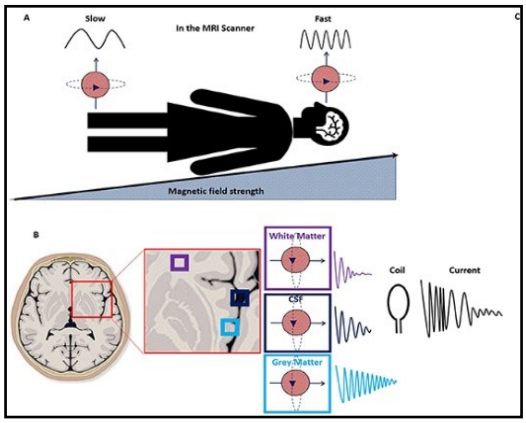


Hydrogen protons and how they behave in a magnetic field. *Image Credit: https://www.khanacademy.org/test-prep/mcat/physical-sciences*

Hydrogen protons in the head will then be spinning faster than the others. Then the RF pulse is tuned to the processing frequency of the hydrogen protons in the head. At that point the RF pulse will only be resonant with the protons present in the brain. Therefore, only the protons in the brain will be absorb energy from the RF pulse and be flipped away from the B0 field. Similarly, we can tune RF pulse to be resonant with protons in other parts of the body.

How do we get an image from these spinning protons?

Once the RF pulse is turned off, the protons are flipped back and realigned along the main magnetic field (B0). Consequently, the amounts of energy emitted by the tissues in the body are different from one another. A special equipment called a coil measures this energy, in which the released energy is detected as an electrical current. In other words, this coil is behaving like an antenna. This electrical current is then transformed into a highly detailed image of the respective tissue using a mathematical calculation, a Fourier transformation.



obtaining an image from spinning hydrogen protons Image Credit: The Physics of MRI https://kids.frontiersin.org/article/10.3389/frym.2019.00023

Benefits, Risks, and Limitations of MRI

The MRI scan is a painless and safe scan that produces more explicit images of the body and its tissues at any angle. It is instrumental in detecting tumors. An MRI is a sensitive technique. It uses no radiation for scanning, eliminating the health risk of x-rays that do use radiation. Although it is safe, there are still several risks. If the patient is pregnant, or suspects they may be, the doctor should be informed.

There is also the risk of patients being injured if they forget to remove pieces of metal from their bodies or clothing. In cases if a contrast dye is used, there is a small risk of an allergic reaction. An MRI is expensive and relatively time consuming. Therefore, it is not a particularly good investigation for emergencies or accidents. All the equipment has to be removed from the room while the machine is running, limiting its applications

to their bodies or clothing. In cases if a contrast dye is used, there is a small risk of an allergic reaction. An MRI is expensive and relatively time consuming. Therefore, it is not a particularly good investigation for emergencies or accidents. All the equipment has to be removed from the room while the machine is running, limiting its applications.

We are magnets! Really?

Magnetic field of MRI> (1000 4000) x (Earth's magnetic field)

The magnets used in MRI scanners must be cooled to a temperature of absolute zero

Ridmi Nisansi
4th Year Physics Special (2019)

Best Wishes for,

1st Annual magazine of the Department of Physics.

Ø6

From

2012 PHYSICS SPECIAL BATCH

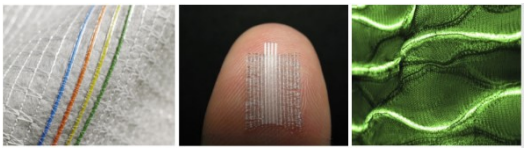
Smart textiles applications for healthcare

Smart textiles are considered a new scope for products with the possibility of the textile and apparel market. Smart textiles are named as textile products with added value. They have numerous properties of textiles, but ensure additional functions, providing attractive solutions for a wide range of application fields. They are used in healthcare, clothing for protection, and sports and technical textiles for the automotive industry.

However, smart textile products' manufacturing demands modernization and a complex technological approach, combining traditional textile manufacturing technologies such as knitting, weaving, embroidery with technologies originating from lithography, coating, and ink-jet printing. Functionalization of textiles may have schemed at different levels, such as fibers, fabric, or even ready-made clothing.

Smart textiles have many applications and have outstanding aspects in every case of human activities. Many research projects are devoted to developing smart textiles for medicine and healthcare. Such smart textile materials vary from in-vitro applications to use as a behoof in-vivo in everyday activities and accomplish such functions as physiological monitoring and communication with the environment.

Another smart textile application field is technical monitoring of structural health, automotive, geotechnical civil and other engineering industries. Besides high functionality, some smart and intelligent textiles have aesthetic values for applications in fashion and design.



Examples of optical fiber applications in smart textiles for engineering (a sensor integrated into geotextiles for temperature and strain measurements), medicine (a woven sensor for pulse oximetry assessment), design.

These examples have proposed that smart textiles can be characterized by their functionality, application field, and composition level of the "Smart Compound".

A significant role of the research is that it focuses on rational systems for medicine and healthcare. There is high competition in the textile market and new scopes are available in communication technologies, engineering, and information. Tempering the population leads to increasing patients and demands more investments in the nursing and medical sectors.

These textiles and clothing sectors are characterized by the micro-segment of smart textiles and extreme competition. This field is one of the good scopes for business development in new technology transfer from research institutions to industry and the R&D platform. These results are in investigating and producing wearable textile-based systems for the compound of Ambient Assisted Living (AAL) environment and healthcare. The first attempts to manufacture biomonitoring clothing have already started over a decade, and there are a significant number of reports published on cogitations of systems development.

Applications of Smart Textiles in Healthcare

Smart textiles in healthcare include the textile sensors, wearable electronics systems, and actuators, embedded into textiles, that enables enrollment and transmission of physiological data and wireless communication between the wearer and the "Operator," *for example, patient and medical personal. Such systems ensure patients' mobility, thereby providing a higher level of psycho-physiological comfort, especially when long-term biomonitoring is required.*

Generally, applications of smart textiles for medicine and healthcare vary from the surgical applications of single threads to complex wearable and interpetiolar systems for personalized healthcare. There is still no classification of smart textile for these applications, but initially, those can be described as referring to commonly distinguished groups in traditional medical textiles. Due to new functions, several new categories must be highlighted. Those are textile drug-release systems, textiles with biometric performance, and functional textiles for therapy and wellness. The next figures are summarized on the main applications of smart medical textiles.

Some medical applications of smart textiles. Wound dressing with pH sensor, Warming blanket for decubitus prophylaxis, Wearable MotherboardTM for vital signs monitoring, Philips phototherapy blanket for new-born' jaundice treatment.

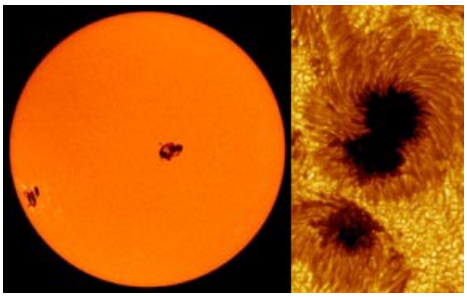
Textile sensors in smart textiles for healthcare

Textile sensors for physiological valuation and therapy purposes vary in their functions, applications, materials, technology solutions and composition level into textiles.

- **Textile electrodes** - Passive electrodes can be defined as textile sensors capable of electrical signal take over. Active textile electrodes for smart medical textiles can be referred to as electrodes for transcutaneous electrical excitation.
- **Temperature sensors** - results from the balance between heat production and heat loss and reflects the processes of the chemical and physical thermoregulation complied with activity of other organ systems.
- **Respiration rate sensors** - measure the process of inhalation and exhalation from the lungs in the body.
- **Textile sensors for kinematic analysis** - Textile materials can tend in kinematic analysis, monitoring of body motion, and positioning.
- **Humidity sensors** – Initially can measure moisture and refer to absolute humidity that indicates the actual amount of vapor.
- **Sensors for pH level estimation** - ensures continuous pH monitoring in real-time.
- **Pulse oximetry sensor** - for estimation of the arterial oxygen saturation (SpO2) in the studied biological tissue.

Lakmini Vithanage
4th Year Physics Special (2019)

How much can sunspots affect the Earth's climate?

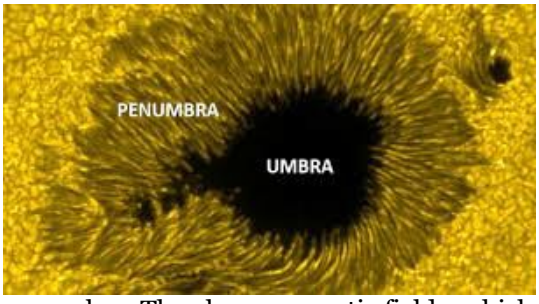


The sun is a typical star with a diameter of nearly about 1,400,000 km (approximately 10 times larger than the diameter of Jupiter) and is mainly composed of hydrogen (H2). The temperature and pressure of the sun's core are about 52,200,000^{o}C and 100 billion times the Earth's atmospheric pressure. Hydrogen atoms come so close together with these temperatures and pressure conditions and then they fuse. Right now, about half the amount of hydrogen in the sun's core has already been fused into helium. Roughly, this process took 4.5 billion years to accomplish. When the hydrogen atoms are exhausted, the surface temperature of the sun will start to cool, and then outer layers will expand outward till the orbit of Mars. At this point, the sun can be named as a "red giant". This red giant is 10,000 times brighter than the sun's present luminosity. After this red giant phase, the sun will shrink into a white dwarf star, about Earth's size. This white dwarf slowly cools through for more than several billion years.

Sunspots

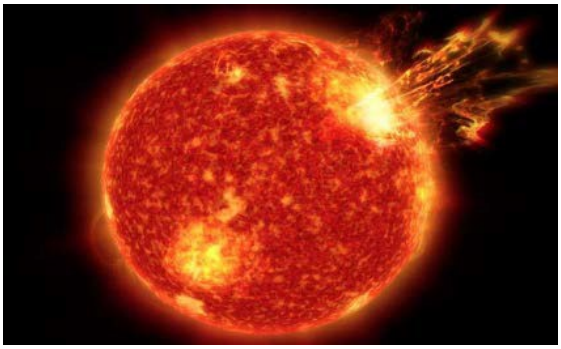
Sunspots are one of the exciting features of the sun. These sunspots are the areas of the sun's surface, where the magnetic field is nearly about 2,500 times stronger than the Earth's magnetic field and also much higher than the magnetic field in other places on the sun's surface. The magnetic pressure of the sunspots is relatively high due to the strong magnetic field, but the surrounding atmospheric pressure is relatively low. The temperature of these sunspots is relatively low than their surroundings due to the flow of hot gases from the sun's interior to the surface.

Sunspots consists of two parts, umbra, and



penumbra. They have magnetic fields, which points in opposite directions. The dark region of the sunspot is called the umbra and the surrounded lighter region is called the penumbra. The temperature of the umbra is about 3500^{o} C. The sunspots appear as relatively dark regions because the surrounding surface temperature of the sun's photosphere is relatively high, which is about 5,000^{o} C.

Sunspots, Solar flares and their influences on the Earth



Solar flares are extremely large explosions, which occur on the photosphere of the sun. Solar flares occur nearby sunspots, usually at the line between the umbra and the penumbra. Within a few minutes, they get heated to several million degrees and release as much energy as a billion megatons of TNT. Hot matter on the sun's surface is called plasma. To interact with the magnetic field, this plasma sends a burst of plasma in the form of a flare, up and away from the sun to interact with the magnetic field. Solar flares emit x-rays and magnetic fields. These

emitted x-rays and magnetic field bombard the Earth as geomagnetic storms. Hence increase in solar flares causes an increase in geomagnetic storms on Earth. Therefore, during maximum sunspot activities, there will be an increase in the northern and southern lights (aurora borealis, aurora australis). Also, it may cause disruptions in the radio transmissions and power grids. These storms can also change the polarity of satellites. Changes in polarity can damage the sophisticated electronics of the satellites.

The Solar Cycle

Sunspots and all other Sun's activities change through an average cycle of 11 years. Since 1749, the Earth has experienced 23 full solar cycles. The amount of sunspots changes from a minimum value to a maximum value and goes to next minimum, through this 11-year solar cycles. The Earth is now experiencing the 24th solar cycle.

One strange feature of these solar cycles was a comparable near zero sunspot activity period from 1645 to 1715. This period is called the "Maunder Minimum". During the Maunder Minimum, the "Little Ice Age" occurred over some parts of the Earth. This little ice age period shows that how many solar activities can affect the Earth's climate. There was a debate within the scientific community about the effects of solar activities on the Earth's climate. Also, there was research on the same topic. Maximum sunspot activities cause a very slight increase in the energy output of the sun. During the maximum sunspot activities, the ultraviolet radiation increases dramatically. This ultraviolet radiation can have a significant effect on the Earth's atmosphere. During minimum sunspot activities, the opposite may occur. Scientists were trying to reduce sunspot activities on the Earth's climate with the noise created by a complex interaction between our atmosphere, land, and oceans. However, it can be difficult. For example, research shows that the Maunder Minimum occurred during a time of minimum sunspot activities and related to the period which consisted of large volcanic eruptions. Large volcanic eruptions block the incoming solar radiation. Also, there is evidence that the ice ages may occur due to the deviation of Earth of its axis. However, when examining the Earth's climate on a global scale and over long periods, it is evident that the sunspots and other solar activities affect the Earth's climate. However, there are some views and discussions regarding the effect of the terrestrial and oceanic interactions on the Earth as well.

Dilki Madhushanka
4th Year Physics Special (2019)

Climate changes

The Earth is getting warmer. The oceans are getting deeper. The glaciers are getting smaller. Even the animals are changing their way of life. All these things happen because of a century-by-century changes in climate. Long term changes in the global climate are referred to as climate changes. The Sun, Earth, seas and oceans, wind, rain, snow, trees and all human activities are combined to form the global climate system. Science has revealed & proved that climate changes are harmful effects of global warming.

Since the late 19th century, the average temperature of Earth's atmosphere and oceans has begun to rise, now commonly known as global warming. Global warming is due to the trapping of heat that strikes the Earth, in the lower atmosphere. This process is called the 'Greenhouse Effect'. If there is no greenhouse effect, Earth's atmospheric temperature may be of extremely low sub-zero values which is not suitable for the survival of life. However, it is important to distinguish between the natural greenhouse effect and the man-made conditions which escalate the greenhouse effect above and beyond the acceptable limits. The problem today is that too much of the sun's radiation is being trapped by the atmosphere which causes the rise of Earth's average temperature faster than at any previous time in history. This increase in the temperature causes the melting of glaciers and a rise in sea level. Global warming and climate changes occur as a result of greenhouse gasses emitted by human activities such as the burning of fossil fuels in vehicles, buildings, factories, and power plants. Deforestation also contributes to global warming by releasing huge amounts of trapped carbon into the atmosphere thereby pushing the carbon-cycle out of balance. Water vapor, carbon dioxide (CO_2), methane (CH_4), Ozone (O_3) and nitrous oxide (NO) in Earth's atmosphere can be named as main greenhouse gasses. Increased amounts of these gases in the atmosphere would result in the air absorbing more heat than usual, thereby increasing global average ambient temperatures.

In 2019, we lost more than 900,000 hectares of the Amazon rainforest due to a wildfire. Human driven deforestation of the Amazon rainforest has been a concern for decades as the rainforest's impact on the global climate has been measured. The Amazon, being the world's largest CO_2 absorber, absorbs 6% of global CO_2 generation in plants and other biomass. The deforestation of the Amazon would vastly increase atmospheric CO_2 concentrations, thus making the survival of the Amazon, a global concern. Further, additional CO_2 and carbon is released into the atmosphere when the forest is lost through fire. Therefore, this hazard became a considerable threat to increasing global warming & changing climates worldwide. At the very beginning of 2020, we were unfortunate to witness another catastrophic bushfire that happened in Australia, which summoned death for an estimated 480 million animals. Although the Australian bushfire season is an annual occurrence in the summer months, it has been reported to worsen over the last few years as a direct result of increasing temperatures.

Sri Lanka contributes to climate changes at a very lower level when compared with the US and Europe. Nevertheless, since we all share the same atmosphere, Sri Lanka is also experiencing several harmful effects of climate changes including droughts, increase in rainfall, sea level and temperature. Each of these effects has another set of side effects that may finally cause a negative impact on the economy. In the dry zone of the country, there is a hike of temperature over 2 °C while the in other areas, an average hike 1 °C or more are reported. Since the dry zone

receives less rain than the wet zone, the dry zone has to face more droughts frequently. Due to this dry weather, most of the cultivations are being destroyed while having a heavy impact on the country's economy. By 2050, these effects of climate change is expected to be much more severe. For example, agriculture will be affected by droughts and will reduce food security in the country. It affects the farmers who are in the dry zone thereby increasing poverty. On the other hand, rising temperatures can cause an imbalance in the global weather phenomena thereby increasing the severity of storms, cyclones and floods. Floods will facilitate the spreading of diseases such as malaria and dengue. Storms will affect the fishermen's day to day life by putting their lives at risk. With the rise of sea levels, cyclones will push the waves further inland, eroding the coasts. People should not be located close to the sea; it is unwise to build right down to the sea shore. Infrastructure is another area that would be affected due to climate changes.

Is it still possible to stop this catastrophe? Scientists warn that we are at a critical point of no-return, however drastic changes today might help to lessen the impact in the coming years. To protect our world from climate changes, we must reduce the emission of greenhouse gases into the atmosphere. So, we can take some precautions such as shifting to renewable energy resources, recycling, new agriculture methods, reforestation, usage of energy efficient products, and planting trees. When we travel by plane, pay carbon offsets, usage of energy-efficient forms of transportation like bicycles, and use less energy at home we would be helping the cause. Moreover, we can vote for leaders who pledge to solve this crisis, and who abide by green and sustainable policies. We can encourage others to conserve nature. You can improve your knowledge about climate changes and share your knowledge with others to reduce the causes for changing climates. Give your support to national and international efforts to reduce climate change. We still have to change. As the inheritors of the Earth our responsibility is to protect it for us and the future. Let us protect our Earth and the lives of millions of humans, animals and plants from global warming and climate change.

Tilishi Dilani
4th Year Physics Special (2019)

Solar radiation and human health

Solar radiation is vital to maintain our lives. It gives light, heat and energy to our Earth. As you know, solar radiation is electromagnetic radiation. Electromagnetic radiation is an energy that travels in the form of electromagnetic waves. Solar radiation consists of infrared, ultraviolet and visible radiations. Due to the rotation of the Earth around the sun and the internal reactions, the amount of solar radiation that enters Earth varies in time and location.

Sometimes solar radiation may be hazardous for human beings. Excessive exposure to solar radiation causes many adverse effects. Erythema, Photoaging and cataracts are some examples of that. This article provides a broad view about the effects of solar radiation on human health.

Skin:

Ultraviolet radiation can be divided into three categories based on the wavelength. They are UVC radiation (100 to 290 nm), UVB radiation (290 to 320 nm) and UVA radiation (320 to 400 nm). Among these types of UV radiations, UVC has the shortest wavelength and highest energy. Therefore, it must be very dangerous. Fortunately, it can be completely absorbed by the ozone layer and does not influence human health.

However, UVB and UVA radiation affects the skin. Approximately 95 percent of UV rays that reach the Earth's surfaces are UVA. This UVA radiation causes many skin problems. Some of them are wrinkles, skin cancers, DNA damages in skin cells, mutations, etc...

UVA rays can penetrate our skins than UVB rays. It damages the innermost part of the top layer of skin. UVA rays cause many skin cancers, and UVA rays are considered the sun's silent killers due to that reason. We cannot feel the effects of UVA rays for a long period. Also, these UVA rays penetrate glass plates and cloud covers.

The ozone layer partially absorbs UVB radiation. Hence the amount of UVB rays that reach the Earth is approximately is 5 percent of UV radiation. UVB rays damage the outermost layer of the skin. That means it affects cells in the top layer of skin. There are some short-term effects on the skin from UVB rays. Some of them are delayed tanning, sunburn, blistering, redness, ulcers, and lesions. Skin cancers and premature aging can be mentioned as long-term effects.

Eye:

Eyes can be damaged due to solar radiation. The amount of damage depends on the intensity and time of exposure. Infrared radiation in solar radiation damages the inner eye. That means the crystalline lens and the retina. Also, this infrared radiation affects external parts. Those are conjunctiva and the cornea.

Most of the UVA rays cannot penetrate the cornea. However, a small amount of UVA rays is absorbed by the crystalline lens. That small amount of UVA rays penetrates to the

inner eye leading to damage to the retina. Also, it causes certain eye diseases. Some of them are macular degeneration and cataracts.

UVB rays are also harmful to the human eye. These UVB rays can damage the outer part of your eye. Mostly UVB rays cause to occur eye sunburns. These sunburned eyes are caused to photokeratitis (inflammation of the cornea).

Immune system:

The immune system is an essential system for the human body. The immune system is the body's natural defense, and it reacts against diseases. UV radiation causes many immunological changes in the human body that leading to suppression of the immune response. Weakened immune system can lose its ability to resist diseases.

How to protect from solar radiation?

Most people have to work outside day time. Solar radiation is strongest during the day time. Therefore, we must protect our body from solar radiation. The ozone layer protects us from UVC radiation. However, the ozone layer cannot protect us from UVA, UVB, and infrared radiations. Hence, we must control overexposure to UV radiation.

The followings are some methods to protect yourself from UV radiation.

- Stay in the shade and limit exposure to the sun during the solar radiation strongest hours (10.00 a.m. to 4.00 p.m.)
- Wear a wrap-around sunglass that blocks UVA and UVB radiation.
- Cover your arms and legs using clothes (There are some clothes to protect from UV radiation)
- Wear a wide-brimmed hat (it can cover your face, eyes and neck).
- Use a suitable amount of SPF 30 or higher sunscreen (it can protect your skin from UVA and UVB rays).
- Pay special attention to the children. because they can burn easily from UV radiation. Use sunscreen about 30 minutes before your child goes outside.

Udara Jayasinghe
4th Year Physics Special (2019)

The wonder of Quantum Biology

"The key to practical high efficiency solar cells and quantum computing may rest in the huge green world outside the physics laboratory".

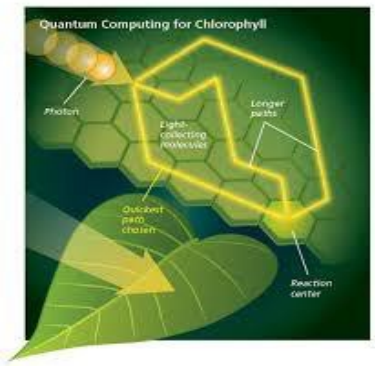
According to their backgrounds, quantum effects and living organisms seem to have quite different phenomena. We usually observe only on the microscopic scale, surrounded by a strong vacuum, a tightly controlled laboratory environment, and extremely low temperatures. However, the macroscopic world is warm, messy, and uncontrolled. A quantum phenomenon, superposition or coherence, in which the wave patterns of every part of a system stay in step, wouldn't last a microsecond in the boisterous realm of the cell.

However, most recent years we found that nature knows a few tricks that physicists do not; superposition quantum processes may be mostly available in the natural world. The most common examples are the ability of birds to navigate using Earth's magnetic field (Magneto reception) and the inner working principles of photosynthesis. Plant and bacteria's process turn sunlight, water, and carbon dioxide into organic matter, and disputably the most important biochemical reaction on Earth.

However, some researchers have begun to discuss a new era called quantum biology, arguing that quantum effects are vital, if rare, the ingredient of the way nature works.

Energy route finder

Researchers have long suspected that something unusual is occurring in photosynthesis. The particles of light called photons, streaming down from the sun, arrive randomly at the chlorophyll molecules and other light absorbing antenna pigments that cluster inside the cells of every leaf, and within every photosynthetic bacterium. However, once the energy of the photons is placed, it does not stay random. Somehow, it gets routed into steady flow towards the cell's photosynthetic reaction center, which can be used at maximum efficiency to convert carbon dioxide into carbohydrates or sugars.



Since the 1930s, scientists have recognized that this voyage must be described by quantum mechanics, which holds that quantum particles such as electrons will often act as both waves and particles. This phenomenon commonly known as wave-particle duality.

Photons hitting an antenna molecule will kick up currents of energized electrons called excitons. These excitons then pass from one molecule to the next until they reach the reaction center. However, are their path random or undirected steps, as researchers initially assumed? Or could their motion be more organized?

Therefore, nowadays some modern researchers have pointed out that the excitons could be coherent, with their waves extending to more than one molecule while staying in step and reinforcing one another.

If so, there is an unusual effect. Superposition quantum waves or states can exist in two or more states simultaneously, so coherent excitons would be able to move through the forest of antenna molecules by two or more routes at once. They could simultaneously explore multiple possible options, and automatically select the most efficient path to the reaction center.

The bird's-eye compass

Another major biological puzzle that might be explained by quantum effects is how some birds can navigate by sensing the Earth's magnetic field.

The avian magnetic sensor is known to be activated by the light hitting the bird's retina. Researchers recently made a reasonable guess on the mechanism, the energy deposited by each incoming photon of light creates a pair of free radicals — highly reactive molecules, each with an unpaired electron. Each of these unpaired electrons has a spin or an intrinsic angular momentum reoriented by a magnetic field. As the radicals separate, the unpaired electron on one is primarily influenced by the magnetism of a nearby atomic nucleus. In contrast, the unpaired electron that is further away from the nucleus and feels only Earth's magnetic field. The difference in the fields, changes the radical pair between two quantum states with differing chemical reactivity.

This quantum assisted magnetic sensing could be widespread. Not only birds, but also some insects, animals and even plants show physiological response to magnetic fields.

Using these wonder inspiring effects, they suggest practical use. Sometimes most obviously, a better understanding of how biological systems achieve quantum coherence in suitable conditions will —change the way we think about the design of light trapping structures. This could allow scientists to build technology such as solar cells with improved energy conversion high efficiencies. Also, the discovery of environmental noise will be useful for photonic engineering systems using materials such as quantum dots (nano scale crystals). Also, another area of possible application is quantum computing.

Therefore, learning from nature is an excellent idea as old as mythology. No one has imagined that the natural world has anything to teach us about the quantum world until now. When we think deeply, nature helps us build a beautiful world full of amazing things according to our own rules.

Ishara Weerasinghe
4th Year Physics Special (2019)

Quantum Teleportation

Teleportation is firmly situated within the field of science fantasy. We may not be able to teleport individuals or objects from place to place in a second, but there are contexts where teleportation is possible. Not only is it possible, but it's being accomplished in physics labs across the world.

There are three different kinds of teleportation, which are teleportation through a wormhole, or something similar, where your body is simply relocated to another place; the Star Trek kind where your molecules are disassembled, beamed somewhere else, and get back together in the same way and the last kind which we are talking about here.

The property of quantum mechanics called "quantum entanglement", scan and reassemble type of teleportation is possible.

Quantum entanglement explains how two or more particles behave in similar independent states, that simultaneously determine other states.

If two particles are considered to be in quantum entanglement, knowing the state of one particle, automatically gives out the state of the other particle.

As this does not depend on the physical distance, quantum entanglement can be used for teleportation.

In quantum teleportation a qubit which is the basic unit of quantum information is transmitted from one place to another. Here, the qubit is not transmitted through the intervening space. Within this entanglement assisted teleportation process, a replica of an object appears somewhere while the original object is disintegrated in one place.

The quantum teleportation theory was accepted as a real possibility and ceased to be fiction in 1993. This idea was first explained by Charles Bennett and his co-workers at IBM. They proved that quantum teleportation is possible, but only if the teleported original object is destroyed. The technique for teleportation in science fiction differs from story to story but normally goes as follows,

- A machine scans the original object to extract all the information required to describe it.
- A transmitter transmits the information to the receiving station to obtain a replica of the original.
- According to Heisenberg's uncertainty principle, higher precision of the scanning procedure results in higher disturbance for the object. Because of this, all information needed to develop the exact replica cannot be extracted before completely disturbing the original state of the object. This principle describes the inability to carry out the full process of scanning the object, which to be teleported, was violated.

- The velocity or location of every atom and electron would be subjected to errors.

- The law makes it impossible to read the exact quantum state of any object with certainty.

Together with two European teams, in 1998, the physicists of the California Institute of Technology were able to complete the process of teleporting an energy particle that carries light. In other words, a photon using a phenomenon known as ENTANGLEMENT or EINSTEIN-PODOLSKY-ROSEN (EPR) effect, which says that the "entanglement" of two particles are developed when they arise out of the same particle generation process and only interact with each other.

When two particles are entangled, even though they are situated apart, the second particle is affected predictably by the effects on the first particle, as they are in the same quantum system.
This gives out how the principle of quantum entanglement explains why entangled particles are considered "transporters".

At least three entangled photons are required to obtain quantum teleportation.

i. *Photon A*: The photon to be teleported.
ii. P*hoton B*: The transporting photon
iii. *Photon C*: The photon that is entangled with photon B

Entanglement of photon B and photon C can help extract information on photon A, which scientists would miss and therefore change as a result of looking closely at photon A without entanglement. The rest of the information would pass on to photon B by way of entanglement and then photon C.

When information from photon A is obtained and sent to photon C, to create a replica of photon A, photon A ceases to exist as it did before transmitting information to photon C.

However, there is a problem with transporting an atom. Because photons have very few pairs of parameters such as color, duration, amplitude, phase, polarization, beam size so on, that is about it. However, atoms have a lot more (about 100 different pairs considering sub atomic particles).

Modern discoveries have led to the teleportation of photons. A group of researchers from Italy, Sweden and Austria has successfully demonstrated teleportation using on-demand photons from quantum dots. The group describes how they accomplished this and how it applies to a future quantum communications network in their paper published in the Journal of Science Advances.

However, we are still far from using teleportation to transport any living creatures. The smallest existing organism is a viroid, which is as small as 10,000 atoms combined. Although we have been successful in teleporting one pair of information, teleporting a viroid would be roughly a million (100*10,000) times harder.

There are about 10^{27} atoms in a single human. With 100 parameter pairs per atom, that's about 10^{29} pairs of information. So far, we have done only one pair, so a human is about 10^{29} times harder. To transport a human, all 10^{27} atoms, which the human body consists of, would have to be identified and analyzed by the device.

Although the application of quantum teleportation seems un-achievable at present, there are a number of applications that successfully use quantum entanglement in a practical setting. Some applications in the real world are Quantum cryptography and Quantum computing.

Quantum cryptography

They are used in the commerce and military sector to transmit information guaranteed with full security by physics laws.

Quantum computing

According to Moore's law, computers double their aspects such as speed and memory twice every three years, while physical aspects of a computer remains the same.

This implies that fewer and fewer atoms are needed to meet higher expectations as time goes. This would result in the invalidation of classical physics ultimately leading to a need of developing new methods of computing.

Kusal Abeywickrama
4th Year Physics Special (2019)

Black Holes the Biggest Mystery in the Universe

A black hole is a region of spacetime exhibiting strong gravitational acceleration such that no particles or even electromagnetic radiation such as light can escape from it. Theoretically Black holes were first predicted by Einstein in his theory of General relativity. According to the prediction, a sufficiently compact mass has the ability to deform spacetime and it was assumed to be one of the solutions of the equation of Einstein's General relativity.

Is there a limitation on the size of a Black Hole?

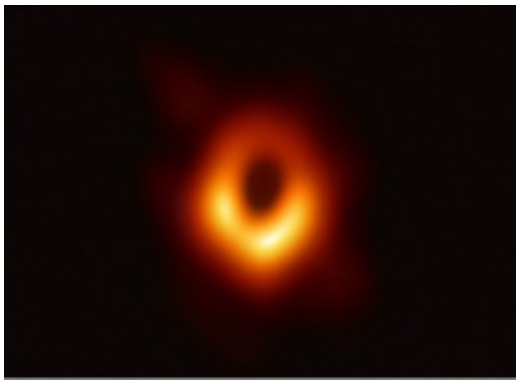
According to Einstein's General relativity there is no limit to the size of a Black Hole, However, to understand exactly how gravity works, a combinatory theory involving Einstein's General relativity and Quantum mechanics has to be built up, which has failed so far. According to the experimental and theoretical knowledge the largest Black Hole in existence can have a mass equivalent to a billion solar masses. Their radii can be predicted to be a fraction of our solar system. Similarly, scientists predict that the smallest size of a Black Hole has a radius around $1\,x\,10^{-35}\,m$.

Can you observe a black hole?

You cannot observe a Black hole directly since not even light can escape the Black Hole and at the same time black holes are surrounded by material that can obscure the light surrounding the Black hole.

If we cannot observe a Black Hole, what are we observing in the first photograph of a Black hole?

Black holes only emit a slight amount of radiation, However, according to what Einstein predicted, the outline of the black hole and its event horizon which is defined as the boundary beyond which light can't escape from the Black hole can be seen. The dark circle seen in the middle of the Black hole is named the shadow, and it is revealed by the glowing gas that sits at the event horizon around the shadow. The extreme gravitational pull of the black hole, has the ability to superheat this gas, causing it to emit this radiation.



The first image of the supermassive Black hole, 55 million light years away in a galaxy called M87.

Is the event horizon orange in colour?

No, the event horizon is actually not yellow or orange in colour. The astronomers involved with the project chose to colour radio wave signals with orange to depict the brightness of the emissions. The yellow colour depicts the most intense emissions, red color depicts the lower intense emissions, and the black represents the area of no emission.

Why is the image blurry?

With the currently available technology, the highest achievable resolution is what is seen in the picture. The Event horizon telescope has a resolution close to 20 micro-arc-seconds. It is considered a remarkable achievement since the Black Hole seen in the photograph is situated 55 million light years away.

Why is the ring around the Black Hole irregular in shape?

The scientists still do not know the reason behind this, they predict that the future data would present a solution to this problem.

Is there a specific reason for measuring radio waves rather than visible light to capture the image?

The resolution that can be obtained using radio ways is considerably large compared to

that of visible light. Radio waves consist of the highest angular resolution (the ability to differentiate between two separate objects) of any technique that is currently present.

Is the Black hole image an actual photograph?

It is not a traditional photograph. The scientists captured enough emitted radio waves from the black holes event horizon and processed the data into the image obtained.

So, was Einstein correct after all?

Yes of course. Einstein's theory of General relativity speculated that black holes exist and that they consist of event horizons. Einstein's equation also predicted that the event horizon should be somewhat circular in nature and the size of the ring should be directly related to the mass of the Black Hole.

Hawking radiation and Black holes?

Due to the observation that particle and anti-particle will be formed spontaneously in a vacuum, Hawking predicted that near the event horizon of black holes that the same phenomena is occurring and that there is a finite chance that one member of the pair would be lost inside the black hole where as the other would escape. There is a net loss of mass or energy in the aggregate, which gives rise to Hawking radiation. It is a subtle phenomenon, and the Hawking radiation of a dead star is about one billionth of a kelvin which is practically immeasurable. So theoretically black holes would be losing mass due to Hawking radiation, and this concept is known as black hole evaporation.

What happens to the information that is lost in a Black hole? Information paradox

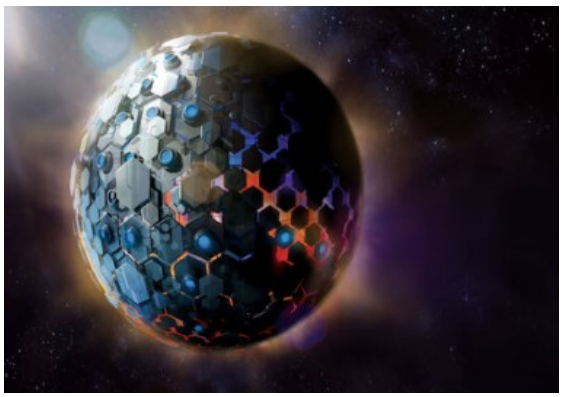
This is a problem. According to Quantum mechanics all information in any interaction is preserved. However, this phenomenon is violated at the event horizon. Information paradox is a statement to dictate that our current gravitational theory and Quantum mechanical theory are not compatible. A popular theoretical idea among physicists is that when something falls inside a black hole, its time slows down infinitely. The information is preserved as matter falls into the black hole similar to a hologram and could be extracted later.

(The short goodbye) What would happen eventually?

In 10^{12} – 10^{50} years of time all stellar fusion and light from stars will end after a trillion years It is theorized that in the future dark, dissipating universe, energy can be extracted from the rotation energy of black holes by sending in and retrieving probes with suitable trajectories.

The long goodbye

It is theorized that Black holes will be the last concrete objects in the universe. Advanced civilizations in the future will use black holes to run their civilization by harnessing the feeble energy using the concept of Dyson spheres. Black holes will be the stars of the far future.



Dyson sphere – It is a hypothetical mega structure that completely encompasses a star and captures a large percentage of its power output.

Channa Hatharasinghe
4th Year Physics Special (2019)

Nuclear Powered Vehicles, is That Possible?

After the Americans dropped the nuclear bombs on Hiroshima and Nagasaki during the Second World War, it was evident that nuclear energy can generate unprecedented amounts of power. Therefore, controlled nuclear power would be an ideal solution for the power crisis in the future. Therefore, after numerous engineering and physics experiments, nuclear power plants became a reality. Despite their huge energy generation capacity, these reactors also carry considerable risk for human health, which was proven by the Chernobyl disaster. This article focuses on the possibilities of applying nuclear energy in the future automobile Industry.

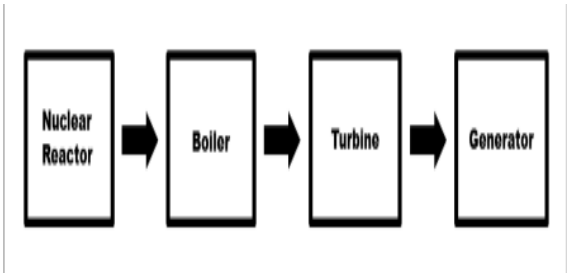
Before discussing the future, let's see the development of the automobile industry up to today. Humans tried to invent and develop several transportation methods since ancient times, but 1769 was the year that changed everything. In that year, Nicolas Joseph Cugnot invented the World's first self-propelled vehicle with a steam engine. In 1807 Isaac De Rivaz invented the first internal combustion engine that used hydrogen and oxygen as fuel. Almost after 60 years from that, in 1862 Joseph Etienne Lenoir invented the first gasoline powered engine but it was developed and first used in a vehicle in 1885 by Karl Benz in the worlds' first car named known as the 'Motorwagen'. Since then, various car manufacturers worldwide have been developing gasoline powered vehicles up to today.

Gasoline works as the primary fuel source for vehicles, but according to calculations, the remaining amount of crude oil won't last beyond 2050. Also, with the number of vehicles increasing in recent history, fossil fuels became a major threat to both nature and human health. Therefore, scientists and engineers started to develop alternative sources to fuel vehicles. One of the current solutions in the market is to replace gasoline fueled vehicles with battery powered electric vehicles.

The history of battery powered vehicles goes back to the early 20th century. However, a few years later, this technology went through a silent period from the 1930s to 1990s because of the long-range travel requirements and reduced gasoline prices. After the issues with gasoline came into the discussion, battery powered electric vehicles came back to production around 2007. Since then, engineers have kept working on increasing their range and reducing their recharging time. Even though those efforts gained some success over the past years, these vehicles still take a considerable time to recharge their batteries and offers a much less range than gasoline powered vehicles.

Therefore, the suggested solution for both these issues is a hybrid system, with a rechargeable battery pack to power the vehicle and an inbuilt power generator to generate electricity using an eco-friendly, renewable fuel source to recharge the batteries. So, this article aims to discuss the possibility of using nuclear power to fuel these generators. Before that, let's see how a nuclear power plant generates electricity. Nuclear power plants generate electricity using nuclear fission. As shown in figure 1, the energy released during a nuclear reaction is converted into heat which is used to boil water in a boiler. Then water vapor generated during this boiling is used to power up turbines which are connected to generators that generate electricity.

The first time the nuclear-powered car came into development was in 1958 by the Ford Company, where they built a concept car powered by Uranium. The technology behind that car was a scaled down submarine reactor in the back of the car which would heat stored water into high pressure steam, driving two turbines. One to power the wheels and the other one to power up the generator. Since then, a few concepts have been introduced,



but none of them came close to becoming a production vehicle because of safety issues. So, It is essential to address these safety issues when using nuclear power to fuel a vehicle because a section of these cars work as a nuclear reactor. The major issues are as follows.

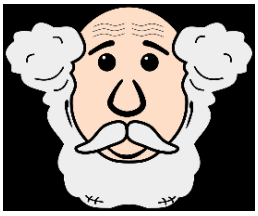
- It is necessary to have a huge metal or concrete barrier between the nuclear reactor and the passenger area to verify the driver and the passenger's safety, but that is practically impossible.
- Also, it is important to pay attention to the safety of the vehicle and the passengers in the situation of an accident.
- Other than that, paying attention to the methods of managing nuclear wastage is also important.

Therefore, solving these issues doesn't seem entirely possible with the latest technologies, because we are talking about inserting a scaled down nuclear reactor and a nuclear power plant into a vehicle travelling on a regular road. However, if the scientists could solve these issues, the world can experience a completely eco-friendly vehicle that requires to refill once a decade or once a century.

Transportation is an essential thing in human lives. Even though there were a number of transportation media that existed since ancient history, the industry was revolutionized after the internal combustion engine. Over the past century, gasoline extracted from crude oil was used as the main fuel source for these engines until the world realized that the remaining underground oil will not last longer than 2050. Therefore, an alternative was invented to power vehicles including electricity stored in batteries. This alternative still shows some faults. Therefore, using nuclear power in a hybrid type system is an ideal solution for these issues which is still not an easy task even with modern technologies.

Nirmal Ravindra Kularathne
3rd Year Physics Special (2021)

The Grandfather Paradox



Time traveling is an interesting concept in physics. Can we really travel back in time? Let us say it is possible for a moment. If it is, now I would take you through a mind-blowing question.

Here is *John* and he has made a time machine to travel back in time. John was not happy about his grandfather. Since his grandfather was a rude man, killing his grandfather was his main purpose. After he got his time machine he went back to the past. At this time his grandfather was young. He saw that his grandfather is walking in the garden. John had a clear shot, and he took his chance!

Now the question arises here! Since John has now killed his grandfather at his young age, grandfather was unable to marry. Since he did not marry, John's father will not born. Since John's father did not exist, John also will not be born to travel back in time. Then how could he kill his grandfather? A paradox!

This is called the famous grandfather paradox. How do we solve this? Scientists have explained this by using both classical and quantum mechanics theories. However, they are quite different.

Here we focus on one of the quantum mechanical solutions of this paradox. In quantum mechanics, sub atomic particles stay in a superposition state composed of two or more other states. However, we can only observe one of those states at a time. Then what about us? Are we also in a superposition state? Yes!

A famous experiment was devised by an Austrian physicist called **Erwin Schrödinger** in 1935, which is called **Schrödinger's cat experiment**. In his experiment, he put a cat into a box and added some radioactive material into that box with a 50:50 chance of decaying. If it decays, it will be registered by a Geiger counter installed inside the box. If the counter detects the radioactivity, a hammer will fall and smash a glass container of some vaporized poisons which can kill that cat inside. Then the system was sealed and no one from the outside can know the true nature of the system until it is opened. Outsiders can only say that either cat is alive or dead since the killing chance is 50:50. When they open the box, they can exactly say the current state of the cat. However, until the box is opened, the cat would exist in a limbo state between life and death.

The same theory applies here. What if we live in a superposition state of life and death? Then John's grandfather is also in a superposition state of death and life. Since John is a natural result of his grandfather, John is also in a superposition state of death and life.

|Gfalive > + |Gfdead > |Johnalive > + |Johndead >

If the grandfather is alive, John is born, and he will travel back in time to kill his grandfather. If the grandfather is dead, John will not be able to kill him. Whatever the final result of any of these two possibilities again the superposition of two states, John's grandfather is alive and dead. Logically this entire timeline is looping, and there is no paradox! However, no one has proven yet that traveling to the past is possible.

Kavindu Sellahewa
4th Year Physics Special (2020)

Activities of the Physics Society

1) The program “Mini workshop on frontier research in condensed matter physics” was held on the 21st of February 2019 from 2pm to 4pm in Physics laboratory theatre. Prof. Der Jun Jang, Prof. Feng-Chuan Chuang, Prof. Chien-Cheng Kuo and Prof. Chao- Kuei Lee were participated in representing the “Sun Yat-Sen” University China to conduct this program.

2) Physics society represents the exhibits on behalf of the Applied Sciences faculty stall in the " Invoation and Invention exhibition 2019," held on 2nd and 3rd of April 2019 at Bandaranayake Memorial International Conference Hall.

3) An invited talk on " Seeing Beyond Visible Light" was held on 23rd of May 2019 at 3 pm at the PLT lecture hall. The resource person was Dr. P.K.D.D.P.Pitigala, Department of Physics, University of Sri Jayewardenepura.

4) The Higher Studies program was held on the 27th of June 2019 from 1 pm to 3 pm at the PLT lecture hall. The PhD candidates of USA universities of Mr. A Mahanama and Mr. Tharaka Missaka participated as resource personnel to share their experiences throughout the Graduate Admission process.

5) The Practical session regarding “Electronics” for advanced level students jointly organized by Sri Lanka Association for the Advancement of Science (SLAAS)-Section E1 and Physics Society

of University of Sri Jayewardenepura was held on the 1st of July 2019 from 8 am to 5 pm at PLT Lecture hall. One hundred school students participated in the practical sessions.

6) A guest talk on "Two Dimensional materials @ 3M" was jointly organized by the Sri Lanka Association for the Advancement of Science (SLAAS)-Section E1 and Physics Society of University of Sri Jayewardenepura on 31st of October 2019 from 3.30 pm to 4.30 pm at the PLT lecture hall. The resource person was Dr. Ranjith Divigalpitiya, Senior Specialist, at 3M Canada company.

7) The welcome program for the 1st year-students 2020 was held on the 13th March 2020 at the Department of Physics. This program consisted of many activities, such as a quiz, the mini challenge to construct the toy structures, a message pass game, and a creative activity based on the physics concepts. Most of the lecturers in the Department of Physics contributed to evaluating the activities. The students were highly motivated and attracted to this successful event.

8) A guest talk on "Wireless Power Transfer and its applications" jointly organized by Sri Lanka Association for the Advancement of Science (SLAAS)-Section E1 and Physics Society of University of Sri Jayewardenepura was conducted by Dr. Aruna Ranaweera from university of Kelaniya and was held on July 29th at 6pm via Zoom.

9) An online forum on "Physics for Professional Development" was jointly organized by the Sri Lanka Association for the Advancement of Science (SLAAS)-Section E1, Physics students society university of Kelaniya and Physics Society of University of Sri Jayewardenepura with the participation of Dr. Chinthaka De Silva, Mrs. W.D. Ruwandi Fernando and Mr. A.D. Deepal Naminda on 7th October 2020 at 6pm via Zoom.

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 and most recently in 2019, Mr. Channa Hatharasinghe were able to participate in the programme.

In addition to undertaking a small project, summer students get the opportunity to participate in a well-organized lecture series covering a wide range of topics in physics, statistics, and mathematics. They include Standard model, Beyond standard model, Theoretical particle physics, Cosmology, String theory etc. Also, they get the opportunity to visit several experiments including the ATLAS, CMS, and the LHC, which is the largest particle accelerator in the world.

Mr. Hatharasinghe's short project at CERN was based on the ATLAS experiment. ATLAS is one of the four major experiments at the Large Hadron Collider (LHC). He was involved in analyzing correlations using the Boosted decision tree machine learning algorithm and constructing a new code using C++ on the Higgs Boson reconstruction technique in $t\bar{t}H$ (H $\rightarrow b\bar{b}$).

Annual publications and conference proceedings

- R.M.D.M. Senarathna, W.K.I.L. Wanniarachchi, S. Jayawardhana, Replication of the Surface Wettability of Plant Leaves with Different Surface Morphologies Using Soft Lithography, International Journal of Nanoscience, vol 19, issue 3 (2020) DOI:10.1142/S0219581X19500182

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