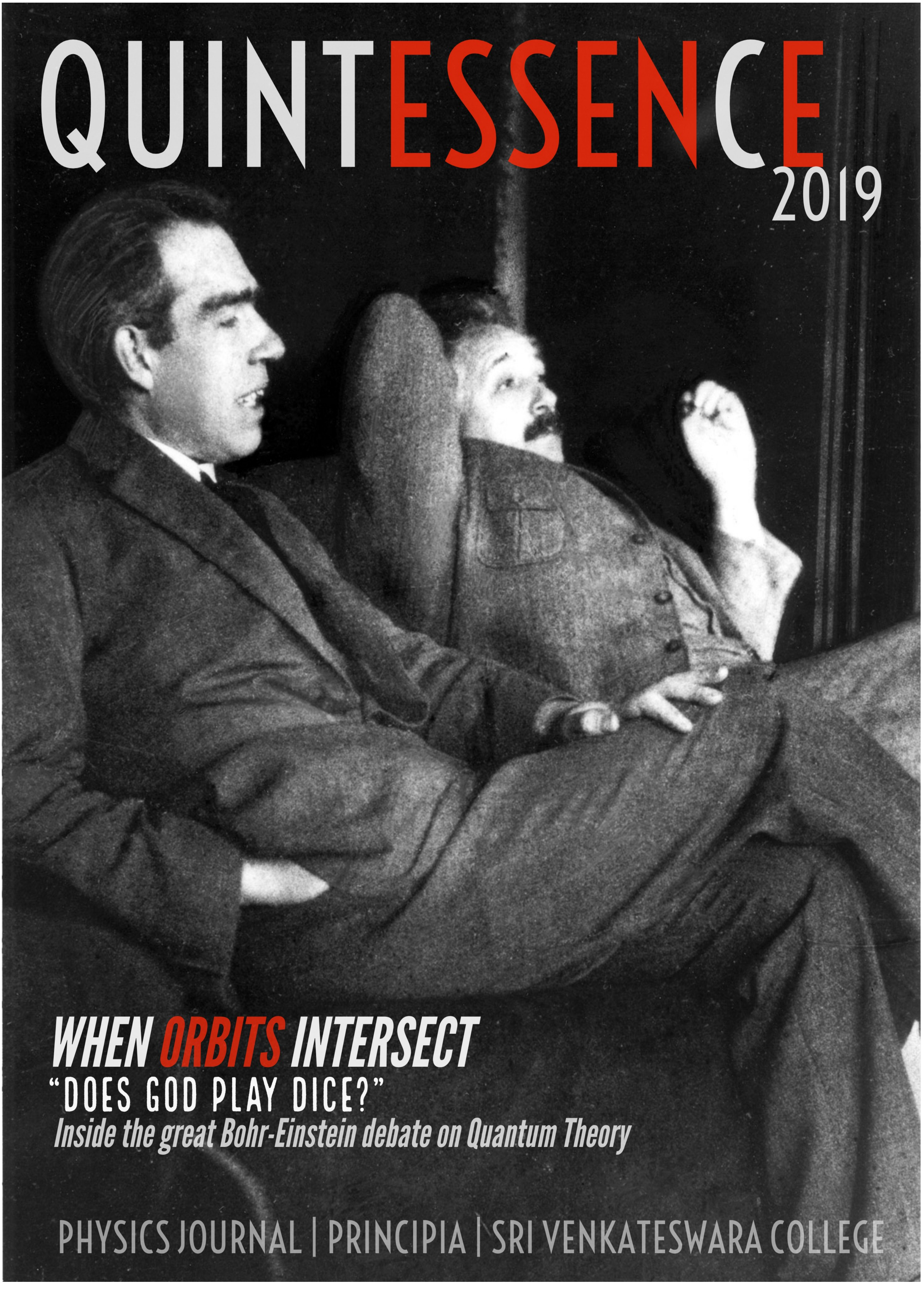
QUINTESSENCE
2019



WHEN ORBITS INTERSECT

"DOES GOD PLAY DICE?"

Inside the great Bohr-Einstein debate on Quantum Theory

PHYSICS JOURNAL | PRINCIPIA | SRI VENKATESWARA COLLEGE

CREDITS

THE EDITORIAL TEAM

Mansi Tomar
Aakash Kumar
Najdeep Kaur Sidhu
Ruderaksh Baigra
Pranav Singhal
Gunjan
Aditi Rawat
Shrishti Kunwar
Lalit Kumar
Shivansh Hoon
Tanushree Chowdhury
Yashvardhan Shukla
Prerna Joshi

SPECIAL THANKS

Dr. Piyush Kumar Parashar
(Staff Advisor)

Shivika Walia
(President - PRINCIPIA, The Physics Society)

FACULTY

2017-2019

Dr. B.V.G. Rao
Dr. Renu Jain
Dr. Pratima Vyas
Dr. Chiranjeev Kaur
Dr. A.K. Chaudhury
Dr. K.C. Singh
Dr. Anant Pandey
Dr. Manoj Giri
Dr. Garima Saxena
Dr. Piyush K. Parashar

GUEST FACULTY

Ms. Geetika Jain
Dr. Alok Shukla
Dr. Ravinder Goyal

CONTENTS

GUEST AND FACULTY ARTICLES

MISCELLANY

Nobel Prize in Physics - 2018
Gunjan

Science and Religion
Mansi Tomar

Scanning electron microscope
Jatin Arora

Turbulence
Yashvardhan Shukla

STUDENT RESEARCH ARTICLES

Study of solar activity cycle and the oscillations in the solar atmosphere
Pranav Singhal

Modifying and optimising transient pipeline
Ishita Chaturvedi

Deposition of thin film and magnetron sputtering machine
Dipankar Das

శ్రీ వేంకటేశ్వర కళాశాల
Sri Venkateswara College
(University of Delhi)
NAAC 'A' Accredited, DBT Star Status
Benito Juarez Road, Dhaula Kuan, New Delhi-110021
Ph.: 011-24112196, 24118590, Telefax : 011-24118535
principal@svc.ac.in

Dr. P. Hemalatha Reddy
Principal

From the Principal's Desk,

I would like to congratulate the Physics Department of our college for successfully bringing out this edition of Quintessence. Year by year, the efforts of the staff and students have taken the department and the college forward in terms of excellence. The Physics society "PRINCIPIA", and the Physics Department has shown its enthusiasm by organizing various events. The practical knowledge that the students have gained by seeing the application of Science, has really encouraged them to seek answers for many queries.

I am glad that students have put together their ideas, and compiled them to bring out this magazine.

Best wishes, and all the best!

Dr. P. Hemalatha Reddy

From the teacher in-charge

Dr. Renu Jain
Teacher in-charge
Department of Physics
Sri Venkateswara College

I would like to thank all my editorial team members for helping each other to come out with this print of Quintessence. I express my considerable appreciation to all the authors of the articles in this magazine. It is this willingness to share knowledge, concerns and special insights with fellow beings that has made this magazine possible.

Thank you all!

CONVENER'S NOTE

Dr. Garima Saxena

Human mind has always been intrigued by nature. The never ending unsatisfying quest to understand the existence of being and not-being led to the formulation of subject 'Physics', the name getting derived from Greek theological term '*Physis*' meaning nature.
Early Physics was far different from what we see now. There was little degree of experience and observation, the approach was primarily philosophical at heart where the laws of nature were constructed to conform to a particular philosophical outlook. This was the classical Greek period during which Physics slowly shaped as a separate entity from natural philosophy. With the advancement of time, philosophers adopted rational exploration of the subject. Aristarchus challenged geocentric model of solar system and gave explicit arguments for heliocentric view. Further Galileo, Seleucus, Ptolemy, Hipparchus and many more thinkers focused more on the use of geometry and algebra. Scientific progress saw a gigantic revolution with the development of calculus by Newton and Lebniz. The power of calculus established the need to forgo ontological metaphysical explanations and now mathematics became the backbone for laying any theory. The evolution of physical science till this stage had made clear that rational reasoning was the key to see the unseen. Thereafter, the interplay between conformists and contrarians unleashed spectacular sides of Physics like the development of mechanics, thermodynamics, electromagnetic theory, famous Michelson Morley experiment disproving ether, quantisation of light, wave-particle duality, special & general relativity, astronomy, cosmology, quantum mechanics, a wide field of material science, and many more, all impossible to cite in few words.

During this journey of Physics, the element of Quintessence was conceived, confuted and finally readopted in a new context... The Dark Energy, something that might be responsible for the accelerating expansion of our Universe. We here in Principa's Quintessence cherish the same spirit of evolution aiming to accomplish Aristotle's vision of supralunary heights while sticking to the vision of modern science. The ideology is aptly reflected through the contents of the magazine wherein authors have tried to map the entire range of physics from quantum scale to cosmological distances. The magazine is organized in three sections, of which one section is written by faculty and two are student's contributions. First section by students has articles which aim to give readers insights to different phenomena and works in Physics. The second student's section is designed especially for the newcomers who aim to pursue research in future. It has articles by the project doers about their research work carried out at esteemed national institutes alongside the regular studies of graduation.

This print of Quintessence is the outcome of exuberant zest of the authors, the editorial board and all the team members, carrying a hope that it will serves as a knowledge contributor and inspirational source to everyone.
I end up wishing readers an enlightening and thought provoking experience, with a humble reminder to **Answer at the end *" Does God play dice?"***

From the President's Desk

Annual Report

Shivika Walia

President, The Physics Society

If Mathematics is the language of the universe, then Physics is a poem. If Mathematics is the heart, then Physics is the soul. One of the main reasons why most people are intrigued by Physics is due to its mind bogging ability to explain almost everything happening around us. Why is the sky blue? Rayleigh scattering. Why is water wet? It isn't until you touch it. The list of questions, and their respective answers can go on forever. At the same time, a plethora of questions have had people scratching their heads for quite some time now.

Are we the only living beings in the universe? Is time travel possible?

Physics is perhaps one of the only fields that takes into account, all the other sciences, juxtaposing varied facts and numbers to explain the most complex everyday phenomena.

Having realized the power of studying this subject, I decided to join this journey of being a student of Physics(H) in Sri Venkateswara College. On the very first day of mine in this college, I decided to actively participate in all the activities of the department and took charge as the Joint Secretary of the department followed by Vice President in the 2nd year and then having learnt all the duties under my seniors and the expert guidance of my teachers, I was chosen as the President of the Society.

Hence, I would like to take this opportunity to express my gratitude to the people who were responsible for the journey that I as an individual and the Physics society as a whole have made in the past 3 years. I would like to thank Respected Principal, Dr. P. Hemlata Reddy for her restless efforts of encouraging interdisciplinary science education and showing us the right path and also our Head of the Department 2018-19, Dr Renu Jain, who has been our pillar of support, not just when it comes to Physics but also in other walks of life. I would also like to thank our Convenors of the society Dr. Manoj Giri and Dr. Garima Saxena for their undeterred support and guidance. I also extend a heartfelt thanks to our staff Advisor Dr. Piyush Kumar Prashar who joined in August 2018 and from the very beginning, left no stone unturned in encouraging not only me , but every student, to get involved in the activities of the Department. Last but not the least, I would like to thank everyone from the Physics Department - teachers, Lab Staff, students , alumni and the College for helping in all the activities, including the forging of this magazine.

For a wonderful start to the year 2018-19, on 10th of August,2018,the Physics society conducted its investiture ceremony with an inaugural lecture by Dr. K.J. Ramesh, Director General of the Indian Meteorological Department, who enlightened us in the field of Atmospheric Sciences and Monsoon dynamics. On 25th September, 2018 , a workshop on Digital Forensics was organized where Mr. Omveer Singh, director/scientist 'F' at CERT-IN made the students aware about Cyber Forensics, Imaging Analysis and also hands on session on the above mentioned topics.

I would now take the opportunity to list the achievements and immense amount of potential displayed by our students.

Students from our department displayed multifaceted talent throughout the academic year. The likes of the same included Ishita Chaturvedi(III yr.), who worked on multiple projects, including 'Detection of Radio Transient Events in real time using GMRT' and organizing events like Indian National Space Settlement Design Competition and Asian Regional Space Settlement Design Competition. Her achievements also include an internship, 'Think Robots', where she wrote Arduino based codes as a project to introduce school students to coding and robotics using a hands on approach. Sanchi Virmani(III yr.) interned on the topic 'Projectiles and proposing a design for its launch' and also attended a workshop on nanomaterial synthesis, also being a part of the Western Music society of our college. Tanushree(II yr.) attended multiple workshops ranging from Nanomaterials and it's applications to Forensics and attended interactive seminars, including an interaction with CERN scientists at Miranda House College. Bharti Ojha(II yr.) participated in TERI-NCSTC Eco Eureka training in December 2018.

Outside academics, our students actively participated in a plethora of extra curricular events. Suraj Bhambhani (III yr.) a member of the SVC pistol shooting team, won brought home many laurels, including a gold medal at the Inter College Pistol Shooting Competition 2018-19 at Hansraj College, a silver medal each at Delhi State Shooting Competition in 10m Air Pistol and North Zone Shooting Championships in 50m Free Pistol. He also held the National Rank of 8 in Free Pistol in 2018. Rochi (II yr.) won meritorious awards in SCUDEM organized by Department of Mathematics and attended various seminars and talk sessions on cosmology. Soumendra Goswami(III yr.) is the President of Alaap- The Indian Music Society of SVC. Radhika Juglan(II yr.) is also a member of Alaap and recently completed five years as a student of Prayag Sangeet Samiti, Allahabad University. Tamanna(II yr.) is an active member of Fine Arts Association alongside Principia. Divyanshu, the Vice President of Principia, is also the member of the English Debating Society since the very first year. Lalit from 2 nd Year was a part of Verbum while Riya was a part of Leonci. Aditi, Sejal and Shriya from 2nd Year have been a part of NSS.

The latest string of alumni from the Physics Department did our college proud by continuing their education in prestigious institutions. Shaoni Kar got into University of Cambridge, a university that has produced greats like Sir Isaac Newton and

Dr Stephen Hawking. Puneet Parekh got into IIT Delhi while Sonia Rani,Abhilash Ranjan, Prakhar Sharma got into IIT Bombay. Ankit Khandelwal continued his education at IISc Bangalore while Mehul Jotshi is now at Freie Universität, Berlin. Chirag is pursuing Astronomy and Astrophysics at Tuebingen University, Germany. Ankit Dulat made it to TIFR. Many students including Kanika, Shashi, Vikram, Abeer Arora and Geetansh Arora are pursuing their education from Delhi University itself.

On the eve of National Science day, 28th February, 2019, The college decided to have science fair on 28th February and 1st March, 2019 which was marked by the auspicious commencement of the day and related events where in students of Department of Physics took active participation and acquired commendable fields within the realm of competitiveness.
Day 1 was marked by T-shirt Redesigning competition organized by Indian School of Design and Innovation(ISDI) Mumbai in our college. The theme given to participants was Sustainability. As a visible proof to the sheer determination and enthusiasm, students of Department of Physics namely Nidhi and Aarushi (I yr.) came 1st in the competition, closely followed by Gunjan and Srishti(I yr.) as 3rd position holders. Second event was a Model Making Competition, where in many students of various institutions took part, making it competitive and equally exuberant. Ishita of 3rd year batch won 1st prize in the following event with her model being centered on 'Detecting Radio Transient Events in Real Time'. The atmosphere was ingrained with challenging minds with astonishing ideas drafted into a model for display. This event saw test of her perseverance, making the Department of Physics proud in the process. Various other students also participated in the model making competition namely Shanu, Rudraksh, Ravi and Aakash with commendable model presentations.

Ten students of Department of Physics led by Dr. Anant Pandey went to attend the rare yet exemplary, real time talk with renowned Prof. Ajoy Ghatak at Inter-University Accelerator Centre(IUAC). There the students discovered various essential tech based on application of physics like Linac, XRD and Neutron Detector. It was a perfect amalgamation of enthusiasm and curiosity with Prof. Ghatak being magnificent in explaining the concepts and working of the recipient technologies. On the same day, our Department of also coordinated with the college administration to attend a mesmerizing Shanti Swaroop Bhatnagar Prize for Science and Technology function. Being one of a kind, this event was graced by our honorable Prime Minister Shri Narendra Modi.

The students were led by our honorary Principal of Sri Venkateswara College Dr. P. Hemalatha Reddy accompanied by Head of Department of Physics Dr. Renu Jain. This function being of such importance will remain forever as a good memory of the journey of our department. Last but not the least, an event of Science Quiz witnessed active participation of Physics students in the realm of quizzing. 3rd year students namely Suraj and Aakash with others namely Ravi appeared as champs bagging the 2nd prize to their sleeve along with Radhika and Ravi being the active participants till they laid down their swords.

Day 2 was also full of exciting events. Amongst them, the Scitales was an important chapter. This event, organized by Department of Physics, was a cleave of Science and Storytelling with being an on-the-spot competition. Panel of judges was graced by Dr. H. C. Tandon from Department of Chemistry, Dr. Garima Saxena from Department of Physics and Dr. Vertika Mathur from Department of Zoology. In this heated event participants along with judges and fellow audience shared chuckles and skills of storytelling. Being an event, there must be a winner, a criteria fulfilled by Tushar Jawalia(III yr.) being victorious followed by Ishita and Krishit sharing the 2nd prize together. With these kind of events, the history is written and the glory days are remembered, for good and for all.

In conclusion, I would like to thank all my team members for their exceptional help and support without whom this edition of " Quintessence" could not have come into existence, and I hope that this journey has sparked zeal and enthusiasm in the minds and hearts of my juniors to continue this tradition with all their efforts and sincereity.

"Everthing is energy and that's all there is to it. Match the frequency of the reality you want and you cannot help but get that reality. It can be no other way. This is not Philosophy. This is Physics."

-Albert Einstein

Nobel Prizes in Spectroscopy

Dr. Manoj Giri

Department of Physics, Sri Venkateswara College, University of Delhi-110 021, India

Spectroscopy is perhaps the most important versatile tool of science and technology by which we explore the matter at micro, macro and astronomical scale. When the spectroscopy word comes in our mind, the name of Prof C V Raman comes first in picture. We feel proud that one branch of spectroscopy is named as Raman Spectroscopy after Prof C V Raman for his discovery and explanation of a new type of inelastic scattering of light by which frequency increases-commonly known as Raman effect. Prof C V Raman became the Ist Indian who received Nobel Prize in Physics in 1930 for this extraordinary achievement.

Spectroscopy started with findings of Issac Newton from an optics experiment, performed during 1662-1672, submitted to Royal Society in which he permitted sunlight to pass through a small hole and then through a prism. He found that sunlight which looks white to us is actually made up of mixture of all the colors of the rainbow and introduced the word spectrum. In the early 1800's Joseph van Fraunhofer made experimental advances with dispersive spectrometer that enabled spectroscopy to become a more precise and quantitative scientific technique. Since then, spectroscopy has played and continues to play a significant role in physics and astronomy.
We divide spectroscopy mainly into two branches namely Atomic and Molecular spectroscopy which are further categorized in to several branches such as X-ray spectroscopy, Atomic Absorption Spectroscopy, Atomic Emission Spectroscopy, Mossbauer Spectroscopy, Gamma ray Spectroscopy, UV-Visible Spectroscopy, Infrared Spectroscopy (IR), Nuclear Imaging Resonance (NMR) Spectroscopy, Electron Scanning Resonance (ESR) Spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR), Fluorescence Spectroscopy etc.

Spectroscopy studies were central to the development to quantum mechanics such as Max Planck's explanation of black body radiation, Albert Einstein's explanation of the photoelectric effect and Neil Bohr explanation of atomic structure and spectra. Spectroscopy is used in physical and analytical chemistry due to uniqueness of spectra of atoms and molecules. Spectroscopy is also used in astronomy and remote sensing on Earth. Most research telescopes have spectrographs. The measured spectra used to determine the chemical composition and physical properties of astronomical objects.
The list of relatively high number of winners of Nobel Prizes highlights the historical development of spectroscopy through the contributions of researchers from experimental and theoretical field as well as, which follows as:
Experimental Contributions to Spectroscopy: The following details provide the information about discoveries/contributions of Nobel Laureates along with their names and award of year:

(1902) Hendrik A Lorentz and Pieter Zeeman: In recognition of the extraordinary service they rendered by their researches into the influence of magnetism upon radiation phenomena i.e. splitting of spectral lines in magnetic field.
(1919) J Stark: For his discovery of the Doppler effect in canal rays and the splitting of spectral lines in electric fields.
(1930) C V Raman: For his work on the scattering of light and for the discovery of the effect named after him.
(1955) Willis E Lamb: For his discoveries concerning the fine structure of the hydrogen spectrum.
(1966) Robert S Mulliken and (1971) Gerhard Herzberg: For their pioneer work in molecular spectroscopy.
(1981) A L Schawlow and N Bloembergen: For their contribution to the development of laser spectroscopy.
(1999) Ahmed Zewail: For his studies of the transition states of chemical reactions using femtosecond spectroscopy.

Theoretical Contributions to Spectroscopy:

(1918) Max Planck: For discovering the elementary quantum of action h.
(1922) Niels Bohr: For his services in the investigation of the structure of atoms and of the radiation emanating from them.
(1933) Paul A M Dirac and E Schrodinger: For the discovery of new productive forms of atomic theory.
(1945) Wolfgang Pauli: For the discovery of the Exclusion Principle, also called the Pauli Principle.

Inventions and Discoveries Related to Spectroscopy:

(1907) Albert A Michelson: Invention of the interferometer, a hallmark in spectroscopic instrumentation.
(1964) C H Towens, N G Basov and A M Prokhorov: In recognition of their fundamental work in the field of quantum electronics, which has led to the construction of oscillators and amplifiers based on the maser-laser principle. This led to development of the laser and opened the field of modern spectroscopy.
(1966) Alfred Kastler: In recognition of discovery and development of optical methods for studying Hertzian resonances in atoms.
(1989) Hans G Dehmelt and Wolfgang Paul: Received this honor for invention of the ion trap, an important tool in current spectroscopic research.
(2018) Arthur Ashkin, Gerard Mourou and Donna Strickland: The Nobel committee in 2018 recognized the work of three scientists as instrumental to the task of harnessing laser light for miniaturized tools.

Recycling of silicon photovoltaic panels: Trashes to Treasure

Dr. Piyush Kumar Parashar

The energy industry has been experiencing a radical change and the gradual shift towards renewable energy especially in solar photovoltaic sourcing is more than evident. Solar, as a form of renewable energy, offers many advantages. It is safe, reliable, efficient, and non-polluting, and can be widely distributed. Solar energy especially photovoltaic (PV) technology has become a hot topic of global interest. Recent trends in the international photovoltaic (PV) sector indicate strong growth in terms of capacity and production, which is positively influencing the process of energy system decarbonisation.

In recent years, International electricity markets have witnessed a formidable growth in the photovoltaic (PV) sector, mainly due to a robust increase in installation capacity and energy production. Global installed PV power reached 310 GW in 2016, and is expected to reach approximately 395 GW by the end of 2017, an increase by 85 GW. In the mid-term (by 2020), the global capacity could triple to 700 GW, while in the long term (by 2050), it could amount to 4500 GW. India also has launched the National Solar Mission on the 11th January, 2010 with the ambitious target of deploying 20,000 MW of grid connected solar power by 2022. The set target of grid connected solar power further revised from 20,000 MW to 100,000 MW by the year 2021-22.

A typical solar panel consist of crystalline or multicrystalline silicon solar cells which are connected in array form and mounted within the aluminum (Al) alloy frame along with tempered glass, EVA (ethylene/vinyl acetate copolymer) and aluminum frame and a battery piece as shown in Fig. 1. The design life of a solar panel is roughly 20 to 30 years, and most solar panel manufacturers provide a performance guarantee. Therefore, the issue of disposal occurs after completion of lifespan of a solar photovoltaic module. In fact, if recycling processes were not put in place, there would be 60 to 78 million tons of PV panels waste lying in landfills by the year 2050 report by the International Renewable Energy Agency (IRENA).

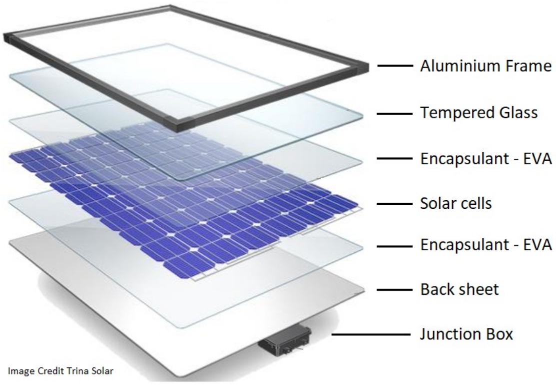


Fig. 1. Illustration of different layers used to make a crystalline silicon solar panel.

Recycling is essential because all photovoltaic cells contain certain amount of toxic substances that would truly become a not-so-sustainable way of sourcing energy. Besides this, there are other valuable material such as metals used for contacts, silicon, glass, and aluminum shown in Fig. 2 (a) which need to be recycled otherwise, valuable resources that could be used to make more solar panels will end up in landfills. The maximum 96% of the material can be reused and this waste can produce 2 billion new panels from the available PV panels' waste that can provide ~600 GW extra capacity as shown in Fig. 2 (b).

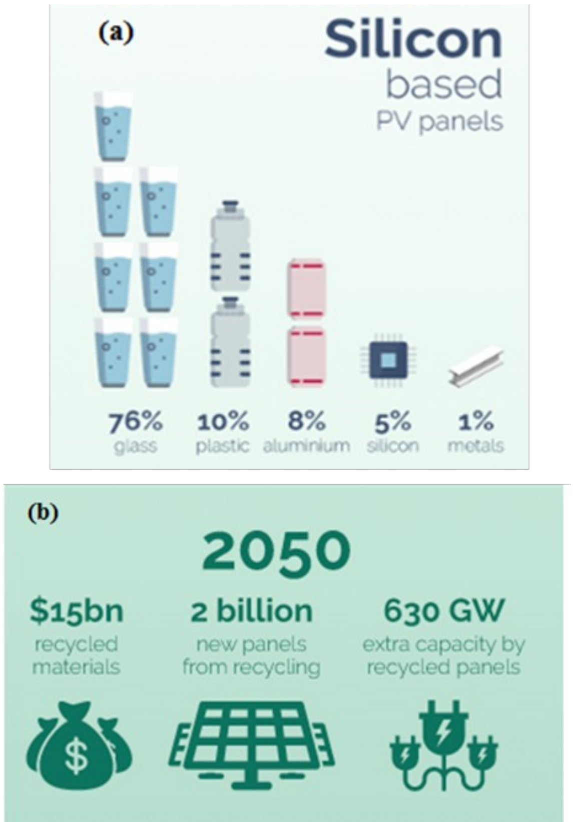


Fig. 2. (a) Percentage of recyclable material from silicon based panels, and (b) Recycled materials' cost, estimated panels and generated capacity from the recyclable solar panels by 2050.

Fig. 3. Recycle flow diagram of crystalline silicon photovoltaic systems.

Figure 3 presents the process developed by Deutsche Solar which involves heating to separate the plastic components of the panel followed by manual recovery of solar cells, glass, and metals or alloys, such as Al, Cu, and steel. The solar cells are processed chemically in order to obtain new wafers, which after further processing represent the primary structure for creation of new cells. The other materials are forwarded to recovery and recycling operations. This process, in addition to achieving high recovery rates (~ 85%). This process has two main limitations. The first is the requirement for various manual activities, limiting production efficiency and economic benefits. The second is the widespread market availability of specific treatments plants of different Si-based solar cells which have not been commercialized yet due to the economic stress Therefore, further research to reduce technological complexity and for maximum recovery of material along with economic models are the requirement for treating c-Si modules.

The Great Bohr-Einstein Debate

Yashvardhan Shukla

Peek-a-boo!

Synonymous with one of the first games most infants are exposed to, peek-a-boo contains everything that a good joke should have: surprise, balanced with expectation. A similar example is that of whack-a-mole!
You might wonder as to how this correlates with Physics.
Swiss psychologist Jean Piaget's theorised about "object permanence," or the ability to know an object still exists even when it's hidden. Watching his 13-month-old nephew at play was when Piaget first noticed something unusual about the way babies perceived things. When the boy's ball rolled under a table where it was still visible, he would retrieve it and keep playing. But when it rolled under the couch where it wasn't visible, the boy looked for the ball where he had seen it last. This led to further investigations by Piaget with reference to exactly when babies develop object permanence. He suggested that babies spent the first two years of their lives working it out.

National Geographic's famous television series *Genius,* based on the life of Albert Einstein addressed the same issue in an awe inspiring sequence: Einstein and Bohr walk into a shop and asks the keeper a simple question: "Does anything cease to exist when you can't see it?" The shopkeeper denies it right away. Einstein goes on to draw a parallel with the same, debunking the uncertainty principle, supported by Bohr. Both of them walk out as a flustered Bohr sarcastically suggests that Einstein takes the opinion of the butcher from the next block too. Einstein laughs it off while they near a busy road. Bohr notices a car approaching and pulls Einstein back, almost rebuking him for his ignorance. Einstein justifies his actions using the Bohr's argument against object permanence.

This was just one of the many face-offs between two great minds; a precursor that revolutionised modern physics for the years to come.

So how did it all begin? The premise was laid down during the Fifth Solvay International Conference on Electrons and Photons in 1927. Einstein explained how it was possible to take advantage of the laws of conservation of energy and of impulse (momentum) in order to obtain information on the state of a particle in a process of interference which, according to the principle of indeterminacy or that of complementarity, should not be accessible.

Bohr's argument about the impossibility of using the apparatus proposed by Einstein to violate the principle of indeterminacy depends crucially on the fact that a macroscopic system obeys quantum laws. On the other hand, Bohr consistently held that, in order to illustrate the microscopic aspects of reality, it is necessary to set off a process of amplification, which involves macroscopic apparatuses, whose fundamental characteristic is that of obeying classical laws and which can be described in classical terms

The next Solvay conference took place three years later, where Einstein came up with his second criticism. He proposed a box made up of perfectly reflective mirrors. Inside the box was a stream of light bouncing around and an inbuilt clock that would open a hole in the side of the box for any amount of time the light would take to exit it. Einstein then asked Bohr to weight the box. This appeared to be a serious anomaly in Bohr's propositions, as weighing the box before and after the photon left the box would help determine the mass of the photon itself. Using Einstein's energy mass equivalence, it would then be possible to determine the energy of the photon. According to the uncertainty principle, however, it was not possible to determine the energy and time of a particle simultaneously and to top it all, Einstein's box demonstrated the exact opposite. Bohr argued that the moment the photon would leave the box, the box itself would recoil due to conservation of momentum. In order to weigh the box, it would have to be in a gravitational field since weight means nothing without gravity. But due to gravity's distortion of space time, in according with Einstein's theory of relativity, we can't determine how much the clock inside the box would be affected. This way Bohr one-upped Einstein using his own theory.

The debates carried on for half a decade before culminating into Bohr's triumph. The two stalwarts of Physics may have had a plethora of scientific ideological differences but the camaraderie showcased by them will continue to inspire a generation of Physicists for years to come.

Unknotting the String Theory

Aayush Saxsena

The mere uttering of the words 'String Theory' is sure to turn heads and raise eyebrows in a room filled with physicists, engrossed with conversations regarding the unsolved problems of modern day physics. Most of the raised eyebrows belong to those who actually have little or no knowledge about this potentially ground breaking theory. Trust me, I was one of them. There is no harm in being oblivious to the existence of this theory. The primary reason being that it is still, but I do sincerely hope that not for long, just a theory. The secondary, in my view, being that it is just so complex. So what exactly is String Theory and what are its implications?

Let us start with the very basics about how physics, as a subject is currently being studied. As the name suggests, String Theory is studied under the broad subject of 'Theoretical' physics. A major breakthrough occurred when Sir Isaac Newton, probably one of the greatest theoretical physicists in history, gave us the famous Laws of Motion. To successfully study and understand the physics of moving objects, Newton had to actually invent calculus! Newton's Laws of Motion were later verified experimentally, by a separate group of physicists called 'Experimental' physicists. In today's times, theoretical physicists are trying to explore new areas in the nature of mathematics and physics that technology so far does not allow us to experiment. With the knowledge of what exactly is the difference between theoretical and experimental physics and how research is carried out in these two fields, we would be able to understand better, the need for the String Theory.

Another breakthrough in the history of Physics came when the 'electron' was discovered. This gave rise to a new field called 'Particle Physics' that was propelled by the mathematics of 'Quantum Mechanics'. While particle physics developed, increasing observations indicated that light, as an electromagnetic radiation, travelled at one fixed speed in every direction, according to every observer. This led Einstein to develop his Special Theory of Relativity, and when this was combined with Quantum Mechanics, it gave rise to a new field of study called Relativistic Quantum Mechanics. This new field is the foundation for our present theoretical ability to describe the behaviour of subatomic particles. But Einstein then extended the scope of his Special Theory of Relativity to encompass Newton's Laws of Motion, and gave rise to the General Theory of Relativity. This remarkable theory has had some tremendous observational successes and has firmly established itself.

Now, quantum mechanics and the particle theory have worked very well to describe the behavior and property of the elementary particles. But these theories work best only when gravity is extremely weak and can be neglected. General Relativity on the other hand, has enjoyed tremendous success in describing the Universe, the orbits of the planets, the evolution of stars, the Big Bang, and more recently, Black Holes. However, this theory only works when we pretend that the entire Universe is Classical, and quantum mechanics is not involved in our description. String Theory is believed to close this gap. The essential need for this incredible theory arose when it was found out that particle physics interactions could take place at zero distance, whereas Einstein's theory fails at zero distance. The treatment of elementary particles as strings would eliminate the failure of Einstein's theory at zero distance, as the strings will always have a finite length and the distance to be taken into consideration while studying particle interactions will never be zero, but always a finite quantity.

Earlier versions of the theory to unify quantum mechanics and the general theory of relativity suggested an explanation of the relationship between mass and spin of certain particles called Hadrons, comprising of the neutron and the proton. But particles in the String Theory, theoretically, are known to arise due to the excitations of the 'strings'. Due to some limitations arising from this hypothesis, string theorists suggested that the String Theory be applied as a theory of quantum gravity, where each quantized particle would be known as a Graviton. This was received with a lot of enthusiasm, but the mathematics involving the graviton at collisions happening at a single point in space-time, i.e. at zero distance, behaved very badly and failed to provide sensible answers, and also rendered useless, the very use of 'strings' in the String Theory.
In the string theory as known in its current form, strings collide at a small but finite distance, and the answers do make sense. This does not mean that the string theory is not without its deficiencies. But it does allow us to combine quantum mechanics with gravity, and we can talk sensibly about string excitations that carry the gravitational force, as described in the following paragraphs.Think of a guitar string that has been tuned by stretching and holding it at a certain level of tension. Depending upon how the string is plucked, and how much tension it has, a musical note is played. These musical notes could be regarded as 'excitation modes' of the string under tension.
In a similar way, the elementary particles that we observe in particle accelerators can be viewed as excitation modes of elementary strings.

In string theory, just like guitar playing, the string must be stretched under tension. However, the strings in the string theory are floating in space-time; they are not tied down anywhere. Yet, they have tension. Since the string theory is to be a theory involving quantum gravity, each length of the string should be near the length scale of quantum gravity, called the Planck length, which is about 10 -33 centimeters. This length is ridiculously small, and this means that it cannot possibly be seen with the current or expected particle physics technology! Thus, string theorists have to come up with clever ways to actually test the string theory, rather than look for these little strings.

There are a number of different string theories doing the rounds in the world of theoretical physics. The difference in these theories arises due to differences in the space-time dimensions considered, the particles included in the theory, and whether or not the strings into consideration are open or closed loops. Each string theory is unique, and it also seems possible to combine all the theories and come up with a more fundamental theory, colloquially known as the 'Theory of Everything'.

The String theory is resounding, indeed. It holds the power to change physics, as we know it. For instance, the 'Super String Theory' predicts a universe with 10 dimensions. However, we have been made to believe that our universe is made up of 4 observable space-time dimensions, the fourth dimension being time. Another implication is the existence of a multi-verse, where each universe has a unique set of dimensions. Theories with extra dimensions predict that the strength of gravity increases much more rapidly at small distances, than is the case with 3 dimensions. Depending upon the size of the dimensions, it could lead to phenomena such as the production of micro black holes at the Large Hadron Collider (LHC) or be detected in microgravity experiments.

The concept of String Theory is mind boggling, its inception and development is a result of some phenomenal brain racking, and possessing its knowledge is priceless.

Will we ever have "The Theory of Everything"?

Harshit Joshi

In this article, I will take you on a journey where we will see how the idea of the "Theory of Everything" originated. We will explore the possibilities of an exact theory and an equation that can explain everything in this universe. So buckle up, here we go! Imagine yourself in the year 1687. This is when Sir Isaac Newton published Principia, which hypothesized the inverse-square law of universal gravitation. Before that, people knew that every object that goes up, must come down, they (including you) also believed that a mysterious godly power drives the planets around the sun, the moon around the earth. Newton proposed the groundbreaking idea that the thing that's responsible for an apple falling down towards the earth is also responsible for driving the planets around the sun, the moon around the earth. He could explain by his law of gravity all three laws of Kepler and many more observations. This changed everything! If you still wonder why Newton is praised so much, it is because his idea - that the laws responsible for an apple falling down are the same ones that govern the entire universe - is pure genius. In fact, with his laws he was able to explain almost every known motion of his time. You wake up the next day to find out the eclipses are not a bad sign of god that misery might come but it's a result of shadow formed due to relative motion of Earth, moon and sun. This opened a totally different way to view how this universe works. The idea propagated that laws of nature are simple, symmetric and exact and we can explain how things work without referring to the god as an answer. The law of gravity and its vast applications suggested that there could be a single law that can explain everything in the universe.

Let's come back to the future in 1862, this is when Maxwell gave his 4 famous equations that combined together the phenomena of electricity and magnetism as discovered by Michael Faraday, and presented the idea that light is an electromagnetic wave. After this, almost all observable phenomena including motion, gravity, electricity and magnetism could be explained by the laws of Newton and equations of Maxwell. I should remind you that it has been about 175 years and Newton's laws are still celebrated! After explaining all the diverse phenomena that we observed till date people thought that "Physics is done"! There is no more left to explain and we have found the ultimate answer to 'How this universe works?'

Fast forwarding to about 15 years, you might be celebrating this big achievement with your colleagues when the news comes by that we can't explain ether theory for propagation of light (light as wave needs a medium to travel, that medium is ether) has been experimentally falsified! I would be both sad and excited about this news as this opens up new possibilities. People at this time believed so much in the existing theories that they tried to explain the existence of ether that satisfies the experimental results, no matter how radical the ideas may sound. In case you are wondering why is it so important to cling on to the idea that wave needs medium to travel, you are not completely imagining yourself in those years, back when all the known waves travelled in a medium. Moreover, according to Newton's laws and Galilean relativity, speed of things is relative, but Maxwell's equations implied that speed of light is 'c' in vacuum, so the question was with respect to what? So the existence of ether became important so as to "conserve" Galilean relativity and to get rid of the exceptionalbehavior of light waves. You would have done the same, after all the existing theories explained everything else so well (Actually the 'everything' here is the everything that had been observed and not included things that were yet to be observed).

Years passed and after keeping your nose to grindstone for explaining the results of experiment of Michelson and Morley you couldn't give a reasonable answer; neither would have I! You might think that Maxwell's equations are wrong, after all there is no preferred "rest frame" and the equations say speed of light is 'c' in vacuum without telling with respect to what. Actually this might come a bit of a shock that actually Newton was wrong, Galilean Relativity was wrong! The laws that explained every observable motion for almost 2 centuries had the flaws no one could possibly see without experimental conclusions! (Actually I should use the word "approximately correct" instead of wrong, for his laws explained many things that you could ever think of and are the approximate form of the new corrected version.) Firstly, you wouldn't believe this one guy who claims Galilean Relativity is not completely correct for you can question this guy, "What's wrong in this? Velocities add together and space and time are absolute, this is what we 'see' in our daily lives, do you see your clocks tick at different rates in different conditions?". "Well, yes!" he says, "time is not absolute and neither is space, in fact they are not abstract things that do not participate in reality, they are not just basis for measurements, they do take part in measurements. You may see a cat throwing a glass off the table and record that it takes 2 seconds for the glass to reach the ground while your friend would say it took 3 seconds and you both are equally correct". Forget what you know about Einstein at the present and question yourself would you trust what he claims at that time, the time when Newton's laws were still taught as if they are the absolute truth, comparing their validity to religious texts? I would have surely walked away from that guy thinking he is making some kind of stories. Imagine you getting up in the middle of the conversation, ready to leave and he adds," I can show the relative nature of time and space mathematically, assuming only that all the laws of nature are same in all inertial frames (frames moving with uniform velocity with respect to each other), and speed of light is same for all observers just as Maxwell's equations claim".

You would stop right there, totally surprised by what he just said and ask him to do it. Well, he presents before you the transformation equations, now known as Lorentz transformation equations (since Lorentz gave them first but his theoretical foundation behind them was rather radical and complex, as compared to the simple two assumptions Einstein put before you), which tell you how space and time are relative (how you would age less with respect to someone at Earth if you travel at very high speed with respect to Earth), using only his two simple assumptions. The assumptions are as simple as the one made by Newton about the apple and other heavenly bodies, but the conclusion is so "out of common sense" that anyone who encounters this for the first time can't resist saying "Wow".

Now we can explain physical phenomena in a much accurate way. You must have recognized that we have come much closer to the "truth", our theory of everything must incorporate this behavior of space and time. In fact, about 10 years later Einstein was able to show that gravity is a result of matter and energy bending space-time (he also showed space and time are not separate things but same entity called space-time) and objects moving through this bent curvature follows a particular path that we observe. This theory explained many new results and claimed existence of things that has been proven only recently. During the years Einstein did this "magic" another anomaly aroused that was going to give birth to one of the strangest things we have encountered so far! You may have guessed it, it's "Quantum Mechanics". What's special about this theory is that it is the outcome of contributions from many great scientists of its time. Although Einstein was one of the majorcontributor towards its origin through his explanation of photoelectric effect, he always despised it. Quantum Mechanics took over Newton's laws of motion for particles that are far too small to be governed with same laws as Newton assumed governed the motion of macroscopic bodies. It poses some results that are quite opposite to common sense. The main concern of this theory lies in the fact that how a system looks before you make any observation, and if you think deeply about it, you will really embrace quantum mechanics, although you could have never deduced the form of a system before measurement through pure logic and imagination the way quantum mechanics does. I will not take you to the time when quantum mechanics emerged, it's an achievement of years of efforts of intellects and would be too long to deal here. I wanted you to know that whatever I discussed here forms a pattern, a pattern that can help in seeing what theory of everything should be all about.

Now, let's say there is Theory of Everything and we will eventually find it. Let's travel in the future to the day when everything can be explained by a single theory, a single equation that governs the laws of universe. A scientist gives you the equation claiming it explains everything: You can see all the fancy things over there, actually I must tell you something important before proceeding. Scientists have found that 4 fundamental forces work in nature namely gravity, electromagnetic, weak nuclear and strong nuclear force. The equation above tries to combine all fundamental forces known and this is what scientists call "Grand Unification". They believe that if we have theory that can explain all 4 forces then we will have The Theory of Everything. The only problem is combining gravity with other forces, and apparently we have done it at this time! You may believe that Theory of Everything should exist for I guided you through the history and we noticed that how simple principles that apply to normal daily objects are same that apply to everything else in the universe, suggesting a common law for everything. Now, I will try to explain why this time where we are at can never exist! When you finally get this equation, you would think," This is what god wrote down when he was modelling the universe, how beautiful!". If you think of the consequences that follows, you would already know the outcome of every possible experiment you can conduct! This is actually rationalism which was first coined by Pythagoras in 6 th century BCE. This means that all the things can be reasoned out and need not to be verified experimentally! Then you may want to shut every practical lab down and start teaching theoretical physics for you can now account for any experiment you can perform with the theory! Do you remember the time we were in when you were partying with your colleagues for having completed physics, just before the result of Michelson Morley Experiment? What if people stopped performing experiments then, thinking they can already deduce the results? You wouldn't have to come this far to the future then! You might want to suggest we keep doing experiments even when we can predict results with our Theory of Everything, I don't know, just for the sake of fun watching something you can predict. But if you find one little flaw ever in the result then you will have to start all over again just as you did in around 20th century.Then what you had found was never really a “theory of everything”, right? let’s say you don’t find any flaw for like 1000 different experiments, you would now consider performing experiments as something unnecessary as the conditions would be same if you didn’t. Then we are back to rationalism! The horrible nightmare of 20th century would still haunt us. This is one reason for you to not believe that we can ever find the Theory of Everything. Now let me give you a somewhat mathematical answer. You know that Law of gravity looks like: $G\ Mm / R^2$ How do you know this? Well you might say we have seen it experimentally. Then I might ask,” How precise your measuring tools were, how can you be sure that this holds for things as small as electrons as well as large as black holes and stars?”. You might say,” My experimental results can be slightly off the real value but that only takes me a little further from the real equation, and for the size scale you mentioned if same principle governs an apple and planets, then the equation must also look same”. Well nice arguments, however, you must not assume that governing principle ensures the mathematical texture, you always have the power to “see”, to experiment and check how it really is and that is what can bring you closer to the Theory you are looking for. Since you can always perform experiments, you can come as closer as you want to the Theory or equation that can explain everything, but there will still be some gap, however small, filled with experiments yet to be performed!

In this journey I presented before you two things:

1) There are certain principles that governs nature of entire different things (like an apple and a star). This suggests that there are some underlying principles that tells universe how to work. This means there are CERTAIN fundamental laws that can explain everything in this universe.

2) Experiments play a very important role in advancing science, you can never be sure you are right, no matter how logical you sound without having experimental agreements, for the logic is biased with the common sense and common sense with experiences.

The theories that you form to explain the universe are based on your experimental evidences which are further subject to inaccuracy. You can’t claim your experiment is 100% accurate for your measuring instruments are limited in accuracy in the first place. This means, the equation you get using experiments, whether it’s the Maxwell’s equations or Einstein’s or Newton’s, as Einstein said it, “No amount of experimentation can ever prove them right, but a single experiment is enough to prove them wrong”.

This suggests one possible conclusion to me:
No, we can never KNOW whether we can have The Theory of Everything, whether we can ever have a single equation that can explain everything. Although there are certain laws of nature that govern the universe, we can only get as closer to them as we want using experiments, there will be no day when everything will be sorted out and the need of experimentation will be exhausted by theoretical conclusions. If someday we find a theory that explains everything well, we must not forget to look for more, carry out experiments to check if there is any gapleft and sadly there will always be for there can be no day when we can say looking at the sky, “There is nothing left untested now! We have verified every possible thing we ever could.” Should we be disappointed by this? No, certainly not! Think of a world where we would have find out Theory of Everything. There would be nothing left to do, no surprises, nothing. Then science would turn into religion. Being in a world of uncertainty about the exactness of the laws of nature, devoting life on questioning- ‘is this the way god created it ?’- is a humbling and character building experience and one should always be delighted that science will

never be over, there will still be things for people to work out and see the world in a different way, in the way they think god created it.

You might think I believe in god, well, yes I do, but I don't answer my questions by saying," God is the answer", I feel like giving credit to some super intellectual entity that created everything so perfectly using mathematics, every single thing so connected making perfect sense, this keeps me motivated towards exploring more and finding the answers to How God did all this, and I am happy that although I will never have a perfect answer, but I can and I always will get closer to the truth.

TOKaMAK Reactors: Harnessing the power of the sun

Lalit Kumar

Over the last few decades, we've been reminded several different times that our conventional means of generating energy can lead to extreme consequences. As long as fallible humans are involved, the risk is always present. Thus many great minds are at work, developing technologies that can (hopefully) prevent such mistakes from becoming catastrophic. One such technology, called the Tokamak Reactor, is a magnetic containment device that is one of the most researched methods for controlled thermonuclear fusion power (yes, we are talking about a device that can harness energy using the same mechanism that powers the sun [on a much smaller scale]).

The initial design was first theorized by Russian physicist Oleg Lavrentiev in the 1950s, but it wasn't until a few years later that two Russian physicists– Igor Tamm and Andrei Sakharov–invented what we now know as a Tokamak (though their device is still based on Oleg's initial idea).

HOW TOKAMAK WORKS

A Tokamak of today uses electromagnetism to confine plasma within the reactor, keeping it from actually touching the walls of the reactor. Not only is the torus shape of the Tokamak crucial in achieving the proper plasma equilibrium, but it also allows the magnetic field lines inside the torus to be manipulated in a helical shape, and this shape is created by combining a toroidal and poloidal magnetic field. Electromagnets surrounding the torus create a toroidal field (simply put, a toroidal field is a magnetic field traveling in circles around the torus). Similarly, electromagnets are used inside the torus to induce the poloidal field (it is generated by the electrical flow of plasma); this poloidal field travels in circles orthogonal to the toroidal field, resulting in the required helical shape.Even though the technology has been around for quite some time and has proven to be effective, it doesn't come without constraints. Due to limited advances in technology, the biggest issue that has always held back the Tokamak reactor is the problem of heating the plasma. In order for the plasma to reach its operating temperature, it must be heated to 10 KeV, which is equivalent to approximately 100 million degrees Celsius. Various methods are used to heat the plasma, which range from using magnetic compression to bombarding the plasma with high-frequency microwaves.

CONVERTING ENERGY FROM HEAT:

The Tokamak creates energy by absorbing large amounts of high energy neutrons. These neutrons are created by the heated plasma spinning around the reactor. Because these neutrons are neutrally charged, they are no longer held in the plasma stream by the magnetic fields, and continue outwards until they are stopped by the inner walls of the reactor. The heat from these neutrons is then converted into energy; however, a lot is lost in the process due to cooling. The neutrons yield so much energy; they could actually melt the walls of the reactor, which is obviously not good. So to prevent this from occurring and destroying the system, a cryogenic cooling system is needed. Such a system utilizes a mixture of liquid helium and liquid hydrogen.

When combined with ceramic plates, they protect the superconducting magnets and reactor walls.There are currently around 30 known Tokamak reactors in operation around the globe; the majority of them scattered across Europe, Russia and China.

HOW THEY COULD IMPROVE THE FUTURE:

Currently the largest Tokamak reactor, ITER which is an acronym for International Thermonuclear Experimental Reactor, is being constructed in Cadarache, France. As the name suggests, it is an international joint program between the European Union, India, Japan, China, Russia, South Korea and the United States. The European Union is contributing 45% of the 16 billion Euro cost; with the other six participants contributing 9% each. ITER is designed to produce 500MW of energy, which physicists believe is approximately ten times the amount of energy required to heat the plasma to the required temperature to sustain fusion; however, because this is the first reactor of its kind, there are no plans to use the excess energy to create electricity as of yet. ITER's proposed mission is to demonstrate the feasibility of a fusion reactor and to show that it can operate without negative impact on the environment or on the surrounding ecosystems. The ITER project is expected to last 30 years, with 10 years being allotted for construction and 20 years for experimentation. Ground was broken on the construction site in 2008 and they started building the reactor in 2015; by 2020, they are hoping to achieve first plasma. And finally, by 2027, they hope to start Deuterium-Tritium reactions.

THE SOUND OF MUSIC

Aakash Kumar

Ludwig van Beethoven, the father of western classical music spent most of his career going DEAF. Sounds peculiar? It is indeed but the physics behind it is even more irresistible. The credit for those intricate and euphonic compositions goes to science of music. Beethoven added the unquantifiable elements of emotion and creativity to the certainty of Mathematics.

Music is one of the closest acquaintance of Physics and Mathematics. Albert Einstein had his musical life ran in tandem with his scientific one, often becoming inseparable. Werner Heisenberg on one occasion, after playing Beethoven's last piano sonata (op. 111) said, “If I had never lived, someone else would probably have formulated the uncertainty principle. If Beethoven had never lived, no one would have written op. 111." As truly stated by James Sylvester, “may not music be defined as the Mathematics of the sense and Mathematics as the music of the reason?"..."The musician feels

Mathematics. The mathematician thinks music. Music, the dream. Mathematics the working life." Music is nothing but the collection of overtones or harmonics. Every musical instrument in the present era is tuned on the basis of Stuttgart pitch i.e. 440 Hz or A4.

Let's take piano as our prop to get hold of this. Each octave in piano is divided in 13 keys with twice the frequencies of the keys in former octave. This is done by tuning the piano. For tuning of piano an old methodology is to multiply every second note by 9/8. Doing it six times would result in $(9/8)^6 = 2.02728652954101... \neq 2$. This doesn't work in the era of perfection.

Other method is to use major thirds i.e. multiplying by 5/4 for every third note. Doing this for three times results in $(5/4)^3 = 1.953125... \neq 2$. $\{(a/b)^n \neq 2$: a, b are integers and $n>1$: Verified}. The advanced method for tuning an instrument is to use an irrational ratio between the semitones. When every next semitone is multiplied by $2^{(1/12)}$, we get the nearly exact fundamental frequencies for each key. When it's done for 12 times i.e. $\{2^{(1/12)}\}^{12}$. Voila. It's '2' i.e. an overtone. Different combinations of these tones and overtones with varied styles and distinct time signatures results in different melodies, to be exact a different Raga. This pattern together with pakad (encapsulation of the essence of a particular raga) creates the melody of song.
The melody of a music handles the release of dopamine- "the feel good hormone", prolactin- "the hormone that bonds people together" and oxytocin- "the hormone for trust" (when you sing with someone else).

The complexity of music also affects the brain. The 7/8 time signature of beats and notes played in the end of Whiplash is responsible for the adrenaline rush in the body. That's actually 8/7 = 1.14285714285714 notes per beats. So next time when you turn on the music ... "calculate" and let the dopamine flow.

References:

1. TED-ED : https://youtu.be/zAxT0mRGuoY
2. Minutephysics: https://youtu.be/1Hqm0dYKUx4

Giving a new edge to the world of atoms

Prerna Joshi

The quantum world of atoms and particles is widely recognized to be famously eccentric. Though it is quite satisfactory that the properties of quantum mechanics are just not mere chances of occurrence, they have been observed and recorded over and over again in the laboratories and been practically proven and calculated. Thus they have real effects and are themselves something not mere theoretical concepts but something factual.

One of the exemplary features of quantum mechanics is undoubtedly "Entanglement". The Cambridge English Dictionary describes Entanglement as "the condition of being wrapped and twisted together in a mass." Similarly, Mechanics describes Entanglement in a way that particles are mysteriously linked to each other no matter how far away they are from each other. Three European Research Groups recently conducted a research and they have successfully entangled not just a pair of particles, but separate clouds of millions of particles, which has paved the way to turn technological potential into good account.

Entanglement between particles sort of makes them share their properties in a way that results in their dependence on each other, even though they are separated by enormous distances. Experiments, so far, have proved that entanglement is not something new, but has been in existence for a few years now. It is useful in numerous ways too- like the particles linked in that way can be used to transfer one's quantum state which includes spin, from one location to another immediately and could be understood as something parallel to teleportation. A huge amount of information can also be stored (super-dense coding). It is thus a crucial and major discovery in the field of quantum computation.

Entangled photons also can be used to enhance the imaging techniques and one astonishing fact is that researchers at University Of Waterloo are hoping to develop a quantum radar capable of detecting stealth aircraft using these properties. The method of entanglement of lakhs of atoms simultaneously has been an evident fact since years but it was only until now that the thought of actually making use of it has crossed the minds of researchers.However, using these techniques have problems of their own. This is where the new research comes into action. The researchers associated with the current discovery showed that the clouds can be split into groups while still preserving the quantum connection between atoms which was previously lost.

Apart from quantum computing, another field benefitting from this discovery is meteorology. When entanglement is involved, measurements about one particle would reveal half of the information about the other as well. This would allow parameters to be measured with greater precision and accuracy. Entanglement, when used this way, can improve the accuracy of atomic clocks and GPS system and make more sensitive detectors for machines like the MRI machines. The Quantum world of atoms welcomes such new discoveries and researches in the future as well, to benefit the globe as a whole.

Source: https://qz.com/1265736/a-new-physics-discovery-could-change-the-game-for-quantum-computing/

CAN EVEN EINSTEIN MAKE MISTAKES?

Shrishti Kunwar

Who doesn't know him? He's an epitome of dynamism to an extent that calling him unearthly won't be a hyperbole. All his works are simply phenomenal. This is strongly supported by the fact that all of his experiments and theories have been confirmed to an entirely new degree of accuracy. No matter how many times scientists subjected his theories to a practical trial, he always emerged spotless. However, just like any other human, his personality was fallible too. Making mistakes would be the most natural thing to do. Let's talk about a few here.

GRAVITATIONAL WAVES

A couple of years back, scientists announced that they were able to detect gravitational waves, literal ripples in the fabric of spacetime. It , definitely, was a huge validation of Einstein's work. However, there was a time when Einstein himself doubted the existence of ripples. But, of course, we know for a fact that they exist, having actually seen them.

COSMOLOGICAL CONSTANT

The next mistake he encountered was the discovery of the world famous cosmological factor. Everyone back in his era , considered that the universe is static. However, the latest discoveries portray that the universe is uniformly expanding in every direction. But, Einstein, based on what everyone back then believed, discovered this constant, the fudge factor needed while crafting the theory of gravity and general relativity.This is often referred to as THE BIGGEST BLUNDER OF HIS CAREER.

THE BLACK HOLE BLUNDER

Einstein never cared for black holes, a natural consequence of his theory of general relativity , since the laws of Physics go haywire around the singularities at the centre of these black holes. He simply didn't believe in the existence of black holes as their activity couldn't be observed directly. But, again he was wrong here. Now we know that black holes do exist. E=MC 2 Even the venomously famous equation E=MC 2 has some minor errors and strangely, Einstein was very well aware of this fact. He , himself, reported : "You don't need to be very careful. There are incorrect papers under my name too."

Einstein made mistakes in his personal life too. He married his first cousin Elsa Lowental, Nee Einstein. Not only were their mothers sisters but their fathers were cousins too. Though the marriage was a quite fulfilling and a happy one but the biological implications were simply complicated , just as this man himself was.

SPACE RACE

Gunjan

Warfare is known to be the mother of many inventions. And , so it was that man's conquest of the moon which was born out of a cold war between the world's greatest superpowers, the Soviet Union and the United States. A cold war sprouted out of scientific rivalry, fuelled by growing threats of nuclear attacks and widespread espionage, expanding into a display of social and political superiority.

A war which transformed space into a battle frontier where the geniuses of Werhner Von Braun (an ardent Nazi Scientist) and Sergei Korlev (a Russian rocket engineer), two men with a shared dream, clashed and laid grounds for an unprecedented leap in the history of mankind . The initial seeds were sown with Von Braun's invention of V2 , world's first long-range guided missile with a range of 200 miles, capable of escaping Earth's gravity. Post World War 2, the American, the Russian and the English forces trudged into the German heartlands scrounging for secrets to the V2 technology. The Americans discovered a recently abandoned , slave operated V2 factory under the horrific Mittelbau-Dora concentration camp. This was followed by Von Braun's surrender to the US.

Meanwhile, the Soviets landed their hands upon the hidden stashes of documents and spare parts which the Americans had left behind. While Von Braun and his team were kept on ice, their ideas dormant. Sergei Korlev developed V2 into the R7, a modified multi-stage intercontinental missile with a fitted thermonuclear bomb, which was a 100 times more powerful than the one dropped on Hiroshima, capable of reaching American mainland. For the first time ,America was vulnerable to foreign attack. While the R7 technology was wrapped in secrecy, the Russians celebrated their scientific and military superiority in form of Sputnik 1 , the world's first artificial satellite fitted with a radio transmitter, in 1957. And thus began a series of firsts, with Sputnik 2 carrying the first living creature , a dog called Laika in space. This came as a firm blow to the Americans, shaking the American image of being indomitable and pioneering in space and technology. In response, the mission Vanguard (without the assistance of Von Braun) was launched by the US navy, ending in a humiliating explosion at the launch pad, as the whole world sat and watched live. Then American President Eisenhower was forced to employ Von Braun's genius , presenting Von Braun with the perfect opportunity . He became the hero of America's fledgling space program as his rocket Jupiter-C put America's first satellite Explorer 1 into the Earth's orbit in 1958. The Russian space program still maintained it's commanding lead. Korlev accomplished his life long dream of putting a man in space as Soviet cosmonaut Yuri Gagarin headed to the stars in the spacecraft Vostok 1 ,in the year 1961. He became the first man to see his world reduce to the tiny blue ball it was, in front of his eyes , presenting a universe of endless possibilities. The space race reached it's defining chapter when the then newly appointed US President, J.F.Kennedy raised the bar for the American space program with the promise of mounting the American flag on the moon and that too by the end of the decade. As Von Braun's team toiled to meet Kennedy's deadline , Korlev had already succeeded in putting the world's first man-made object called Lunar 2 on the moon's surface.

Von Braun set out to perform the impossible task handed to him with the creation Saturn 5. It worked in three stages and required 5.6 million pounds of rocket fuel to launch. The third successful trial of Saturn V became the Apollo 8 mission. Von Braun and his team rehearsed their final steps for man's first lunar landing in form of Apollo 9 and Apollo 10 whereas the Soviet program slackened and collapsed with thedemise of its leader Sergei Korlev in 1966 and never quite recovered. The Soviet equivalent of Saturn V, called the N1 proved to be a massive failure. It was a huge day for the mankind. A rivalry between nations had activated a chain of events that pushed mankind into unventured territories .The whole world sat and watched live ,wiith their hearts stuck in their throats, as the Apollo 11 blasted off the Earth's surface on July 16, 1969, creating history.

The three astronauts of Apollo 11 arrived in orbit of the moon on July 19. The following day, Mission Commander Neil Armstrong and Lunar Module Pilot Edwin "Buzz" Aldrin climbed into their lunar module "Eagle" and achieved humanity's first landing on another celestial body. And thus the cold war concluded, as Neil Armstrong took his first steps into a world that shown glorious and unattainable as a far fetched dream, from his home. A dream hammered into reality by a vision of two kindred spirits. One tiny step of a man and a giant leap humanity. Five more Apollo missions followed and a total of twelve Americans treaded the moon's cratered surface.

Von Braun came to be known as the father of rocket technology and space science in the US and his team assimilated into the NASA, while Sergie Korlev's ashes remain interred in a place of honour in the Kremlin wall in the heart of Moscow, Russia.

ALAN TURING

Shivansh Hoon

“We can only see a short distance ahead, But we can see plenty there that needs to be done.”
Alan Mathison Turing was a British Mathematician, Cryptanalyst, Philosopher and is known as the pioneer to electronics devices, we simply call computers. He was the first to theoretically models Artificial Intelligence. He possessed as one of the greatest mathematician minds ever, a mathematician with extraordinary capabilities.

Perhaps known today for breaking the Enigma codes used by the German during World War II. Born on the 23rd of june 1912, Turing showed promising talent in Maths and Science from the early days in school. At the age of 15, he condensed the Einstein’s theory of relativity so that his mom could easily understand it. His ability led him to attain a scholarship at King’s College, University of Cambridge.

He conceded of a hypothetical machine that reads binary digits on a tape, rewriting or deleting depending on the input command given on a finite set of rules. This machine would compute until the answer is attained or run forever if the answer doesn’t exist. He returned to Cambridge after doing hid D.Phil from Princeton University, New Jersey in the USA, where he started working for Government Code and Cypher School, the UK’s code-breaking hub, in Bletchley Park. Here Turing with a team of highly talented and ambitious decoders worked for years to decode the messages sent by the Germans to their Naval troops. During the Second World War, the Germans were using a cipher machine called Engima to encrypt these messages. With three rotors and two sets of keyboard, this machine was the size of a typewriter. When one types a letter on the keyboard it reflects a letter by lighting a letter on the other keyboard which creates the code. These three rotors when changed and set to another combination then a new code would light on pressing the same key, completely changing the code. This machine has 159 million million million possible combinations.

Turing’s contributions were vital for the Britishers to decode the Engima. He with Gordan Welchman build a machine the Bombe, an Enigma decoder.
They succeeded with the fact that one of the German coders has been ending with the same phrase each time. So they inserted that phrase that might be a part of the message by which they reduced the possibilities and wait for the machine to decode the whole for them.

In 1945 he received order of the British Empire. He was also honoured by Queen Elizabeth II for his work.Though counterfactual history is difficult it has been stimated that his work shortened the war by more than two years saving millions of lives.

Acclaimed prize in Physics

Ruderaksh Baigra
Aakash Kumar

A variety of prizes are awarded in this highly appreciated section of the natural sciences. The variance of bonanza distributed between Theoretical and practical branches is feeble. Still, an inclination towards applied Physics can be readily seen, partially because of its direct approach to solve real-world problems.

Some prizes are more prestigious - either by virtue of the fact that everyone has heard of them or the prize money associated with them. A few of them are:

Nobel prize - founded by Alfred Nobel, it is a yearly award given by the Royal Swedish Academy of Sciences for those who have made the most outstanding contributions for mankind. It contains a gold medal along with cash of $ 1million.

Breakthrough prize - founded by Yuri Milner along with Mark Zuckerberg, it is a set of international awards bestowed by Breakthrough Board in recognition of scientific advances. Cash prize given is $ 3 million

Copley prize - given every year, the medal is the oldest Royal Society medal awarded and the oldest surviving scientific award in the world. The medal in its current format is made of silver-glit and awarded with a £ 25000 prize.

UNESCO Neil Bohr medal - The UNESCO Niel Bohr Medal was first minted in 1985 to commemorate the 100th anniversary of the birth of the Danish nuclear physicist Neil Bohr. It is awarded by UNESCO to recognize those who have made outstanding contributions to physics through research that has or could have a significant influence on the world.

India science medal - India Science Award is the highest and the most prestigious national recognition by the Government of India for outstanding contribution to science. The primary and essential criterion for the award is demonstrated and widely accepted excellence in science. It contains a gold medal, a citation along with ₹ 25 lakhs.
To be honest; from a physicist's point of view, the most prestigious informal award is to have something named after you! The Planck constant, Avogadro's number, Gauss' law and so on and so on - these have all immortalized these scientists - and will be remembered for much longer than anyone will remember who won a prize or a medal! As said by Linus Pauling “ Facts are the air of scientist ”.

Some little-known facts about Nobel
prize are:-
• The main inscription on one side of the medal for Physics, Chemistry, Medicine, and Literature Nobel Prizes reads: "Inventas vitam juvat excoluisse per artes," which in loose translation means - "And they who bettered life on earth by new found mastery."
• Leon Lederman, Physicist who Coined the 'God Particle' had to sell his Nobel Prize medal for $7,65,000 to pay for his medical care for dementia.
• Not only did Marie Curie win two Nobel Prizes, but her family has been the recipient of five total Nobel Prizes. She won two, her husband, Pierre Curie, won one. Her daughter, Irène Joliot-Curie, won the Chemistry Prize in 1935 with her husband. Her

second daughter was also the director of UNICEF when it won the Nobel Peace Prize in 1965.

- Two members of the family, Sir C. V. Raman and his nephew, Subrahmanyan Chandrasekhar, are the only Nobel laureates in physics from India.
- JOHN BARDEEN, the fact that today we can listen to the latest music hits on the radio, watch television, a talk by mobile phone or comfortably surf the Internet using computers and tablets owes much to John Bardeen, the only scientist in history to have received two Nobel Prizes in the Physics category.
- Lawrence Bragg being 25 was the youngest and Arthur Ashkin being 96 is the oldest Nobel prize winner in physics.

Dissolving this article by an eerie quote of George Bernard Shaw
- " I find it easy to forgive the man who invented a devilish instrument like dynamite, but how can one ever forgive the diabolical mind that invented the Nobel Prize? "

Nobel Prize in Phyiscs - 2018

Gunjan

The Nobel prize in Physics 2018 paid a tribute to the ground-breaking works of scientists,- Arthur Ashkin, Donna Strickland and Gérard Mourou in the fields of laser physics. It was awarded one half to Arthur Ashkin of the Bell labs , Homdel for his " optical tweezers and their contribution to biological systems " and the other half of the prize was shared by Frenchman Gérard Mourou and Donna Strickland of University of Waterloo, Canada for their " method of generating high-intensity, ultra-short optical pulses ", making Donna the 3rd woman to receive a Nobel prize in physics.

Let's take a look at these inventions that revolutionized laser physics.

Ashkin's optical tweezers

A question lies at the root of every discovery and it was this question -
"Whether one could see observable motion from light pressure forces on particles in the lab , using high intensity laser beam " that urged Ashkin, then a researcher at Bell labs to invent a technique that lets you manipulate the physical, tangible world around you using laser beam - a thing of science fictions. We know that light is the primary source of energy that fuels the life processes of our planet and everybody on it. Now , what has energy also has momentum and it is this momentum called radiation pressure that would push you with a tiny force , in addition to making you feel warmer if I were to shine a laser pointer on you. To use this force to levitate something as big as an apple would be impossible since the laser power to achieve this would run in megawatts , enough to vaporize the poor apple before it got off the ground. But, suppose you were to lift off something the size of a cell. The laser power would fall to milliwatts (that of a laser pointer). Motivated by an accidental discovery made while looking at dust particles trapped in a laser beam inside the cavity of an argon laser , Ashkin put his mind to studying how you could use radiation pressure to accelerate and trap individual particles , in the late 1960s and spent years refining his ideas. In 1986, his efforts bore fruit as his paper in collaboration with Steven Chu (a Nobel laureate himself) was published , on what we now call optical tweezers , bringing us one step closer to investigating the machinery of life. In this paper, Ashkin showed that if the laser beam was focused very tightly using a microscope then, rather

than pushing objects away with radiation pressure, it would counter-intuitively attract particles towards it. When the laser beam was then moved, the particles would follow it, held in the focus of the beam at all times. His tweezers have been expanded to entrap multiple particles at once and transformed into optical spanners , lending us a peek at the microscopic world of atoms , bacteria , viruses and other living things without harming them.

Strickland and Mourou's CPA

When early lasers came into picture in the 1960s , the scientists were stranded by the problem of how to scale up the beams without increasing the intensity to potentially dangerous limits. But, sometimes the solution lies right at your feet. All you need is a dash of ' thinking out of the box' and a resilient hand to put the pieces together. It is to them we owe the corrective eye surgery and the latest research in cancer treatment. Strickland was doing her PhD at the University of Rochester under the supervision of Dr Gérard Mourou when she came across this interesting problem of how to increase laser power without ripping apart the machine(directly using even a slightly shorter pulse in the laser rod would drill a hole through the machinery) . They developed the technique which is known as chirped-pulse amplification (CPA), whichenabled researchers to boost laser power but keeping the intensity safe by having incredibly short light bursts. Gérard came up with the original idea for the CPA upon which Donna based the foundation of her PhD thesis .

“Different people were trying to get short pulses amplified in different ways,” Strickland explained. “It was thinking outside the box to stretch first and then amplify.”
CPA first stretches laser pulses over time to reduce their intensity, before amplifying them and compressing them again. If a pulse is compressed in time and becomes shorter, then more light is packed together in the same tiny space - the intensity of the pulse increases dramatically. She used a 1.4 km optical cable, which was what she was left with after accidentally snapping the cable while unwinding it , to stretch the wave in time. It introduced a chirp in the pulse as the frequency of the laser pulse changed , kind of like a bird’s chirp(whose frequency also changes through a note to produce the distinctive sound). She passed the chirped pulse through the amplifier and the compressor she had built and when the device got working , it gave us the shortest , most intense laser pulses ever created by mankind . Her paper with Gérard came out in 1985.It is funny how the project she thought wouldn’t be good enough for her PhD thesis (which she did on multiphoton ionisation using CPA) ,won her the Nobel prize. The CPA enables beams to cut or drill holes in various materials, including living matter, with extreme precision and has become a standard in labs to generate high intensity laser beams, worldwide.

Science and Religion

Mansi Tomar

Science and Religion

“Fact and faith are baseless without one another...”

This has been an issue of a perpetual vigorous debate between the orthodox and the techie groups. The scientists have always approved of walking in stride with the latest technology, and may have pushed the fact that the foundation of their very virtues, that is, science has its origin in the old and discarded religious scriptures, to the back of their minds.

The scriptures, now remain as an evidence of the existence of a mystic period, when sages preached of a Supreme being. Perhaps they have forgotten, that the roots of their advanced medical sciences lie in the ancient “shastras” of Ayurveda. Spas and rehabilitation centres which specialize in aroma therapy, massages, treatment of nerves (“naadi vaidya”), are nothing but commercial “ayurvedic kutiyaa”.

Don’t the designs of our aeroplanes and jets look similar to that of “pushpak vimana” in Ramayana? Can’t the birth process of the Pandavas be related to In-verto fertilisation? Or the “astras” to our present day missiles, bombs, submarines and landmines? Determinism is often taken to mean simply causal determinism: an idea known in physics as cause-and-effect. The Theory of Determinism, states that events within a given paradigm are bound by causality in such a way that any state (of an object or event) is completely, or at least to some large degree, determined by prior states.

Determinism in the West is often associated with Newtonian physics, which depicts the physical matter of the universe as operating according to a set of fixed, knowable laws. The "billiard ball" hypothesis, a product of Newtonian physics, argues that once the initial conditions of the universe have been established, the rest of the history of the universe follows inevitably. If it were actually possible to have complete knowledge of physical matter and all of the laws governing that matter at any one time, then it would be theoretically possible to compute the time and place of every event that will ever occur (Laplace's demon). In this sense, the basic particles of the universe operate in the same fashion as the rolling balls on a billiard table, moving and striking each other in predictable ways to produce predictable results.
In the philosophical schools of India, the concept of precise and continual effect of laws of Karma on the existence of all sentient beings is analogous to western deterministic concept of Cause and effect.Since the early twentieth century when astronomer Edwin Hubble presented the hypothesis that redshift hints that the universe is expanding, prevailing scientific opinion has been that the current state of the universe is the result of a process described by the Big Bang. Many claim that it therefore has a finite age, pointing out that something cannot come from nothing. Then from where did the compressed universe come?

The Big Bang is a scientific theory, and as such is dependent on its agreement with observations. But as a theory which addresses the origins of reality, it has always carried theological and philosophical implications, most notably, the concept of creation ex nihilo (a Latin phrase meaning "out of nothing"), which is the soul of Genesis.

But then, during the Victorian era, when scientists were proclaimed to be a threat to the Catholic society, for displaying a knack of free thinking, even India had its own share of controversies. In 2007, the discovery of “Ramsetu”, saw both the scientists (disbelieving the existence of Rama) and the “peethadipatis” (disconcerting the scientists) raging over each other.

But did any of them try to highlight the fact that both science and religion are not the different faces of the same coin. Instead each has tried to study the nature through a narrow prism, and force it’s entire meaning into a limited space of comprehension. Both science and religion if merged together can be used to provide a substantial proof to many theories. For example, doesn’t the recent discovery of anti-matter, during the LHC experimentation by CERN, and the whole concept of matter and anti-matter,

relate to the ancient Hindu theory that the entire cosmos is a combination of Shiva and Shakti! Where Shiva represents tangible matter and Shakti, the intangible energy!
Even the Theory of Relativity by Einstein, depicts the inter relation of Shiva and Shakti.

Hence Science and Religion are like the yin-yang. The essence of enlightenment with experimentation. And can be portrayed as a living human with a brain to think and “atman”, to implement the thought process. Thus, we do not need a cynical LHC, to unravel the mystery of creation, but a large particle assimilator. Both science and religion must be used to prove the existence of the other and not to exterminate each other.

Scanning Electron Microscope

The Most versatile instrument of a Material Scientist

Jatin Arora

Scanning electron Microscope (SeM) is an e- microscope that comes under the Scanning Probe Microscopy (SPM) category of microscopes. In SEM, samples kept under the microscope are literally scanned with the help of a probe, a certain instrument that may be an electron beam as in e- microscope or can be a pointed pin with a low potential as in Scanning Tunneling Microscope (STM). The probe keeps on moving left to right and back and then down or up to scan the selected area of the sample and then provides an image of the scanned area on a computer screen. This method of scanning is called raster scanning which our simple scanners at home also do.

The e- microscopy is different from optical microscopy. The major principle on which this microscope works is de Broglie hypothesis that a moving material particle also carries wavelength in the probability space associated with particle in space and this wavelength is related to particle’s energy. Higher the energy smaller would be the wavelength. So by the Rayleigh’s criterion of limit of resolution in Optics , smaller the wavelength smaller the limit of resolution ,larger the resolution.

So SeM works completely on the physics of “collision of incident electron beam with atoms and molecules” present on the surface of the sample. And before we delve into the physics behind working of SeM let us have a slight glimpse of the instrumentation of it with shallow approach just to become familiar with the instruments that make up a Scanning electron Microscope.

All electron microscopes have a source of electrons and this source is called an electron gun. There are different methods of emitting electrons from a body by overcoming the energy required to emit e-(work function) in different ways. Namely, by heat energy i.e. by heating the gun to emit e-1 which is governed by the process of thermionic emission which usually we come across in our daily life while cooking, when suddenly a utensil slips on the burning stove and what we observe is a SpArK!!! These kinds of guns are called Thermionic emitters. Another way for emission is by putting up large -ve potential (30-90 KV) at a finely pointed needle type Gun. By doing this we actually increase the E- field intensity around it and thus the -ve potential energy of the electrons lower the +ve work function energy required for emission and there by emitting e- which is completely defined by Quantum Mechanics. Well the fine regularity of the pointed tip is required to produce a narrow beam from the tip only.(Any guesses why?) Now after emission the e- Beam is shaped i.e. converged with the help of a condenser lens that uses magnetic field to converge as an optical lens is incapable of doing so. {You can work out for the kind of geometrical pattern of the B field around the lens to focus an incoming beam of e-}. You must be wondering that parallel wires carrying current in same direction simply attracts then why does the e- beam diverges?? Actually the e- beam diverges due to defeat of magnetic force of attraction by the electrostatic force of repulsion so we use magnetic lens for focusing. These electrons in the beam arealso called primary e-. Then after focusing, the beam is passed through scanning coils which is a lens as well as a diverter. It diverts the beam to different points on the sample to scan it simply by using varying E and B fields as per the requirement of raster scanning. And what left in the section of instruments are the detectors to detect various types of signals that are emitted from the sample by collision of incident beam of electrons about which we have not discussed so far. Now after this short overview of the SeM instruments let us now get introduced to the principles behind the working of SeM.

What happens is that the beam of e- creates a region, a volume in the sample upto where the effect of incident energetic electrons reaches. This volume is called the interaction volume. So whatever signal is given out by the sample due to e- beam collision It is from here!!! The size of this volume depends upon various factors namely: Primary e- energy, Angle of incidence of beam and Atomic no. of atoms in the sample {which can be understood by simply guessing}.

As we know collisions occurs in three modes but here we are interested in two of its mode:

a). Elastic collision where the total kinetic energy is conserved. In this case the primary electrons are scattered elastically after colliding with sample's atoms. Their energy does not suffer much change (simply because the atoms in sample initially have negligible translation velocity). These scatterings occurs frequently at angles very close to 360 degree (can you wonder why??) and thus they have the name Back Scattered electrons (BSE). So the detectors used for detecting them must be placed concentrically with the incident beam as a ring. Well imaging or detecting this kind of signal has importance only if we want to know about the content in the bulk which is also bad if we consider from the point of view of their contribution in providing information regarding the structure of the surface i.e. morphology and topology. This can be guessed easily. The detector superimposes the signal from the surface with the signals from within the sample and information of the surface morphology is lost although not completely. The reason for these signals coming from within the sample is the high energies of BSE which helps them overcome the collisions suffered by them while on their journey back to the surface from within.

Can you make out why the electrons signals coming from the sample surface carry information of its morphology? A hint: This is related to the differences in the energies of e- emitted from different heights from the sample surface.

Try reading out what kind of methods are used in detecting BSE using ring detectors at http://en.wikipedia.org/wiki/Scanning_electron_microscope.

b) Another is Inelastic scattering. Well in this case the incoming e- loses its energy to excite the atom and to eject the e- from the atom. They are called Secondary e- (SE). As obvious as it looks these ejected electrons carry low energy nearly 50- 100 eV or that too may be an exaggeration!! But this is what we exactly require to image the surface structures as when these kinds of signals are emitted from the interior of the sample they loses their energy easily while coming to the surface and are not detected by the detector. Thus what we detect using the dedicated Secondary e- detectors are the signals from the surface. And by detecting the energy map of the Secondary electrons we get a clear picture of the surface structures.

Try reading how we detect the SE using their dedicated- Everhart -Thornley detector at http://en.wikipedia.org/wiki/Everhart-Thornley_detector

There are various other signals, like characteristic X rays which are X rays emitted from the sample surface but characteristic means that the energy of these X rays are fixed for different atoms and thus X rays emitted are characteristic to different elements. So if we detect the energy of these X-rays with an X-ray detector then we can get to know which element on the surface is emitting that X-ray and we get an idea of elemental constitution of the sample. Try guessing whether these X rays are also emitted from the interior of the interaction volume. You can make use of their energy range.

Well, as we know an X-ray is emitted when the electronic distribution around the nucleus suffers a very large electronic transition. Sometimes the photons, that are ejected during the electronic transition have energies in the Visible light range so we can see a glow from the surface if we actually look at the sample kept under the primary e- beam (If somehow we can make up for the damage that X-rays may cause to our eyes). This kind of signal is called cathode luminescence.

If somehow the X- ray photon, while coming out of the electronic distribution of atoms on the surface of sample, strikes an e- in its way out then it leads to its ejection. This kind of signal from the sample is called Auger electrons which are although useful but not much useful than BSE and SE signals.

All this explanations of emission of signals seems very childish but they become a little uneasy when trying them out Quantum mechanically.

Turbulence

Yashvardhan Shukla

I wade through the tempest wind,
Absorbed in self devotion, a servitude,
Fickle, they labelled,
Spontaneous, I'd have preferred,
But life goes on,
And so do I.
The treeware cannot contain me,
The ink hesitates, albeit, joins our religion
Great men falter, greater fall
Naïve, I'd call them,
Navier, they could have been.
I dance, I jump, I change course,
They watch, play oracle, fall on their face.
Gamble a grand or a million,
Stoke your egos,
But I am invincible,
Beyond time and space.
Holy water, holy smoke!
I am everywhere,
Though not holier than thou.
I play along,
I smile.
I stab you,
Right when you blink.

STUDENT RESEARCH ARTICLES

Study of solar activity cycle and the oscillations in the solar atmosphere

Pranav Singhal

Sunspots are one of the most intriguing features on the surface of Sun. They are areas of intense magnetic activity and play an important role in Solar activity Cycle. Sunspots accompany secondary phenomena such as coronal loops, prominences, and reconnection events. Most solar flares and coronal mass ejections originate in magnetically active regions around visible sunspot groupings.

The primary source of energy to the Earth is radiant energy from the Sun. This radiant energy is measured and reported as the solar irradiance. When all of the radiation is measured it is called the Total Solar Irradiance (TSI).

In this project, we have tried to analyse the Sunspot number and the TSI changes over the 11 year Solar Cycle. We have tried to understand the Relation of how Solar Irradiance becomes brighter than average at solar maximum (which corresponds to large number of Sunspots) and dimmer at solar minimum (less sunspots).

This Project also gives an insight about the Solar Flares and the associated changes in the intensity fields . We have analysed the data from MAST (Multi Application Solar Telescope) consisting of intensity images and tried to study the sudden variation of the Chromospheric intensity Fields over the Sunspot as well as the flare region. We observed a periodic variation of intensity over the Sunspot region .

The project is divided into the following tasks:
1. Studying the Variation of TSI and the Sunspot Number over the Solar Cycle
2. Looking for Oscillatory Behaviour in the Intensities of Solar Flares and Sunspots in H-alpha Images of the Chromosphere Collected by the MAST Telescope, USO.

These data were analysed using IDL programming language. The first chapter gives a basic introduction about the Sun and its anatomy, sunspots, and the instruments used to record the solar images. The second chapter and third chapter are about the observational data and the approach used for the analysis. The IDL programs used in analyzing these data and the references are given at the end.

Modifying and optimising transient pipeline

Ishita Chaturvedi

Transients are random radio bursts in the universe. Our aim is to detect them as they happen to better study the sky during the time of the radio burst to gain a deeper understanding of the phenomenon.

Detection of transients is a difficult process because a software is required to run in the background that processes the data in real time and gives detections of events if present instantly.

For this we developed the Transient Pipeline (TP)- a code the reads input data from the GMRT telescopes, takes it through multiple steps to clean the data, bring it to an appropriate format and then find the radio burst if present.
The pipeline runs on CUDA (parallel programming platform by nvedia) and C.

To write such a software involves the following constrains-

1. The incoming signal is dispersed due to the presence of the ISM(interstellar medium) and has to be dedispersed accordingly to get the actual signal back, to run the further processes on. It is one of the most crucial and time taking steps involved.

2. The radio frequency interference needs to be considered and data needs to be cleaned before use to have as little RFI as possible.

3. The GMRT backend must support the pipeline.

4. The process must run in real time, because previous data will be overwritten by new data on the shared memory of the node on which TP is running if it is not processed before next data comes and a time lag will cause loss of data.

5. The code must be dynamic and optimized to deal with any lengths of data given to it as input.

6. The code must make best use of the available hardware.

My work

The Transient Pipeline code was written a few years back at NCRA, however I detected major bugs in the code and have been tasked with debugging it. I changed the dedispersion algorithm being used and optimized the new algorithm which does faster shifting and channel collapsing to dedisperse the data.

I worked on the different modules of the pipeline, understood the way the GMRT backend and front end work, from signal input to the final division of data of different frequencies using filter banks into channels.

I also had to understand how the pulsars emit the radio waves, and how dispersion of signal takes place as it travels through space to reach us, the factors I need to consider while dedispersing a signal, the approximations made while calculating dispersion measure, how to remove RFI from data, how to optimize the code and improve performance.

It also helped me build my logical and thinking skills; critical analysis; sitting for hours to find patterns to generalize over, for correct array indexing (which can mean life or death in a code). In the process I learnt more about radio phenomenon, how they occur, their importance, the working of radio telescopes and the physics behind it.

The opportunity to use the GMRT telescopes to run observations on real data by selecting pulsars myself, to understand how the observations are done, how radio telescopes are configured and divided into arrays, how to run and conduct experiments on it was incredible.

Deposition of thin film and magnetron sputtering machine

Dipankar Das

<u>Description</u>

Sputtering is one of the most prominent method for deposition of thin film on a substrate. Sputtering is a process in which particles are ejected from a solid target material due to bombardment of the target by energetic particles, particularly gas ions in a laboratory. This process involves 1. The creation of plasma by discharge of neutral gas such as Argon. 2. Acceleration of ions by a potential gradient and bombardment of a target or cathode. 3. Through momentum transfer, atoms near the surface of the target material become volatile and are transported as vapour to a substrate. 4. The film grows at the surface of a substrate via deposition. The average number of atoms ejected from the target per incident ion is known as Sputtering yield. MAGNETRON SPUTTERING Magnetron sputtering is a modified sputtering technique to enhance the process of ionisation and the sputtering yield by producing a magnetic field around the target and hence traps the electrons near the target that implies to maximum collision of gaseous atoms and electrons that are produced by potential difference from a power supply around the cathode and anode of the system.

The primary advantages are
i. High deposition rates.
ii. Ease of Sputtering any metal, alloy and compound.
iii. High purity film.
iv. Extremely high adhesion of film

v. Ability to coat heat sensitive substrates. TARGET- AZ0(1%) [Aluminium doped zinc oxide] Deposition on - Polyethylene Terephthalate (PET) and Glass Thin film of thickness Pet - 1525 nm Glass- 1398 nm

THE BATCH

GUEST FACULTY

Dr. Ravinder Goyal
M.Sc , PhD
Space and astrophysical plasma

Dr. Alok Shukla
M.Sc , PhD
Electromagnetic computations at nanoscale and applications

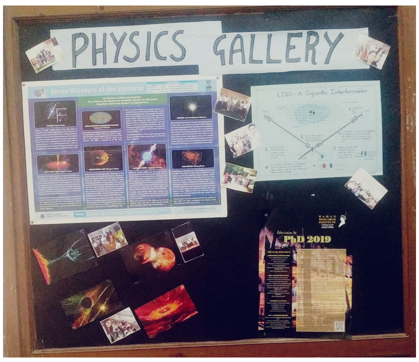
GALLERY

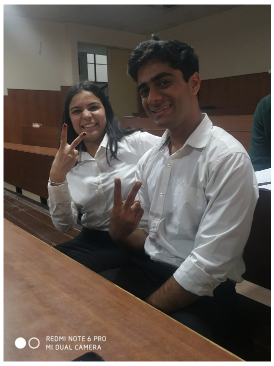

pr√-incipia
THE PHYSICS SOCIETY OF SRI VENKATESWARA COLLEGE
WELCOMES YOU

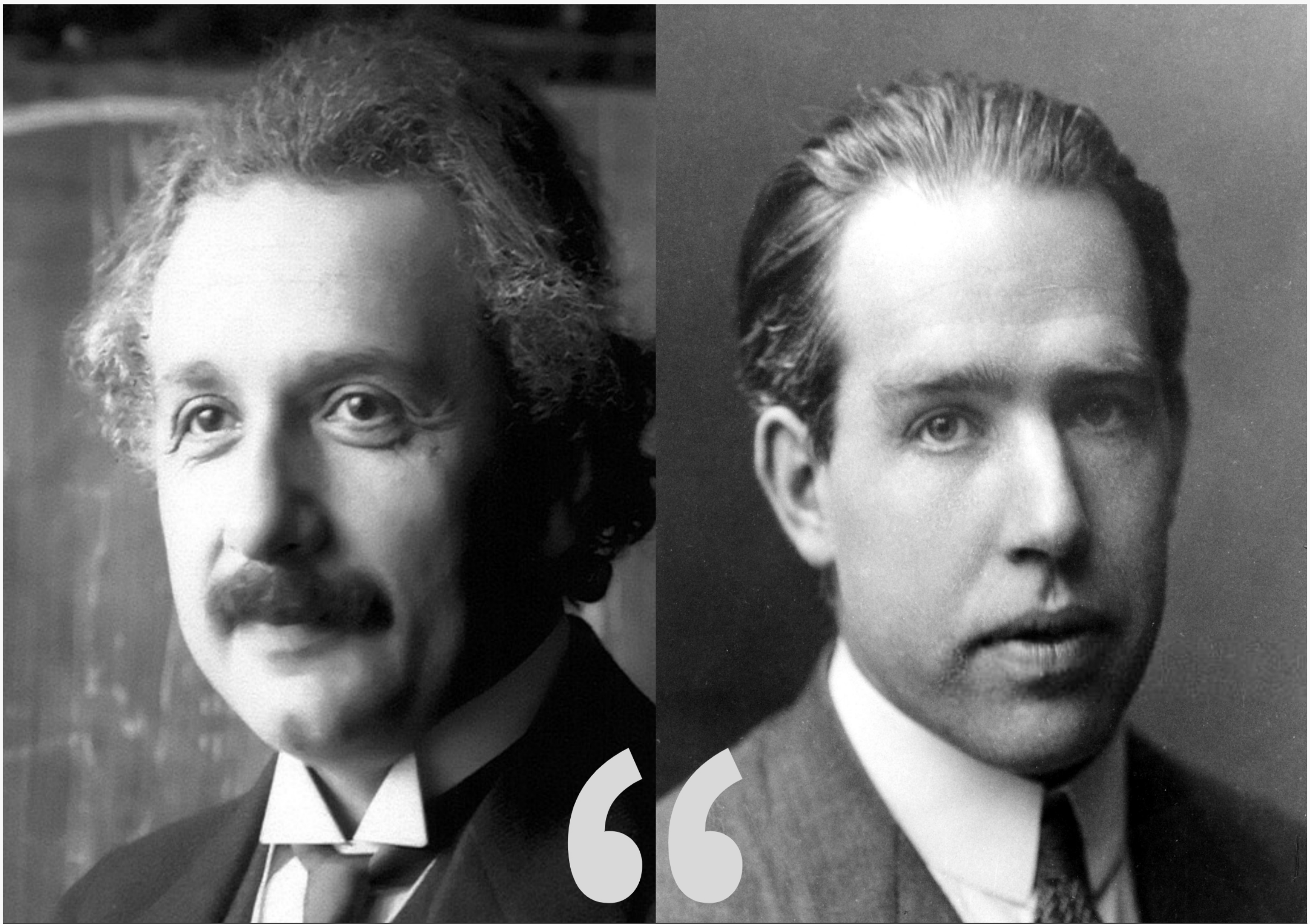

REDMI NOTE 6 PRO
MI DUAL CAMERA


REDMI NOTE 6 PRO
MI DUAL CAMERA


REDMI NOTE 6 PRO
MI DUAL CAMERA


PHYSICS GALLERY
PhD 2019


REDMI NOTE 6 PRO
MI DUAL CAMERA



No no, you are not thinking; you are just being logical.

\- NIELS BOHR

PRINCIPIA - THE PHYSICS SOCIETY