Aug - Sept 2022 | Issue No. 2

Newsletter

PIEAS Society for Physics

ZENITH

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Director's Note

PIEAS Society for Physics is at the moment of dispatching August-September 2022 issue, the second issue of **Zenith**. This issue is inimitable for our audience due to various reasons.

Interviewing Dr. Nasir Majid Mirza and penning down all his motivations and reflections has been a great milestone in this issue. In the words of Dr. Nasir Majid Mirza, curiosity matters the most. In another context, the same being said as: "Curiosity has its own reason for existence."

We, PIEAS Society for Physics, tried our best to showcase our visions and goals in the form of featuring variegated aspects of Physics. We did focus our attention to the Hydrogen Economy Dream (delineated by the cover page), whose depiction can be found in the student project “Hydrogen Sensors” that was supervised by Dr. Aftab Rafiq. We also added a new section in this issue to shout from the rooftops the achievements of the Pakistan Institute of Engineering and Applied Sciences. Further, we included important deadlines in the Pinboard section which required, as always, a smart effort to look for it.

I hope all will enjoy reading this issue and Stay *Curious*, Audience! The journey has just started… for *Physics* …

Muhammad Shuraim

(Director Publications)

Goodbye!

The famed Roman philosopher, Lucius Annaes Seneca, had once said, “Every new beginning comes from some other beginning’s end”. So, we, the PIEAS Society for Physics (PSP) on behalf of the entire Department of Physics and Applied Mathematics, would like to bid adieu to our beloved seniors (BS Physics 18-22) and wish them all the best for both their future goals and life. May God always be with you in overcoming all challenges. Ameen!

Group photo of DPAM faculty with BS Physics (session 18-22)

The first ever graduates of PIEAS BS Physics programme

INSPIRATION

by Muhammad Shuraim and Waddia Summan

Theory of happiness (which was given as a tip to Bellboy by Albert Einstein as he learned of his Nobel Prize in Physics and the tip was auctioned for millions of dollars back in 2017) states as:

> *A calm and modest life brings more happiness than the pursuit of success combined with constant restlessness.*

Whenever I recall these words, I get a flashback of Dr. Nasir Majid Mirza, being a well-spirited embodiment of modesty. He is the most humble and loving person that the Department of Physics and Applied Mathematics, and PIEAS have ever had. He is currently employed as a Rector Pakistan Institute of Engineering and Applied Sciences and under his leadership, PIEAS has reached new levels of glory and recognition. Serving many other organizational duties, he is also working as a member of the Council for Graduate Studies and Research, PIEAS. He has held a post-doctoral research position in Physics at the University of Georgia which was completely funded by the Ministry of Science and Technology, Pakistan, and a Ph.D. in Nuclear Engineering from Purdue University, USA. He completed his MSc in Physics from Quaid-e-Azam University, Islamabad.

For his excellent contributions to research and education, Dr. Nasir Majid Mirza has been awarded Tamgha-e-Imtiaz (Medal of Excellence) by the President of Pakistan in 2020. Several times, he has been among the very top in the list of Productive Scientists of Pakistan. He has been honored with the Research Productivity Award by Pakistan Council for Science and Technology, Gold Medal for Excellence in Research by Pakistan Atomic Energy Commission, and Best University Teacher Award 2002 by Higher Education Commission. Dr. Nasir Majid Mirza with his brother Dr. Sikander Majid Mirza, another inspirational and very talented faculty member at PIEAS, has written international standard books like ‘Modelling and Simulation of Corrosion Product Activity in Primary Coolant Circuit of PWRs: A Kinetic Approach’ and some others.

Dr. Nasir Majid Mirza is incredibly inspiring and he comes from what I could term as a true "Physics Family of Pakistan”: almost eighteen members of his family are physicists. He was thus motivated by his family as well as his teachers to nurture a passion for Physics. He has been intrigued by non-linear differential equations and took interest in improving existing numerical approaches to solve them. He was naturally inclined to study mathematics in university, but his teachers suggested him to join Physics if he wished to get a real taste of Mathematics. So, he chose Physics and went on to be mentored by many renowned physicists like Herman Feshbach who taught him a Mathematical Physics course. Along with being a physicist, he is very good at painting too. Dr. Nasir Majid Mirza is fascinated by literature in both English and Urdu and has been an active writer since his boyhood. He has penned down almost 400 editorial pieces in the Jang Newspaper on how to improve the education system of Pakistan.

Dr. Nasir Majid Mirza has won his spurs and contributed at the international level in Computational Physics, Modelling and Simulation, Radiation Physics, and Nuclear Engineering. Moreover, he is an active academician concerned about improving education and outreach for Physics in Pakistan. He is very optimistic and feels positive about the future of Physics both in Pakistan and globally.

Dr. Nasir Majid Mirza is truly an inspiration for many young Pakistani physicists to come. In his own words, the fulfilment of curiosity matters the most in Physics, as he believes that:

> *Awards and honours have minuscule worth in front of the Eureka Moment, a blessing of God, which only scientists enjoy during the discovery.*

Students' Projects

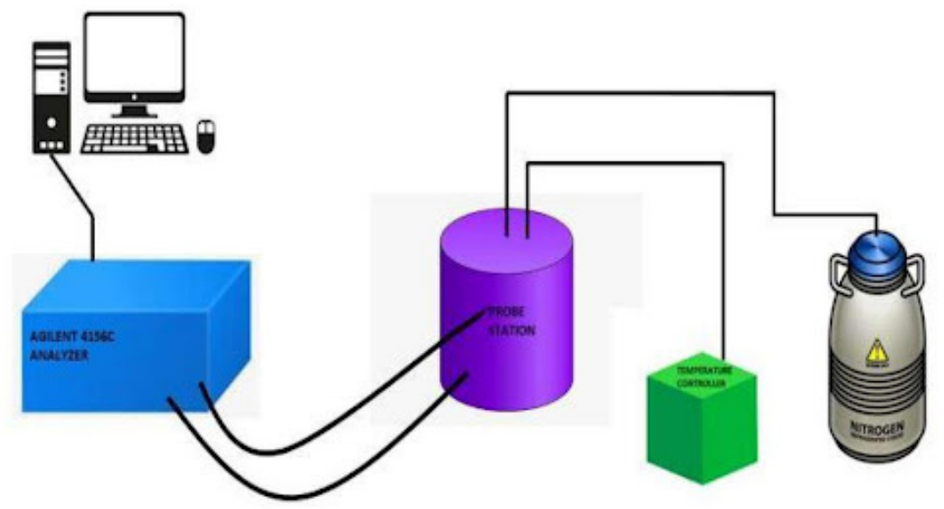
In our efforts to encourage the young audience to explore physics, we have decided to feature a few projects undertaken by our students at DPAM and to appreciate their efforts. We have many more interesting projects earmarked to be shared with readers, but due to brevity and limited energy, we hope to showcase them in future newsletters as we continue this tradition.

Hydrogen Sensors based on Hybrid Nickel Oxide Nanostructures

Ridaa Shahzad (MS Physics '21, DPAM)
Supervised by Dr. Muhammad Aftab Rafiq

As we try to keep up with the long-sought dream of a hydrogen economy, we need hydrogen sensors that offer a quicker reaction and recovery time, a lower detection threshold, greater repeatability, and better selectivity. Owing to the rising importance of hydrogen sensors, semiconductor metal oxides have become one of the newest materials to catch researchers' attention for manufacturing them. Intrigued by research in material synthesis and characterization, Ridaa Shahzad chose this project to enable advancement in applications of hydrogen sensing. Her quest for knowledge and a keen interest in material physics drove her to explore novel nanomaterials for preparing hydrogen sensors.

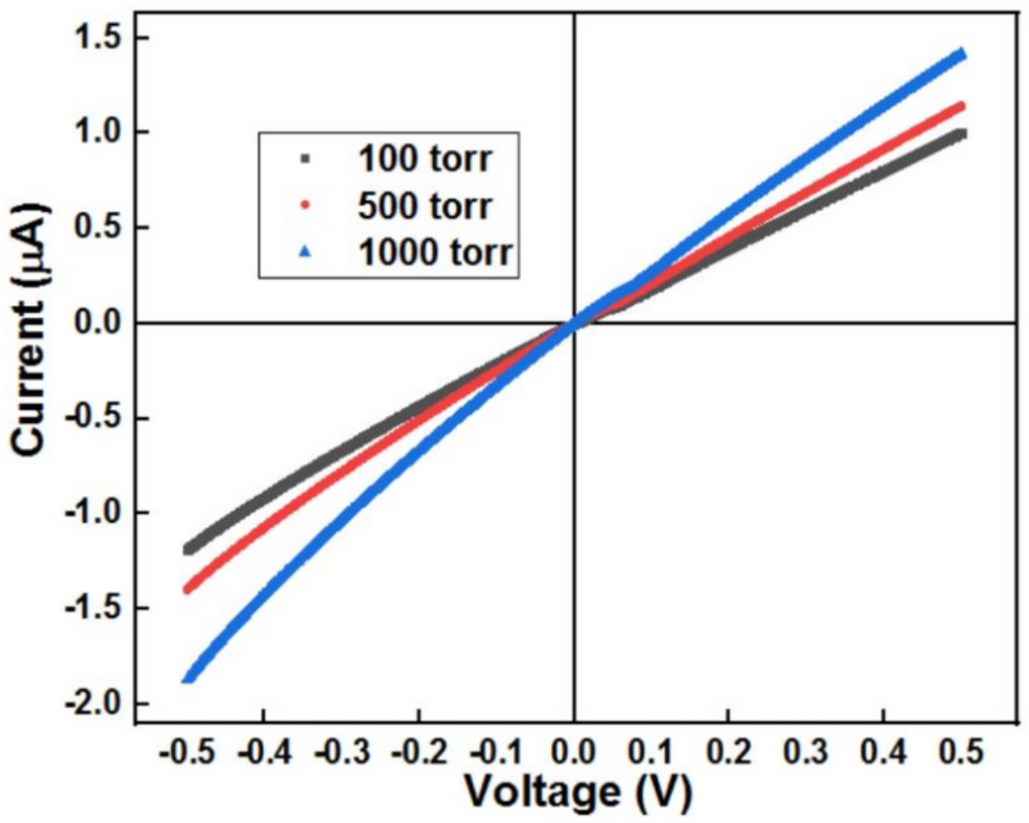
In this project, Ridaa examined hydrogen sensing through various nanoparticles: Nickel Oxide (NiO), Manganese-doped Nickel Oxide (Mn:NiO), Nickel-doped Manganese Oxide (Ni:Mn_2O_3), Copper-doped Nickel Oxide (Cu:NiO), and a hybrid of Nickel Disulfide and Nickel Oxide (NiS_2:NiO). Through the co-precipitation approach, NiO, Mn:NiO, Ni:Mn_2O_3, and Cu:NiO nanoparticles were produced and solid state reaction was used to produce NiS_2:NiO. She confirmed the purity of samples through X-ray diffraction (XRD) and Energy Dispersive Spectroscopy (EDS), and perused the formation of nanostructures



Schematic representation of setup to trace the IV curve for various temperatures

through Scanning Electron Microscope (SEM). Then, she assessed the capability for hydrogensensing of the materials by taking current-voltage IV measurements in the presence of various hydrogen pressures. Similarly, current-voltage IV curves at various temperatures were also taken for three samples with the help of an Agilent 4156C precision semiconductor parameter analyzer.

The XRD results matched the various JCPDS cards with average crystallite size in nanometers. For hydrogen sensing, the *IV* curves for Ridaa's materials show that there is an increase in current in the material when hydrogen pressure or concentration is increased as can be seen in the graph ahead.



IV curves for NiO at various hydrogen pressures

The IV data was used to do a comparison between different materials. For NiO, resistive switching is observed in the IV curve. The phrase "resistive switching" describes a physical phenomenon in which a dielectric abruptly modifies its (two terminal) resistance in response to a powerful electric field or current. The IV curve of NiO at different temperatures showed the presence of ohmic and space-charge limited current (SCLC) regions. In the SCLC regime, the mobility may be determined from a straightforward current-voltage measurement as the current is then solely reliant on the mobility and no longer on the charge carrier density. In contrast, in Ohmic conduction, one needs to know the charge carrier density to infer anything about the mobility.

Ridaa and her supervisor believe that, in the future, the project can be expanded by calculating the response and recovery time for the materials, and a study can be done on the synthesis of p-n junction heterostructures using these materials for p-type and some other metal oxide for n-type. These materials can be utilized for hydrogen sensing in p-n heterostructure and packaging for commercial use.

Compiled by Andal Mehroze and Fiza Masood.

MR-only Based SRS in Brain: Dosimetric Evaluation of MR-based Synthetic CT using Tissue Segmentation Method

Duryab Nasir (MS Medical Physics '22, DPAM)
Supervised by Mr. Harris Arif (SS, INMOL)
Co-supervised by Dr. Tariq Siddique (DPAM)

Planning out a radiation-based treatment for cancer patients can be complicated. A typical prescription of multimodal imaging (CT and MRI) aims to gather enough information for an accurate radiotherapy, but it can cost patients a lot of time and expense, and fusing the images can cause geometrical errors due to different positioning of a patient during different scans. Since MRI gives an excellent soft tissue contrast, it supersedes CT scan as the primary imaging modality for treating brain tumors. So, to simplify the planning process without any loss in quality of treatment, many approaches have been devised to derive "synthetic" CT scan from MRI without the need for a real CT scan. Duryab Nasir worked with experts at the Institute of Nuclear Medicine and Oncology Lahore (INMOL) to investigate how one such approach plays out in a real clinical scenario.

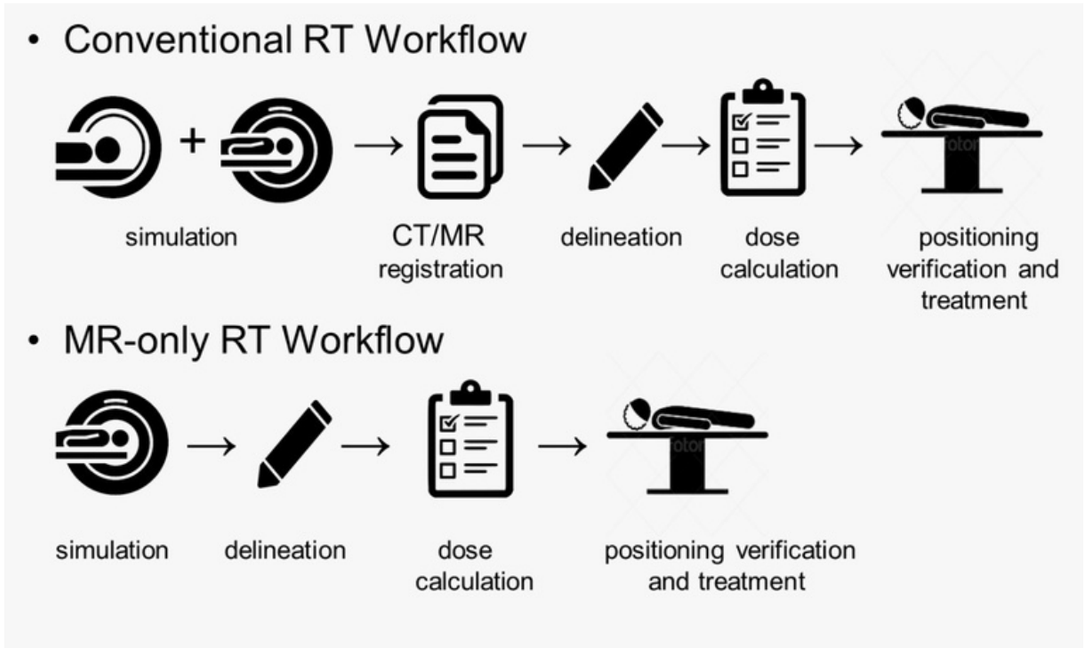
In a typical MRI+CT scan approach, the MRI scans are used to contour and locate the tumor, and CT scans provide electron density to calculate radiation dosage. Duryab prepared synthetic CT scans (sCT from hereon) from MRI scans based on tissue-segmentation approach: for each patient in her study, an intensity-based thresholding was applied through a Python script on different MRI

sequences (T1-weighted, T2-weighted, and diffusion-weighted images)* to segment different tissues such as fat, brain, bone, sinuses, and cerebrospinal fluid. She also segmented various regions in brain, such as white and gray matter, which is a novelty in this study. Then, a Hounsfield Unit (HU) value was assigned to these regions to prepare a sCT image, which is a measure of attenuation coefficient assigned as an identifier to a particular type of bodily matter (e.g. bones) in actual CT scans.

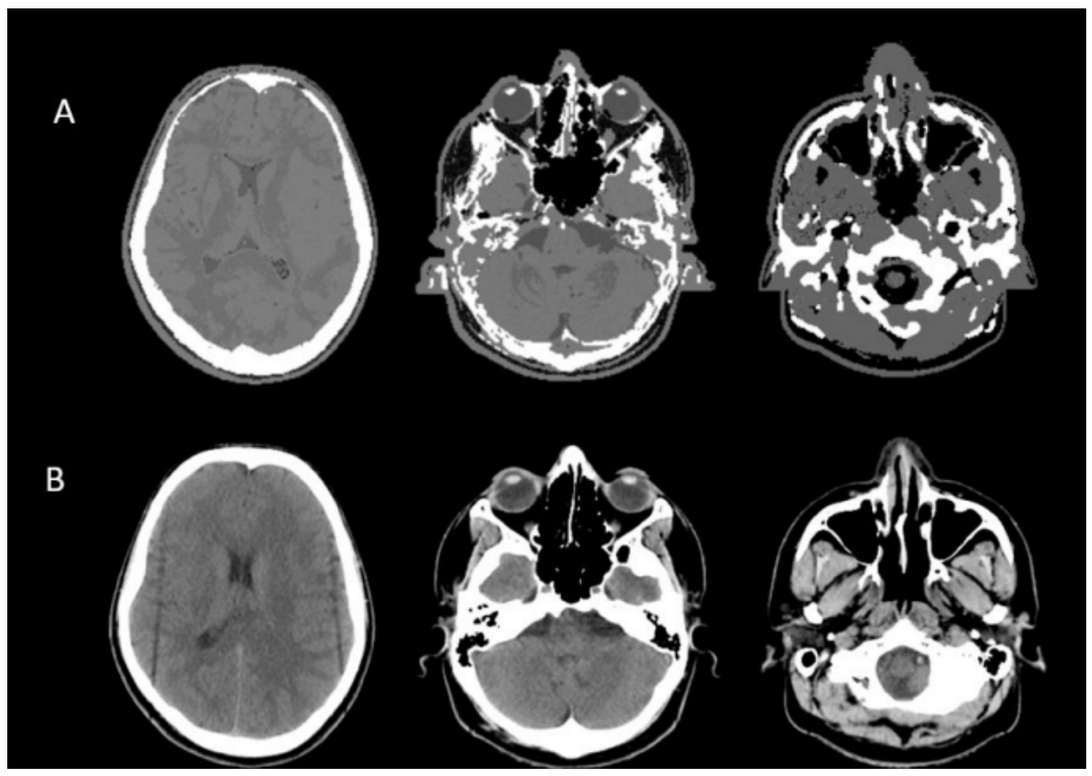
Finally, to compare the dosage requirement implied by both CT and sCT images, Duryab used the same parameters to generate an optimized radiotherapy plan based on target volumes and "organs-at-risk" (OARs) identified in the MRI images by oncologists. How these plans would manifest in sCT and CT was investigated through dosimetric evaluation based on "dose-volume histograms" (DVH) and gamma analysis. The DVH of both the Planning Target Volume (PTV) and OARs in sCT as well as in the actual CT were found to be in excellent agreement with each other. Then, by setting the actual CT plan as the gold standard, a gamma index analysis -- totally unrelated to gamma rays -- was used to assess how well the sCT plan corresponded to it. Barring an inaccuracy in bone segmentation as shown by a large gamma value in one patient, the overall results were strongly aligned with the plan based on actual CT.

Thus, Duryab was able to confirm that a decluttered, MRI-only treatment is clinically viable and accurate. She plans to extend the study to ten patients, and an extra patient has already been examined by the time of writing this article. As a Marie Sklowdowska-Curie Fellow of IAEA, Duryab advocates safe and peaceful use of nuclear technology, and in a bid to her commitment, she explores innovative ways to incorporate nuclear diagnostics (such as MRI) in improving the healthcare industry. She has been intrigued by the emergence of data-driven medical physics, and it inspired her to choose this project as it offered a fusion of radiotherapy, radiology, and computational physics.

Compiled by Waddia Summan.



Typical radiotherapy workflow versus a much simpler workflow derived from MR-only approach (from Duryab Nasir's project poster)



Case example for sCT (A) and actual CT (B) image pairs of brain

For the curious readers, nuclear magnetic resonance (NMR) involves a spin-lattice relaxation time (T1) and spin-spin relaxation time (T2). In T1-weighted image, brightness and contrast are determined by the target's T1 profile, whereas they are determined by the target's T2 profile in the other case. Diffusion-weighted image is based on extent of diffusion of protons (in water) -- the restricted the diffusion, the brighter the spot.

PIEAS Achievements

- PIEAS Society for Physics on behalf of the Department of Physics and Applied Mathematics (DPAM) warmly congratulates our fellows from the '**Team Ascensor**' for winning bronze medals in both the TECHNOFEST'21 and '22. TECHNOFEST is the largest technology-centric competition sponsored by well-known Turkish institutes and companies. Team Ascensor competed with 180 teams from 84 countries in the International Unmanned Automatic Vehicle fixed-wing category.

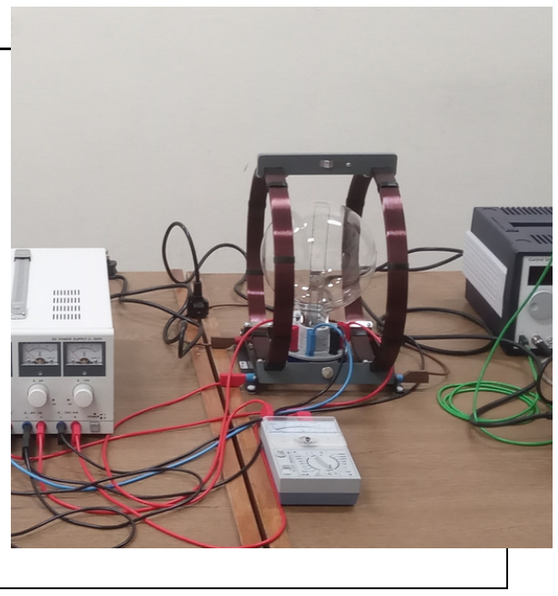
UAV Ascensor Mark-I was the team's first step to enter the Teknofest'21. They secured a high rank by making their own plane and acing all missions. This year, the team graced the grand stage with Ascensor Mark-II. Mark II's amazing flight ability, refined design, vertical and horizontal 360s, and its flashing speed amazed both the pilots and the audience.

- Under the National STEM Career Programme, which is a joint venture of Higher Education Commission and PIEAS, a five-member team of high school students represented Pakistan in this year's International Physics Olympiad (IPhO 2022). The team was mentored by Dr. Shahid Qamar and Dr. Aman-ur-Rehman, and brought home two bronze medals (Muhammad Bilal Asmatullah and Osman Siddique) and one honorable mention (Muhammad Sabeer Asad).

- A research grant of **15.57 million PKR** by Higher Education Commission, under the umbrella of National Research Program for Universities (Project No. 15313), has been awarded to the faculty of Department of Physics and Applied Mathematics, PIEAS. The aim is to develop the **experimental setup for Quantum Key Distribution Protocol**. The project will involve using a balance homodyne detection scheme on pulse laser light signal and vacuum fluctuation to generate Quantum Random Numbers. The Principal Investigator is Dr. Shahid Qamar, Director Centre for Mathematical Sciences, and three co-principal investigators: Dr. Muhammad Irfan, Dr. Muhammad Waseem, and Dr. Afshan Irshad.

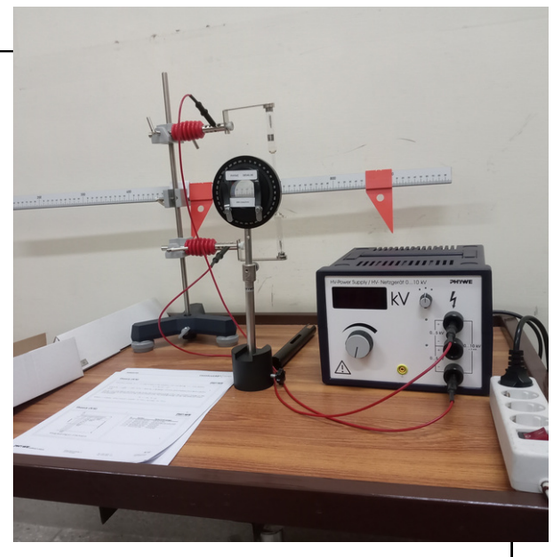
- This summer, one of the undergraduate students from DPAM, Waddia Summan, was selected for a funded Undergraduate Research Fellowship by the Institute for High Energy Physics (the IFAE, Universitat Autònoma de Barcelona) in Barcelona, Spain, to work with the Astrophysics Group associated with the European Southern Observatory. She worked on finding signatures for active black holes (AGNs) in relics of massive compact galaxies born a few billion years after the Big Bang, which may help in solving the puzzle of how some galaxies avoid mergers over the course of eons and, despite being "dead", still show forbidden emission lines usually ascribed to young star-forming galaxies.

- Recently, the Department of Physics and Applied Mathematics (DPAM) has accomplished another achievement in improving education for Experimental Physics by establishing a state-of-the-art **Modern Physics Laboratory**. The laboratory features the setups of important experiments which are crucial for the understanding of Modern Physics. As, the **Balmer Series experiment** which accurately predicts the structure of the Hydrogen atom and a setup for the **Blackbody Radiation experiment** which was fundamental in bringing the idea of "quantization" to the fore in the physics community. An **e/m ratio experiment** that will help students for a better understanding of the elementary particle ‘electron’.



Setup for e/m ratio experiment

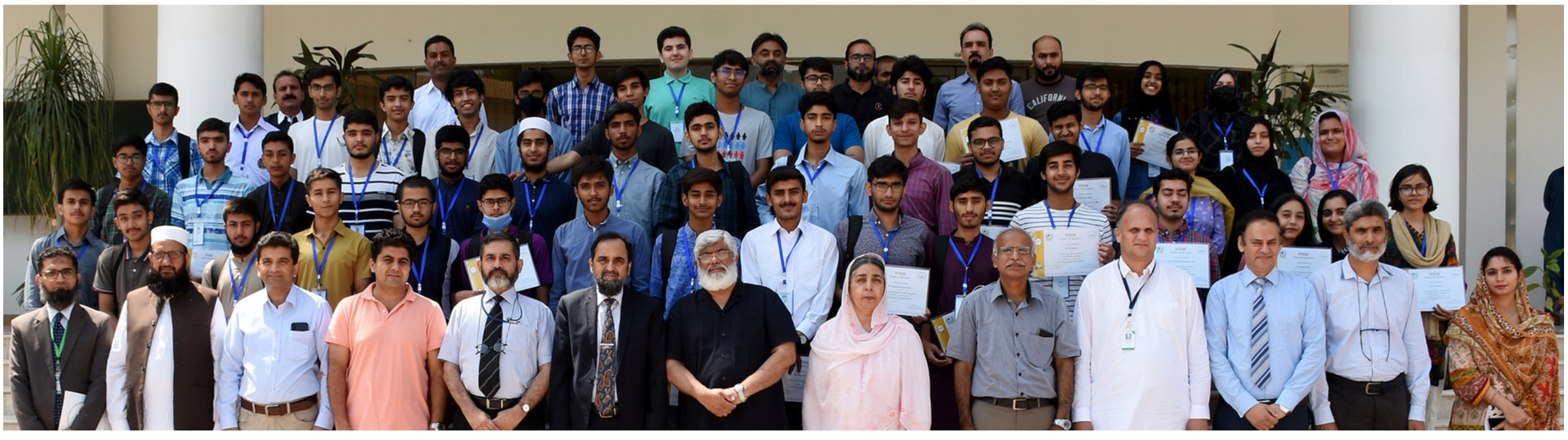
Setup for blackbody radiation experiment



Setup for Balmer series experiment

Event

Department of Physics and Applied Mathematics, PIEAS, arranged a one-week (28th August – 3rd Sept 2022) training workshop for the students selected for National Physics Talent Contest under the umbrella of STEM career program.



Closing Session: Group Photo with Chief Guest Dr Mansoor Hameed Inayat, Director General, National Centre for Physics.

PINBOARD

INERTIA 2022

Come and join the PSP family to celebrate a year of physics outreach at Inertia '22!

We dedicate this annual event to introduce PIEAS Society for Physics, our objectives, activities, and how you too can become a part of it. You'll also find a chance to attend interesting talks and chat with like-minded peers over free supper.

No registrations required. Just find us at **Inam-ur-Rehman Auditorium** on **October 15, 2022 (tentative)**.

GATES-CAMBRIDGE SCHOLARSHIP 2023

For those looking to apply for an M. Phil or PhD course at the University of Cambridge for the fall term next year (Michaelmas term), the University offers a renowned fully-funded scholarship in consortium with the Gates Foundation. Selections are extremely competitive.

To apply, just tick the "Gates-Cambridge Scholarship" on the main Graduate Application Portal, and be sure to apply **by the relevant course deadline**.

More information: https://www.gatescambridge.org/

CHEVENING SCHOLARSHIPS 2023

The Chevening Awards is offering another round of its coveted scholarships to fully fund a year-long Masters course starting from fall 2023 in the UK. Complete applications must be submitted by **November 1, 2022.**

Find out more here:
https://www.chevening.org/scholarships/

LINDAU NOBEL LAUREATE MEETING ON PHYSIOLOGY AND MEDICINE 2023

PIEAS in association with the HEC is inviting applications for the 72nd Lindau Nobel Laureate Meeting on Physiology and Medicine. Interested graduates with 16 years of education and a strong academic profile may apply by **October 9, 2022.**

More information: http://nobel.pieas.edu.pk/

ERASMUS MUNDUS JOINT MASTERS 2023

The Erasmus Mundus Joint Masters program offers an assortment of fully-funded Masters courses in science and technology at various partner universities across Europe. In the last application round, most of the scholarships were granted to Pakistani students. A course typically involves studying at different partner universities, offering the student a diverse outlook. Most programs for 2023 have deadlines **between October 2022 and January 2023.**

Find out more:
https://erasmusplus.ec.europa.eu/opportunities/opportunities-for-individuals/students/erasmus-mundus-joint-masters-scholarships

COMMONWEALTH SCHOLARSHIPS 2023

The Commonwealth Scholarship Commission (CSC) in collaboration with HEC is inviting applications for fully-funded scholarships for Masters and PhD programs in the UK. Please note that two separate applications have to be made at CSC and HEC portals, and only graduated students i.e. degree holders can apply. Applications are due on **October 18, 2022.**

Find out more:
https://www.hec.gov.pk/english/scholarshipsgrants/lao/cwgs/Pages/default.aspx

LUMS WINTER SCHOOL

Offering an array of courses, Lahore University of Management Sciences will host its residential Winter School from *December 19* to *December 31, 2022.* Applications are due before **October 12, 2022.**

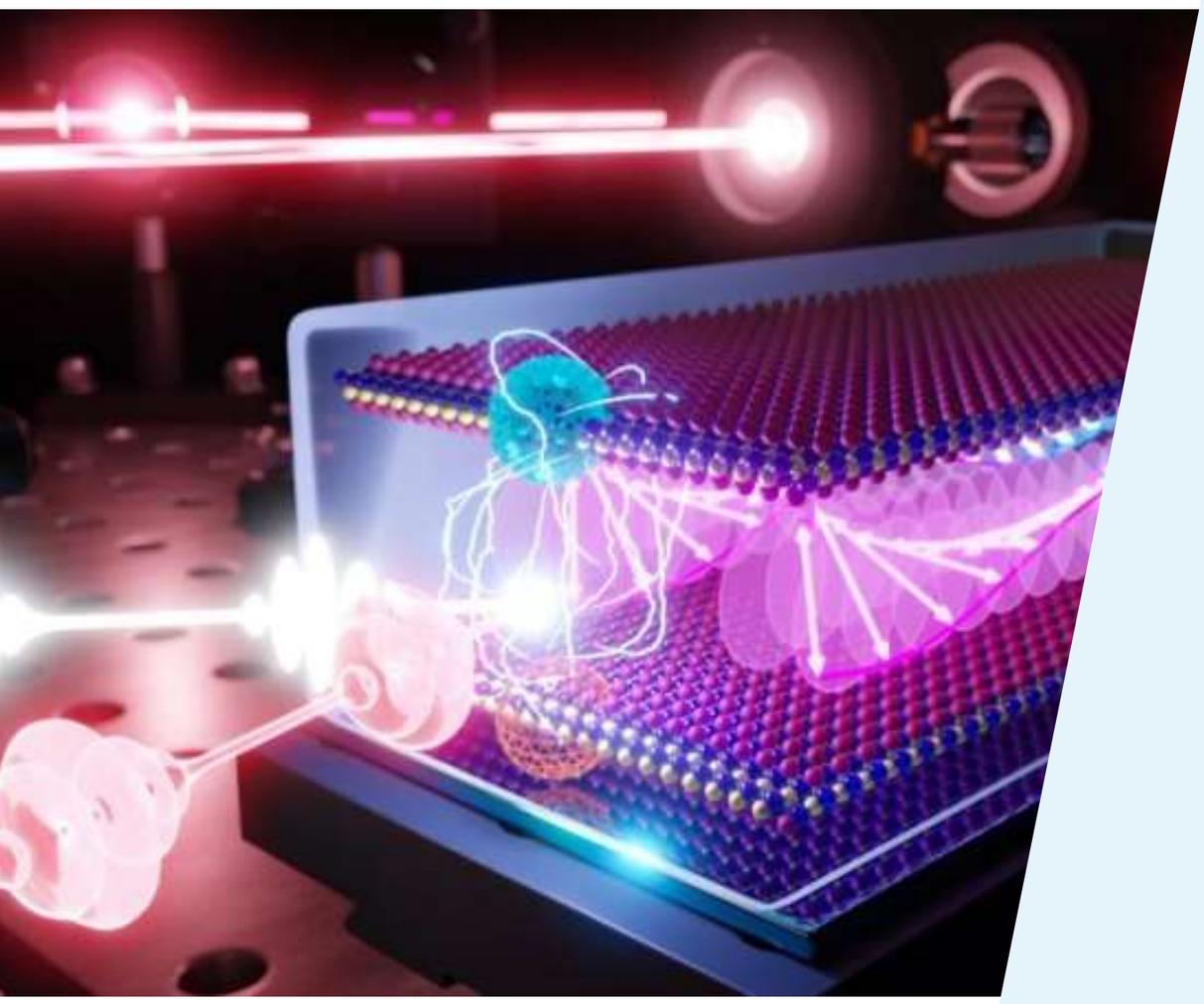
Find out more here: https://winter.lums.edu.pk/course-details.php?cid=164

CERN SHORT TERM INTERNSHIP

6-month administrative and technical internships are open for undergraduates and masters.

Find out more here:
https://jobs.smartrecruiters.com/CERN/743999848702191-short-term-internship-2023

Physics Bulletin



Scientists see spins in a 2D magnet.

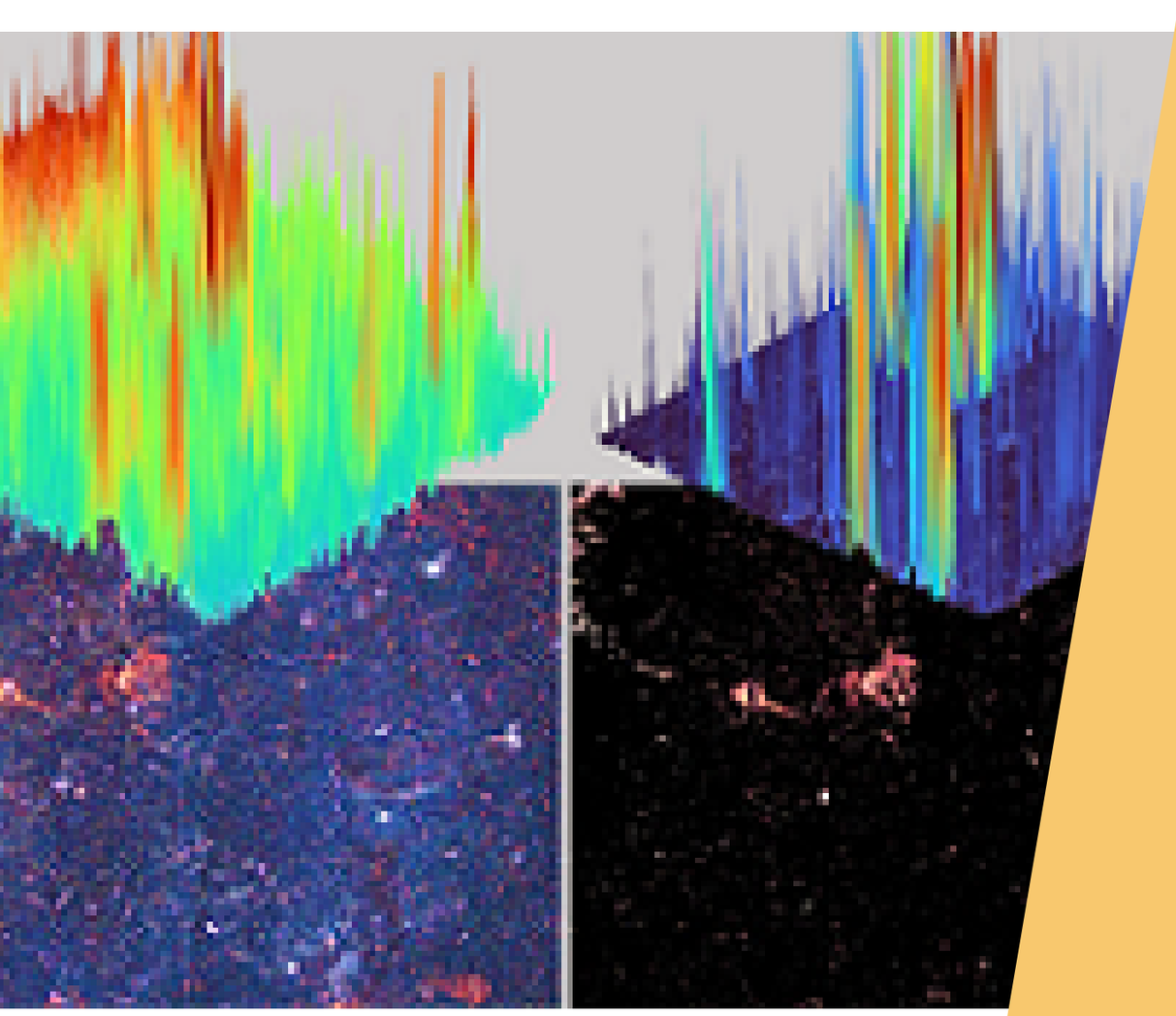
All magnets contain spinning quasiparticles called magnons. Research shows that magnons light up when paired with a light-emitting quasiparticle "exciton", possibly leading to novel quantum information applications. Magnons are difficult to detect, but the project's coauthor Zhu said, "For the first time, we can see magnons with a simple optical effect."

https://www.nature.com/articles/s41586-02205024-1|
https://phys.org/news/2022-09-scientists-2d-magnet.html

NASA's Artemis Programme

The Artemis programme is a series of ongoing space missions run by NASA.
Three Artemis missions are currently in progress. Artemis-1, an uncrewed test flight around and beyond the Moon, launching no sooner than late September 2022 (postponed from 29 August and 3 September). Artemis-2, a crewed flight beyond the Moon which will take humans the farthest they've ever been in space. And Artemis-3, a mission that will land the first female astronaut and first astronaut of color on the Moon to spend a week performing scientific studies on the lunar surface. Artemis-3 will be the US space agency's first crewed Moon landing mission since Apollo 17 in 1972. NASA also intends to launch a future crewed mission to Mars.

https://www.nasa.gov/artemis-1

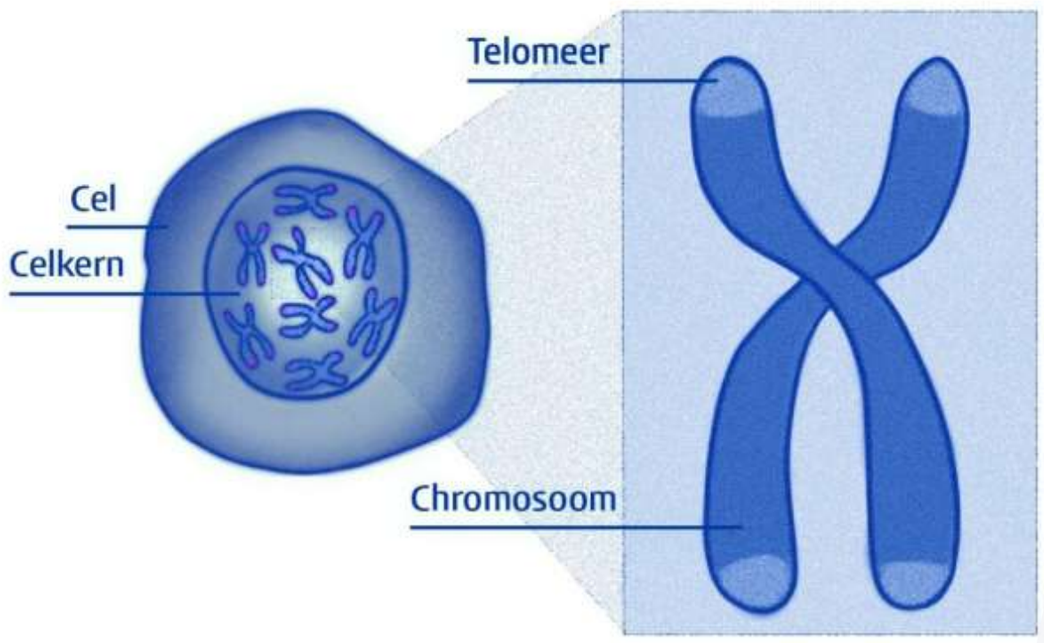


Nanotechnology, Deep Learning Help Detect Pediatric Tuberculosis

According to the research team from the University of Washington School of Medicine and Tulane University, it is particularly challenging to diagnose TB in children. The researchers developed a way to optically detect two virulence factors for TB — the lipoarabinomannan (LAM) molecule and an associated protein called LprG. These factors are found on vesicles in the blood cells of people with TB.

https://www.photonics.com/Articles/Nanotechnology_Deep_Learning_Help_Detect/a68364

Physics Bulletin



Can we live longer? Physicist with the help of a magnetic ball discovers new structure of telomeric DNA

Telomeres are associated with living longer. The new discovery will help us understand aging and disease. It was discovered with a combination of electron microscopy and molecular force spectroscopy. This will help us understand how enzymes in the cells deal with telomeres, how they repair and copy DNA, etc.

https://www.nature.com/articles/s41586-022-05236-5
https://phys.org/news/2022-09-longer-physicist-discovery-telomeres.html

An elementary quantum network of entangled optical atomic clocks

A team of researchers from the University of Oxford has pushed the entanglement limit for atoms to a distance of two meters (about six feet), proving the mathematics continues to hold true over larger spaces. Not only could this improve the overall precision of optical atomic clocks, it also allows for a level of comparison in the split-second timing of multiple clocks to a degree that could reveal previously undetectable signals in a range of physical phenomena.

https://phys.org/news/2022-09-quantum-network-entangled-atomic-clocks.html
https://www.nature.com/articles/s41586-022-05088-z

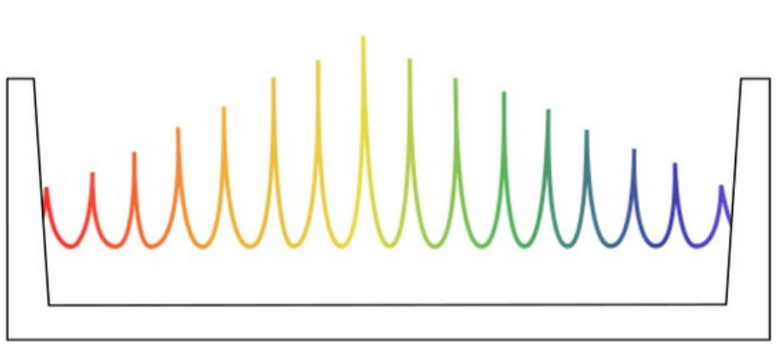
2023 Breakthrough Prize in Fundamental Physics Winners

The coveted prize with a $3 million award for 2023 has been awarded to four physicists: Charles Bennett, Gilles Brassard, Peter Shor, and David Deutsch, honoring their pivotal contributions to quantum information and developing the framework behind quantum computing. This is the second consecutive year when the so-called "Nobel Prize of the 21st century" deviated from an old pattern of cherishing discoveries in the fields of astrophysics and particle physics, as it ushered in a mainstream interest in quantum computing.

https://breakthroughprize.org/Laureates/1

Physics Problems

I. How do we know that the universe is not only expanding but accelerating? A 2011 Nobel Prize was awarded to the scientist who found the answer.



II. Theodor W. Hänsch won the 2005 Nobel Prize for his discovery that laser light can be described as discrete, evenly spaced frequency lines, similar to those in a comb. What innovations has this finding brought about?

III. If we consider the nucleus of charge Q>>e, and mimic it to a black hole (making an analogy of equating gravitational potential with Coulomb potential), what will be the radius of the black hole?

Answers to Physics Problems in Zenith (Jun-Jul, 2022)

1. The friction force is more in pushing than that is in pulling. That's why it is easier to pull an object than to push it. Read the following intriguing thread for the details:https://www.quora.com/Is-it-easier-to-push-or-pull
2. A typical mirror actually swaps front and back depending on incoming rays perpendicular to its surface, so when you look into it, it seems that you are rotated by 180 degrees, giving you the impression that right and left are swapped. More details are in the following video: https://www.youtube.com/watch?v=vBpxhfBlVLU&ab_channel=PhysicsGirl
3. One bit of light cannot bounce off another bit of light directly but they can collide indirectly which is very rare. This process is called photon-photon scattering. Follow the given link to read more about its answer: https://www.wtamu.edu/~cbaird/sq/2013/09/06/can-one-bit-of-light-bounce-off-another-bit-of-light/
4. Majorana Fermion, sometimes referred to as the Majorana particle, is its own antiparticle.

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