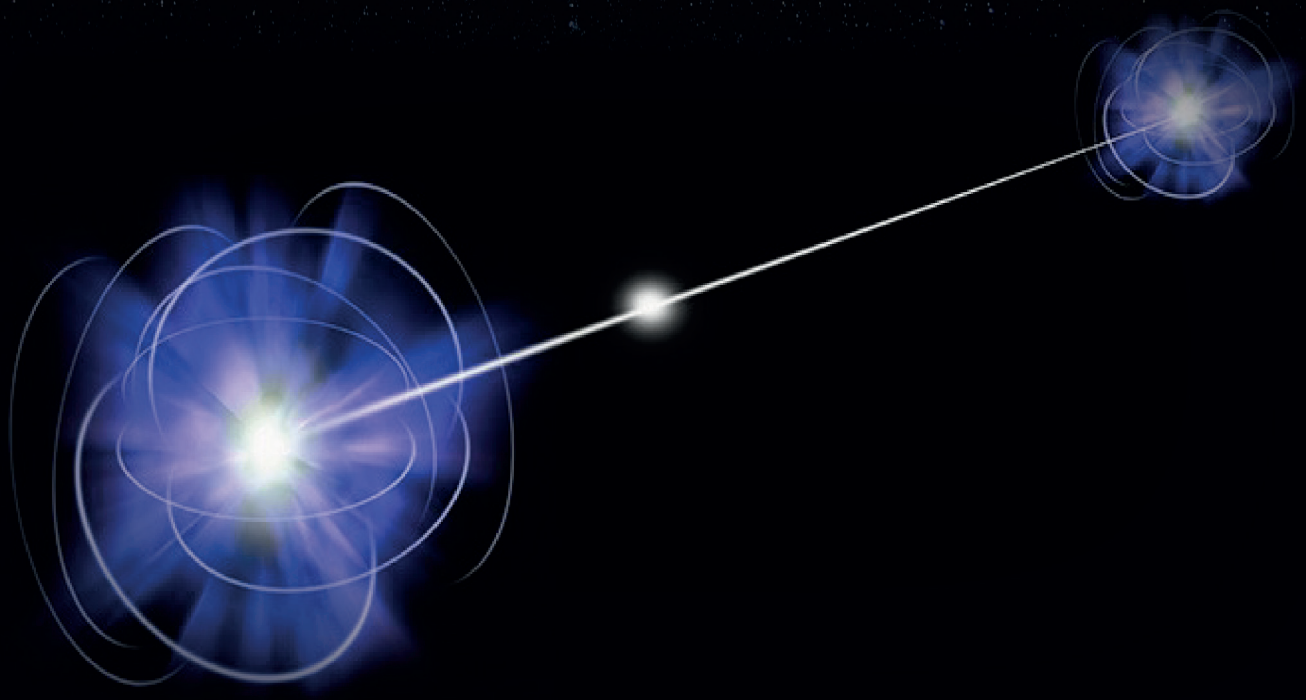
June - July 2022 | Issue No. 1

Newsletter

PIEAS Society for Physics

ZENITH



Pinboard

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Exoplanets
Hefty W-Boson

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Phy/AI Junction
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Data Science
Inertia
Lindau Nobel Laureate Meeting

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Pinboard

Rhodes Scholars 2022
Every year, the Rhodes Trust offers one Pakistani scholar complete funding for a two-year or longer degree at Oxford University. These historically renowned and prestigious scholarships connect talented youth with an elite club of global experts in their fields and nurture their potential. Rhodes scholars include numerous presidents, scientists, global leaders, and Nobel laureates.
Applications are due **August 1, 2022**, for programs in 2023.
Visit:https://www.rhodeshouse.ox.ac.uk/scholarships/applications/pakistan/

4th International Workshop on Ion Beam Applications 2022 (NCP)
A Series of lectures and hands-on training will be delivered by experts on the Ion Beam Applications. The Pelletron Tandem Accelerator facility and implanter installed in NCP, which provide research opportunities in a wide range of scientific fields, are the focal points of the workshop.
Dates: **05 - 07 September 2022**
The deadline for foreign participants is August 19th, 2022. For details visit: https://www.ncp.edu.pk/iwiba-2022.php

Online Conference on Gravitational Physics and Astronomy 2022
World Laboratory for Cosmology and Particle Physics (WLCAPP) and the Egyptian Center for Theoretical physics (ECTP) are hosting an online conference on the topics of High-Energy Physics and Astronomy. Registration is open till mid-September.
Conference Dates:**04 - 09 December 2022**
For more info visit: https://indico.cern.ch/event/1109513/

Metanano School on Optical Biosensing 2022 (online)
A rapidly expanding interdisciplinary field at the intersection of nanophotonics, biochemistry, microfluidics, and medicine is optical biosensing. A 5-day seminar on optical biosensing will feature presentations from some of the greatest experts in the world.
Dates: **15 - 19 August 2022**
Visit: https://school.physics.itmo.ru/

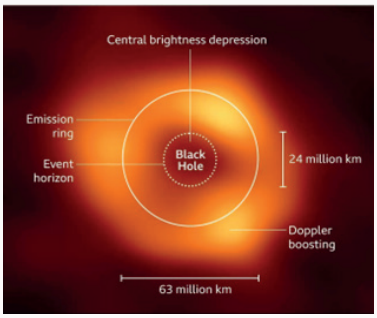
Three Lectures on Quantum Error Correction and Bosonic Coding (online)
Victor V. Albert will provide a brief introduction to the tenets of quantum error correction using the four-qubit code, making contact with concatenated, CSS, stabilizer, and rotated surface codes. He will then cover bosonic quantum memories, organizing them into bosonic stabilizer codes and bosonic Fock-state codes. He will conclude by overviewing six application cases of bosonic encodings, three of which circumvent no-go theorems due to the infinite-dimensionality of bosonic Hilbert space.
Dates: **Aug 1, 2022 - Aug 4, 2022**
Location:
https://umd.zoom.us/j/9893676372?pwd=VVNOd2xNZ3FCblk4aFdTMjkzTllvQT09
Visit for more details: https://rqs.umd.edu/events/three-lectures-on-quantum-error-correction-and-bosonic-coding.html

11th School on LHC Physics - 2022
Young scientists and graduate students will have the chance to learn from the school about the methods and equipment required to understand fascinating results from proton-proton collision data. Students will have the opportunity to take part in lab exercises that teach how to qualify, assemble, and test a silicon sensor. Distinguished particle scientists will present lectures on many aspects of particle physics.The application deadline for local participants is August 08th, 2022.
Dates: **22 August - 02 September 2022.**
Visit for more info: https://www.ncp.edu.pk/slp-2022.php
To register: https://indico.ncp.edu.pk/indico/confRegistrationFormDisplay.py/display?confId=184

Physics Bulletin

1. Breaking Down the "mind-bending" Milky Way Black Hole Image

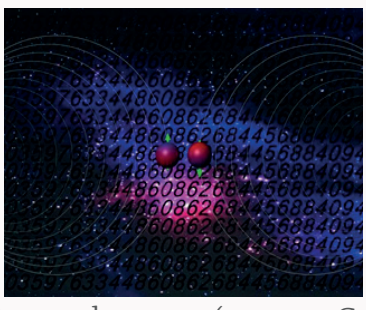
The Milky Way has a supermassive black hole at its center, but we've never actually seen it – until now. The Event Horizon Telescope, funded by the National Science Foundation (NSF), has released the first image of the Sagittarius A*. It has been touted as one of the most breathtaking pictures humanity has laid eyes on.
For further reading:
https://www.cnet.com/science/space



Deciphering the image (source: EHT collaboration, BBC)

2. New record: preserving the Quantum States for more than 5 seconds

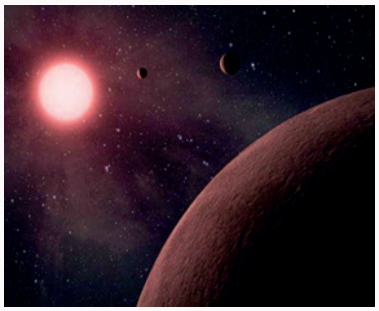
A team of researchers has maintained a qubit coherence time for a record five seconds. The qubits are made from silicon carbide, widely found in lightbulbs, electric vehicles, and high voltage electronics. Quantum science holds promise for many technological applications, such as building hackerproof communication networks or quantum computers that could accelerate new drug discoveries. But the main problem is preserving the quantum states for a long time, as they suffer from quantum decoherence and state fidelity.
Link:https://www.sciencedaily.com/releases/2022220202153853/02/.htm



Quantum coherence (source: Google)

3. AI reveals unsuspected math underlying the search for exoplanets

In a paper that appeared last month in Nature Astronomy, the researchers at UC Berkeley developed an AI algorithm to quickly detect exoplanets. When planetary systems pass in front of a background star, they briefly brighten it through a process called gravitational microlensing. By studying data obtained through this process, the AI algorithm revealed that the decades-old theories now used to explain these observations are woefully incomplete.Find out more: https://phys.org/news/202205--ai-reveals-unsuspected-math-underlying.html



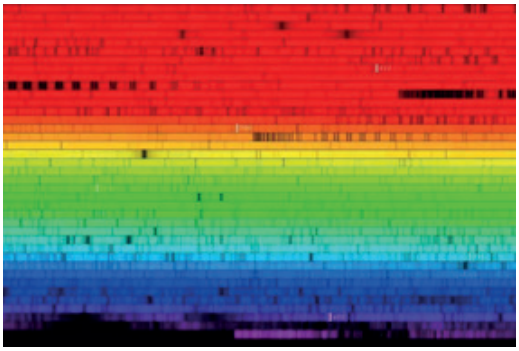
Source: phys.org

4. The W boson might be extra hefty and could hint at new physics

A new measurement of a W-boson mass by the Collider Detector at Fermilab raises excitement and questions. The result hints at a possible flaw in physicists' otherwise stalwart theory of the fundamental bits and bobs of our world: the Standard Model. More: https://www.sciencenews.org/article/w-boson-particle-mass-standard-model-physics

5. New calculations of the solar spectrum resolve the decade-long controversy about the sun's chemical composition

Two different but established methods in the solar physics community have been at odds with each other in giving the right chemical composition of the Sun. By going deeper into the models underpinning those methods and fixing assumptions and oversimplifications, the physicists have been able to resolve the so-called "solar abundance crises". More:https://phys.org/news/202205--so

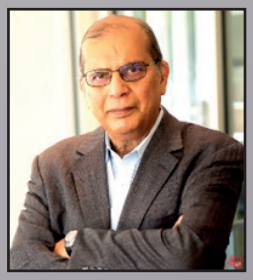


Source: phys.org

6. Researchers teleport quantum information across a rudimentary network

Researchers in Delft have succeeded in teleporting quantum information across a rudimentary network. This first of its kind is an important step towards a future quantum Internet. This breakthrough was made possible by a greatly improved quantum memory and enhanced quality of the quantum links between the three nodes of the network. More: https://www.sciencedaily.com/releases/2220525131156/05/022.htm

Inspiration



Dr. M. Suhail Zubairy

It was 16th May 2022, when PIEAS Society for Physics commemorated the International Day of Light on social media. Jogging everyone's memory with those physicists whose contributions are light-related, it will be unfair to light itself, if we don't think of Dr. Suhail Zubairy. Dr. Zubairy has received his PhD from the University of Rochester. In 1980's, he became the founding chairman of the Department of Electronics at Quaid-e-Azam University. After serving more than a decennium in his motherland, Pakistan, he joined the Department of Physics and Astronomy, Texas A&M University as a professor.

In 1989, Dr. made an assertion regarding Pakistan's education system at Pakistan television (PTV) studio which I need to reiterate here:

"The basic difference between the education system of a developed nation and underdeveloped nations is: there, students emphasize on problem-solving while here, they emphasize on memorizing the facts".

Dr. Zubairy is the inaugural holder of Munnerlyn-Heep Chair and was awarded the Changjiang Distinguished Chair. He has received other honours like Willis E. Lamb, Alexander von Humboldt Research Prize, Abdul Salam Prize, George H. W. Bush Award for excellence in research, etc.

The life of Dr. Zubairy, an inspirational figure for Pakistani Physicists who hope to break the glass ceiling of expectations, is full of efforts, and today, he is renowned for Quantum Optics, Quantum Computing, and Laser Physics due to his pioneering contributions. He has written highly cited research pieces on Quantum entanglement, quantum state measurement, and sub-wavelength atom localization, and is currently working on Plasmonic Crystals and Nano Rings. More recently, Dr. Zubairy has concentrated on Quantum Microscopy and Lithography whose results are seminal. For example, his paper on 'sub-wavelength lithography using classical sources' where he presented a scheme that can fudge a diffraction limit, was well received. It was published in *Physical Review Letter* and *Nature*, and another of his recent was picked by *Science* as a news release with the title *A new way to beat the limit on shrinking transistors*. He is the author of some phenomenal books like Quantum Optics and Quantum Mechanics for Beginners.

~ Muhammad Shuraim

Student 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 Department of Physics and Applied Mathematics (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.

Photon Blockade in Cavity QED coupled with Quantum Emitters

Maham Ibrar | BS Phy '22 DPAM | Supervised by Dr. Muhammad Irfan

How did you enter this field?

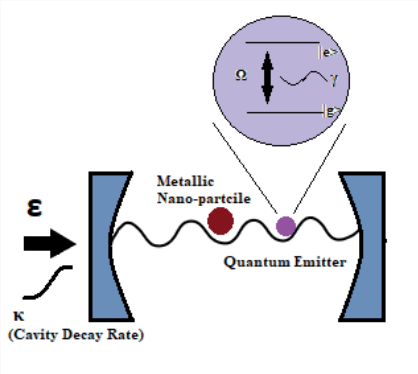
In the beginning, it wasn't Physics that I loved; it was the Universe. My curiosity to understand the universe drove me to where I am today.

Why did you choose this project?

I was originally interested in High Energy Physics but, after a visit to NILOP, I was intrigued by quantum optics. I wanted to understand every bit of it. Basically, at NILOP, it was Quantum Cryptography that I got a glimpse of. So, I started studying cryptography and I found out what has been going on in Quantum Optics. After wandering from one research paper to another, I realized that one thing was common among them: the idea of a perfect practical single-photon source because all applications, like Quantum Computing and Quantum Cryptography, required a single photon to start with. And so, I thought, if I want to enter this field, why not start from the core problem of generating single photon. This project made me realize how quantum devices work. I'm still lacking a lot, of course! But I know that working hard is the first condition of success.

Tell us about your Project

This research project is focused on the computational study of generating single photons by investigating the photon-blockade phenomenon in cavity QED setups. Photon-blockade has two types. The first type is conventional photon-blockade, which expresses itself



when the laser field is resonant with the transition frequency and the energy gap of the two-photon transition is greater than the cavity decay rate, whereas, the second type is unconventional photon-blockade with the underlying mechanism of destructive quantum interference. The generation of single photons is important because photonic qubits can store information and can be sent over large distances with unconditional security. The challenge is generating and controlling single photons. But the intersection of atomic physics and solid-state physics has led to the development of a deterministic source of single photons. The fundamental requirement for a practical single-photon source is the efficiency of the system, determined by the probability of pure single photons being generated. We studied photon-blockade in a cavity QED setup and explored the possibilities to obtain controllable single-photon emission. The system we considered involved a metallic nano-particle coupled to a single-atom cavity QED system interacting with the quantum emitter (atom) as well as with the cavity mode.

To determine the efficiency and photon statistics of the system, zero time-delayed second-order correlation function ($g^2(0)$) was calculated and plotted as a function of different parameters – all in order to explore which parameters upon tuning could lead to an efficient photon blockade and, thus, pure single-photon generation.

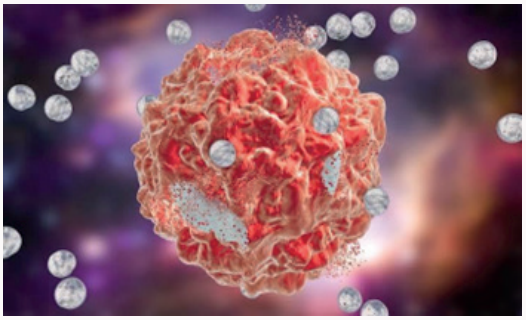
What are the outcomes of your project?
The results shown in this thesis are promising as the system under consideration expresses the combination of both types of photon blockades at specific points, referred to as "chiral" points, due to which the value of $g^2(0)$ is significantly minimized and thus high purity single photons are expected to be generated.

Nanoparticle Synthesis and its Potential Application in Theranostics

Mehwish Israr | BS Phy '22 DPAM | Supervised by Dr Syed Mujtaba-ul-Hassan

Why did you opt for Physics?
I liked it as a subject and thought, "Why not do a major in it and understand it better?" Now, I'm graduating with a thousand more questions than I came in with and seemingly more confused. I guess that's the beauty of physics.

What is Photodynamic Theranostics?
In the scientific and healthcare communities, there has been a struggle to find a convenient method to detect tumors efficiently as well as to kill them with the least damage to healthy cells. This struggle led to the development of nanomedicine, in which Photodynamic Theranostics has emerged as an interesting non-invasive method: it uses nanoparticles that, when irradiated, can act as both excellent contrast agents for biomedical imaging (the "diagnostics") and allow for a controlled and well-targeted killing of cancerous cells



(the "therapeutics"). My project involved developing a novel class of nanoparticles with improved suitability for this purpose.

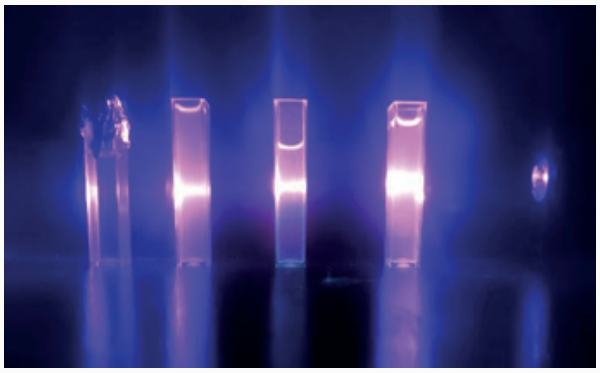
Why did you choose this project?
While exploring nanomedicine, as I realized the potential of a non-invasive multifunctional system based on PSs to fight cancer, I was inspired to study a set of nanoparticles that are good PDT candidates as well as the least toxic and most economical to produce. My inclination for practical work and learning how medical physics has changed the structure of healthcare have all made it so interesting to work on this project.

Tell us about your project.
I proposed to study Zinc Oxide nanoparticles (ZnO NPs) as they are, in traces, biocompatible and have shown great promise in **generating** "reactive-oxygen species" (ROS) through irradiation to kill tumors. Because doping enhances functionality, metal doping made me look for novel candidates that can improve the potential of NPs in bio-imaging: ytterbium and europium. High X-ray/UV absorption, high atomic number, and high K-edge energy make Ytterbium an excellent imaging agent in CT scans, whereas optical and magnetic properties of trivalent Europium make it useful for MRI. So,I prepared Ytterbium-Europium co-doped ZnO NPs of varying doping percentages through a convenient single-step hydrothermal method. Important results of the characterization methods I performed

were that the doped NPs had better emission intensities than undoped ZnO, and doped NPs had good colloidal stability (~12 hrs), which may indicate better physicochemical stability of NPs in bodily fluids. MTT assay tests showed increased cell viability by co-doping with rare-earth metals. To confirm these inferences by experimenting further, I wish to collaborate with biomedical laboratories and pursue a specialization in medical physics.

What are the outcomes?

In short, the rare earth elements my supervisor and I chose for co-doping showed better results as contrast agents with improved cell viability, and so they should be studied further to be incorporated into an improved theranostic system for treating cancer.



Laser light is shone on samples to see how long particles remain suspended in a solvent. (Tyndall test)

Quick reference for acronyms and symbols used

PDT:Photodynamic Theranostics
PS: photosensitizer
NP: nanoparticle
ZnO: Zinc Oxide

Events

Group Photo Taken in Inertia (PSP Inaugural Event) with Chief Guest Dr. Kashif Sabieh

Data Science with Python (January 11-13, 2022):

A 3-day workshop was made possible by Prof. Dr. Muhammad Aftab Rafiq, Head DPAM. A number of students, researchers, and officers from the Nilore community participated and learned about the various aspects of Data Science and Machine Learning in Python. Instructors included Dr. Sikander Majid Mirza (Ph.D. in Nuclear Engineering) and Dr. Atif Imtiaz Butt (Ph.D. in High Energy Physics), who convened interactive Jupiter sessions with problems relevant to scientific research. All participants received certificates in the end.

Where AI meets Physics (January 10, 2022):

A workshop was given by one of our highly esteemed professors Dr. Yousuf Hamza, who has been an integral part of the Department of Physics and Applied Mathematics at PIEAS, and is a leading expert on fiber optics and communication technology. The workshop was a detailed analysis of Dr. Yousuf's main area of research i.e. optical fibers with a focus on dispersion management using AI technology. In the workshop, he discussed problems at the junction of applied physics and artificial intelligence.

Quantum Mechanics: myths and realities (World Quantum Day, April 14, 2022):
A talk was convened on Quantum Physics Dr. Sajid Qamar, a renowned researcher whose work focusus on Quantum Optics and Communication, Sensor Networks, Atomic Emission Spectroscopy, and Digital Signal Processing. In a friendly ambiance, Dr. Qamar introduced Quantum Mechanics through the famous Zeno's paradox and discussed common misconceptions at pedagogical levels. The talk was attended by both the students and faculty and was made possible through the efforts of PSP faculty advisor Dr. Aftab Rafiq and Dr. Muhammad Irfan.

Quantum Entanglement: From intuition to deeper Mathematics (April 22, 2022):
Muhammad Ibrahim Jaffar (BS Phy '22), currently working on quantum computing algorithms, organized a session on demystifying quantum entanglement through mathematics. The workshop targeted young and aspiring physics students to inspire them to explore the weird world of quantum mechanics. He briefly discussed non-locality, multipartite states, Von Neumann entropy, and covered what quantum entanglement is and how it is realized mathematically.

PIEAS Open House 2022 (May 28, 2022):
Keeping up with the annual tradition, the hardworking final-year undergraduates from all departments of PIEAS were invited to showcase their science and engineering projects to industrialists, scientists, and the greater PIEAS community. The event was graced by Dr. Shahid Mahmood Baig, chairman PSF, as the chief guest as well as by Dr. Nasir Majid Mirza, the inspiring rector of PIEAS.

Lindau Nobel Laureate Meetings (June 26 - July 1, 2022)

The prestigious Lindau Nobel Laureate Meetings are convened every year in Lindau, Germany, and gather talented researchers and young students from all over the world to interact with Nobel Laureates and build a stronger academic network that improves their knowledge and supports their scientific endeavors. The student delegates from Pakistan are nominated and sponsored by PIEAS and HEC under the banner of "Interaction of Young Pakistani Scientists with Nobel Laureates" programme. This summer, nine Ph.D. and Master's candidates were selected to represent Pakistan at the 71st Lindau Nobel Laureate Meetings in Chemistry. The delegates came from regions as far as Malakand, and constituted a cohort of both local and foreign-educated scientists. Under the leadership of Dr. Aftab Rafiq, the delegates left for Lindau on June 26 and met about 35 Nobel Laureates whose works have impacted chemistry.

International Workshop on 2D Materials and Quantum Effect Devices (July 19 - July 21, 2022)

Held at PIEAS Lyceum, the three-day workshop explored various aspects of 2D materials and quantum effect devices. Many renowned international experts, most notably the Texas A&M University's Distinguished Professor Dr. Muhammad Suhail Zubairy (HI), Tokyo Institute of Technology's Professor Shunri Oda, and Imperial College London's Professor Zahid Ali Khan Durrani were invited to lecture at this workshop. The workshop provided a platform to its many participants for addressing advances in 2D materials and developing systems with enhanced characteristics for tackling numerous industrial and societal problems. These materials have been transforming many industries, such as semiconductor technology, wearable electronics, optoelectronics, etc.

Opening ceremony: group photo with chief guest Dr.Masood Iqbal, Member science PAEC

Closing ceremony: Group photo with Chief guest Dr Shahid Baig, Chairman PSF

Problems

I. To push an object or to pull it? What is easier?

II. Right and left is swapped when we look in a mirror, that is our image's right hand is our left hand, etc. Why aren't down and up swapped?

III. Can one bit of light bounce off another bit of light?

IV. Which class of particles constitutes those particles that can be an elementary particle and its own antiparticle at the same time?

Send your answers, comments, suggestions to psp.pieas@gmail.com

From the Director

PIEAS Society for Physics was founded with a vision to promote the culture of Physics and Mathematics in society. So, to keep that in mind, after thorough research and hard work, we are heading to dispatch our first bimonthly newsletter "Zenith".
In this issue, we tried to encompass the various subfields of Physics, from atom to cosmos. Specially to mention, the Pinboard which contains workshops, contests, and scholarships and student projects cost the indefatigable efforts of our team. The first Quantum Revolution and now even in the stages of the second Quantum Revolution demand us to pay attention to Physics discoveries and innovations and be a part of research and development to serve humanity and understand Nature.
We hope this informative and intriguing issue sparks both our audience's curiosity and the motivation to pursue those curiosities.

-

Muhammad Shuraim
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