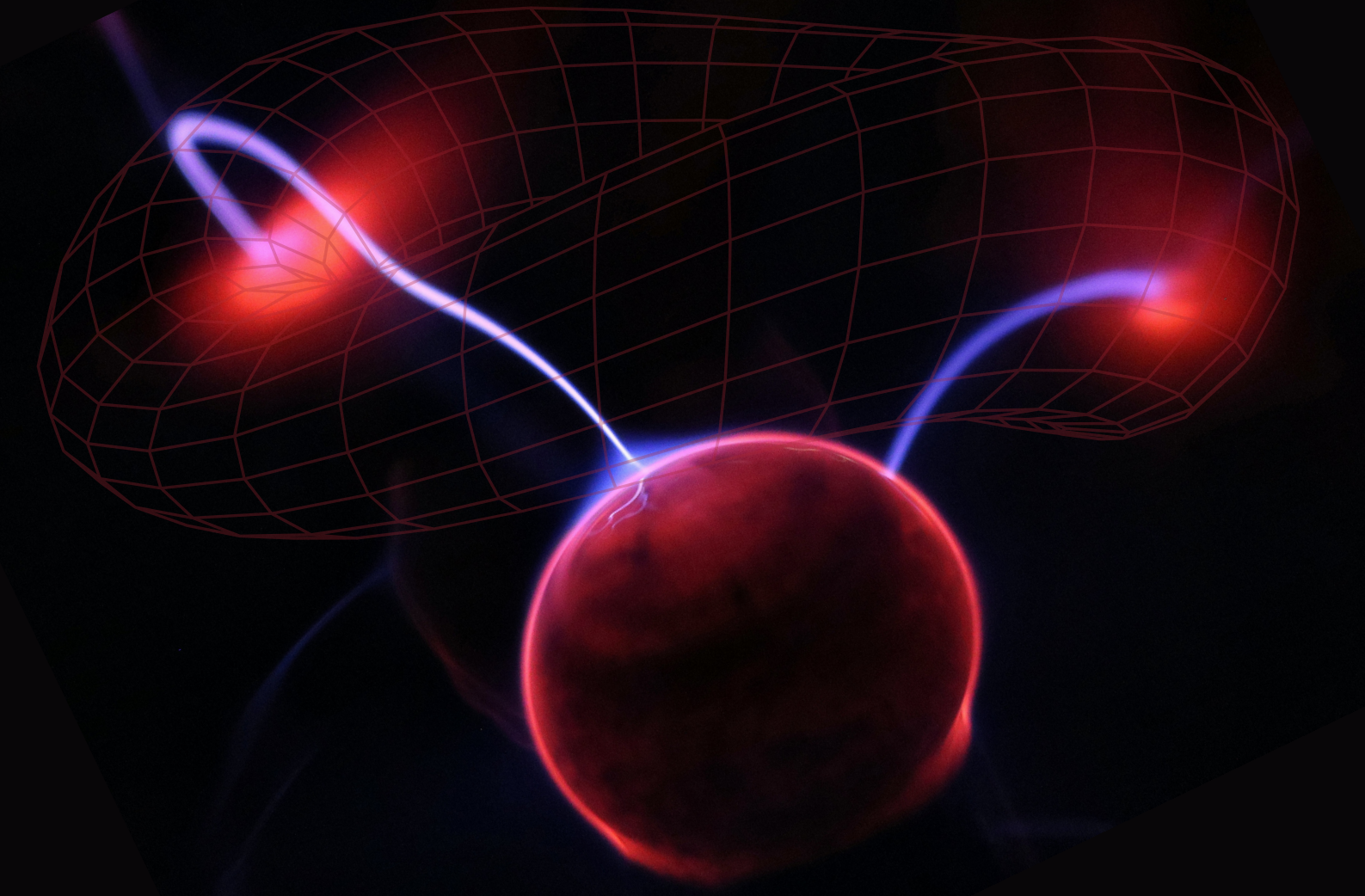
Quarter IV 2023 | Issue No. 3

Newsletter

PIEAS Society for Physics

ZENITH



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@pieassocietyforphysics @_pspofficial @psp-official

Director's Note

Welcome to another exciting issue of Zenith! Here, team publication PSP brings you every quarter a diverse range of fascinating insights, innovations, and inspiration from the captivating world of physics.

This issue features an illuminating interview with a Passionate Physicist and Professor Dr. Shahid Qamar, research project summaries from our talented students, and a Pinboard section packed with essential events, conferences and scholarships.

You'll also catch up on highlights of recent events of PIEAS and celebrate our institute's achievements.

And finally, what's a journey through physics without a few intriguing problems to ponder? Dive into our selection of captivating physics problems that challenge and stimulate the mind. Join us as we unravel the wonders of physics together!

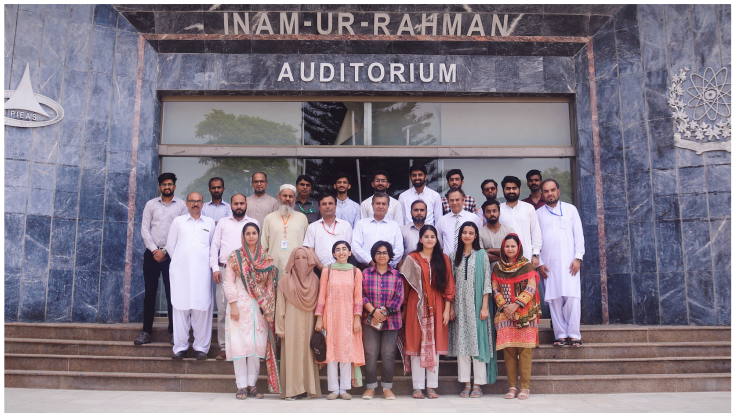
To conclude, I want to express my gratitude towards my seniors and the members of the Advisory Board, Muhammad Shuraim and Waddia Summan, for their unwavering guidance and assistance, which has brought this issue to fruition. Moreover, the trust bestowed upon us by our esteemed faculty advisors has been instrumental in the completion of this remarkable project.

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

Zahid Islam

Goodbye!

Farewell, our esteemed seniors (BS Physics 19-23). Your time at PIEAS has been a journey of growth and discovery. Remember, 'Education is not the filling of a pail, but the lighting of a fire.' Carry the flame of knowledge forward, and may your paths be illuminated with success. Best wishes for your bright futures!



Group Photo of Physics 19-23 with Faculty

Farewell Party of Physics 19-23

Inspiration

Dr. Shahid Qamar

Director CMS & Pro-Rector, PIEAS

What does it take to turn dreams into reality? For Dr. Shahid Qamar, the answer boils down to a single word — discipline. He is currently donning the hat of Pro-Rector at Pakistan Institute of Engineering and Applied Sciences (PIEAS) and director for the newly initiated, Center for Mathematical Sciences (CMS) at PIEAS. Starting his academic career at PIEAS, the then Center for Nuclear Studies, as a senior scientific officer in 1994, his efforts made the unknown word into the routine buzzword "quantum".

His true love for Physics starts off from his father, who played a crucial role in instilling in Dr Shahid Qamar a lifelong passion for physics. His father, who graduated from the University of Pittsburgh in the USA, used to send various science and fantasy books to his disciplined child, Dr Qamar. A few to mention are "Surely You're Joking, Mr. Feynman!" etc. This all led to the situation that Dr. Qamar vividly remembers, during his time at Gordon College, Rawalpindi, when his teacher inquired students about their future careers, and he stood out as the only individual with a definite response: Physicist. In his teenage years, he aspired to study at the International Centre for Theoretical Physics, Italy; however, destiny had different plans for him. Quaid-e-Azam University was where he ultimately obtained his MSc, MPhil, and PhD degrees. He did his MPhil research work and then doctoral studies under the supervision of globally acclaimed physicist, Prof. M. Suhail Zubairy. After completing his postdoctoral research at the Texas A&M University in the USA, he returned to Pakistan to serve— in his words— his own people.

Dr. Qamar stands as the founding director of the CMS, PIEAS. He envisioned the Center as an advanced computational mathematical modeling hub in Pakistan. *Per his expression: he extends a warm welcome to all, especially Pakistani researchers, scientists and students to CMS, as it houses one of the most sophisticated High-Performance Computing facilities in the country and caters to diverse research groups.* Moreover, Dr. Qamar feels proud about one initiative at PIEAS and that is National Science Talent Contest, STEM Career Program, for high school students. It attracts talented kids from all over the country and trains them to represent Pakistan at prestigious science contests, such as the International Physics Olympiad. Without any doubt, STEM Career Program has fostered a passion for science in the younger generation and plays an integral role in shaping the future of the scientific landscape and, by extension, the future of Pakistan.

Dr. Qamar is widely acknowledged for his expertise in quantum optics, quantum computing, and laser physics, and made significant contributions to the field through research work. Dr. Qamar has been teaching various undergraduate and graduate courses on quantum mechanics and quantum optics at PIEAS. During his lectures, I distinctly recall that the first thing he inquires about is the motivation behind the topic. I believe that fosters engagement and attentiveness among the students. He has also been a visiting scientist at the Max Planck Institute for Quantum Optics in Germany, Abdus Salam International Centre for Theoretical Physics, Hong Kong Baptist University. As an inspiring teacher, he is adored by all his students and received the Best University Teacher Award from the HEC in 2009. For his contributions to teaching and research, he was awarded the order of Tamgha-I-Imtiaz by the President of Pakistan in 2010 and the Dr. M. Raziuddin Siddiqi Prize in Physics by the Pakistan Academy of Sciences. Having an industry taste along with his academic, he established a laboratory dedicated to research in quantum cryptography, a project funded by the Higher Education Commission of Pakistan, at PIEAS.

Painting a panoramic perspective, being an associate member of The Abdus Salam International Centre for Theoretical Physics, Italy, Dr. Qamar has a highly positive outlook on the future of physics and mathematics in Pakistan and the world at large. He firmly believes that physicists must make a difference in their field, propelling it forward, and he is motivated by this purpose every day. He is a true embodiment of the adage that hard work, determination with a blend of discipline lead to great achievements.

Compiled by Muhammad Shuraim and Zahid Islam

Students Projects

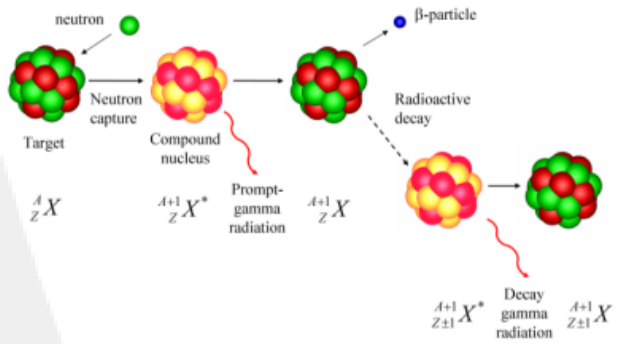
In our efforts to encourage the young audience to explore physics, we have decided to feature a few projects undertaken by our students at DPAM and to appreciate their efforts. Although we have numerous captivating projects in store to share with our readers, we regretfully cannot include them all in this newsletter due to space constraints and limited resources.

Measurement of Absolute Gamma Activity of Activated Samples

Ramsha Wasi Khan (BS Physics DPAM '23)

Supervised by: Dr. Muhammad Sohail (DNE, PIEAS)

Quantitative measurement of radiation activity is very important in many fields. It can be used to measure the strength of a radiation source, and its applications range from nuclear reactors to medical physics. Ramsha Wasi Khan, from the Department of Physics and Applied Mathematics (DPAM), under the supervision of Dr. Muhammad Sohail, took a step towards an accurate measurement of the absolute activity of gamma rays using the gamma-gamma coincidence method. This accurate measure of absolute activity can then be used to calculate the neutron source yield.



The main objective of Ramsha's work was to use the gamma-gamma coincidence method and understand how NaI (Tl) scintillators can be used to measure absolute gamma activity, with an understanding of errors in the accuracy of measurement. Her work majorly relied on the scintillator detectors. Scintillation is the production of light when the material undergoes excitation because of energetic particles. Excited atoms of the scintillator de-excite, producing photons in the visible range. The light created can be of varying intensity proportional to the energy deposited by the electron, which is reflective of the energy of the radiation. This light generated reaches the photomultiplier tube, where the signal is amplified and converted into an electronic signal.

Time coincidence technique is basically the concept of measuring two simultaneous pulses. The nucleus de-excites through a series of multiple gamma rays in cascade. These gamma rays are emitted within an interval of the order of femtoseconds to picoseconds. As the resolving time of coincidence circuits is comparatively larger, this small difference is taken negligible, and hence the two rays are considered simultaneous. Ramsha used two NaI (Tl) scintillators placed 180° to each other, and the source was placed in between them at an equal distance from both detectors. The detectors had in-built photomultiplier tubes and were provided with a high voltage of 6000 Volts. The gain of the system was set at 200. Different parameters were varied to understand their relationship with activity accuracy, including crystal size, detector-to-source distance, operating voltage, and resolving time. The accuracy of measurements was tested with the use of a known source of Co-60, and the most appropriate parameters were selected for measurement.

While the operating voltage has no considerable effect on the activity, crystal size was found to have a direct relationship with detector efficiency; hence, a larger crystal supports better counting statistics, producing more precise and accurate results.

The distance from the detector to the source was optimized for maximum accuracy. Larger distances increase the chances of absorption, scattering, and attenuation of the target gamma rays, while reducing the distance significantly can increase the chance of missing gamma rays in dead time or high pulse piling up. Specifically, for the NaI crystal of size 2" the optimal distance was found to be 14 cm, and for the crystal of size 5" the optimal distance was 16 cm.

The resolving time was also appropriately selected because there was a trade-off between minimizing accidental coincidences and maximizing count statistics. The optimal resolving time is found to be inversely proportional to the maximum activity to be measured.

Ramsha was able to reduce the error in absolute activity measurement from 33% to 16%. She also got a minimum error of approximately 3% calculated for the Co-60 sample of initial activity 18.2 μCi.

Compiled by Syed Abbas Ahmad

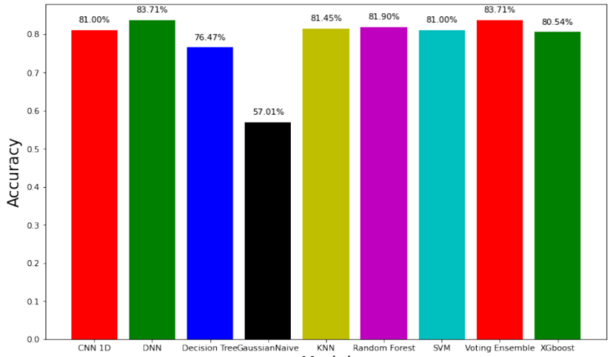
Phase Detection of High Entropy Alloys using Machine Learning Techniques

Talha Nazir Gill (BS Physics '23 , DPAM)
Supervised by Dr. Nadeem Shaukat (DPAM, PIEAS)

When five or more elements are combined in near-equal proportions, High Entropy Alloys (HEAs) are produced, forming various phases such as Solid Solution, Amorphous, Intermetallic, and a combination of Solid Solution and Intermetallic. Each phase exhibits distinct superior mechanical properties e.g. high strength, ductility, and corrosion resistance, and identifying these phases enables the anticipation of optimal material synthesis. For instance, solid solution is ideal for hardness. Instead of relying solely on experimentation, computational tools can be employed to predict these phases beforehand, facilitating informed decisions regarding their utility. In this study, Talha Nazir Gill aimed to develop a reliable and accurate machine and deep learning model for detecting the phases of HEAs based on their features, such as composition, atomic size, and electronegativity.

This work employed a dataset of 1118 HEAs with 15 features and known phases. Six supervised machine learning classifiers, namely Support Vector Machine (SVM), Random Forest, XGBOOST, K-Nearest Neighbors (KNN), Decision Tree, and Gaussian Naive Bayes (GNB), were applied to the dataset for phase prediction. In addition, two deep learning classifiers, 1D Convolutional Neural Networks (CNN 1D) and Deep Neural Networks (DNN)*, were also used to enhance the accuracy of the prediction. Furthermore, a voting ensemble classifier was constructed by combining all the classifiers used in the study. This ensemble method aimed to improve the overall performance and robustness of the model.

Talha's work evaluated the model performance using various metrics, such as confusion matrices, ROC curves, and classification report elements, including precision, recall, F1-score, overall accuracy, weighted average, and macro average. These metrics provided a comprehensive assessment of the models' ability to correctly classify the data points into their respective phases. The study revealed the varying accuracies of different machine learning and deep learning models in predicting phases. Among the machine learning models, the Gaussian Naïve Bayes algorithm achieved the lowest accuracy of 57.01%, while the Decision Tree followed with 76.47%. The SVM and CNN 1D models performed similarly well, both achieving an accuracy of 80.99%. The XGBOOST algorithm scored 80.54%, while the KNN model showed slightly better performance with an accuracy of 81.44%. Remarkably, the Random Forest model surpassed all machine learning models with an accuracy of 81.90%.



Model accuracy comparison

However, it was the deep learning models that exhibited the highest accuracies. The DNN model emerged as the best performer with an impressive accuracy of 83.71%, demonstrating the power of deep learning in capturing complex patterns and relationships within the high entropy alloy dataset. The study's findings contribute significantly to the field by offering a powerful tool for analyzing and processing large datasets, discovering patterns, and making predictions based on data. The application of machine learning and deep learning techniques, especially the success of the DNN model, highlights the potential of these methods in predicting the mechanical properties of HEAs.

In the future, Talha aims to explore different feature selection methods and data augmentation techniques to enhance predictive capabilities. The successful application of deep learning models indicates the potential for predicting various properties of HEAs in future research. The results of this study pave the way for the development of efficient and cost-effective methods for designing and manufacturing HEAs, with potential applications in the aerospace, automotive, and energy sectors. This work has led to a publication in *Materials Today Communications*.

** Deep Neural Network, in simple terms, is a computer system inspired by the working of human brain. It consists of interconnected nodes, or artificial neurons, organized into layers. Information is processed through these layers to learn patterns and relationships within data. Each connection between nodes has a weight that adjusts during training, allowing the network to make predictions or classifications based on input data. The term "deep" emphasizes the depth of the multiple layers within these networks, as they can handle complex tasks and learn intricate features from the input data. Deep neural networks are commonly used in machine learning for tasks such as image and speech recognition, natural language processing, and more.*

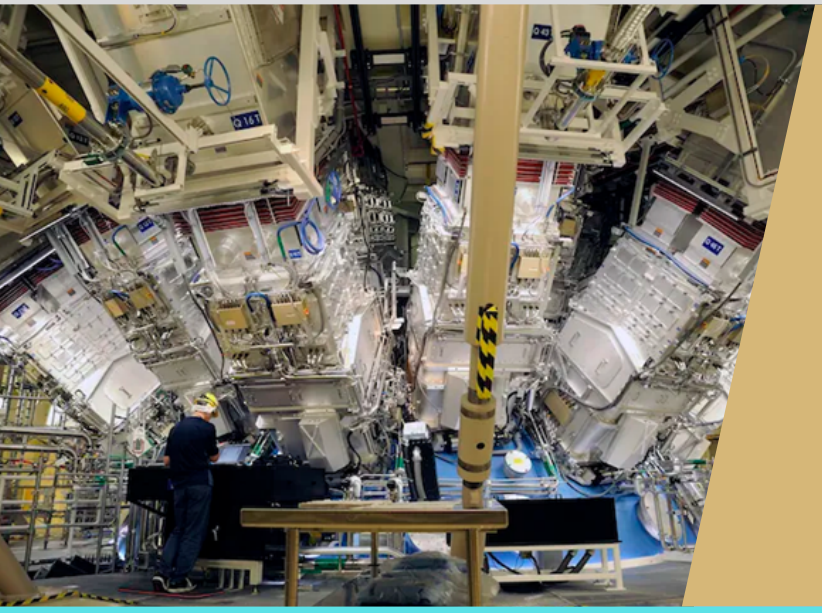
Compiled by Abdul Rehman Shinwari.

Physics Bulletin

The Nobel Prize in Physics 2023

The Nobel Prize in Physics 2023 was awarded to Pierre Agostini, Ferenc Krausz and Anne L'Huillier "for experimental methods that generate attosecond pulses of light for the study of electron dynamics in matter". The three Nobel Laureates in Physics 2023 are being recognised for their experiments, which have given humanity new tools for exploring the world of electrons inside atoms and molecules. There are potential applications in many diferent areas. In electronics, for example, it is important to understand and control how electrons behave in a material. Attosecond pulses can also be used to identify different molecules, such as in medical diagnostics.

Source: Nobel Prize



Nuclear-fusion breakthrough

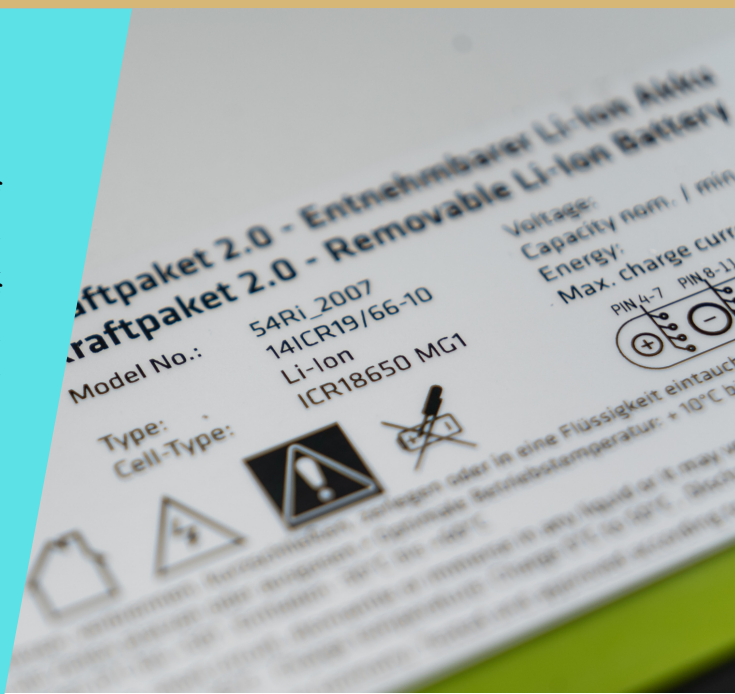
A team of scientists at the US National Ignition Facility (NIF) in California announced they had, for the first time ever, created a fusion reaction with a net energy gain — a phenomenon known as ignition. Using 192 giant lasers, the team delivered 2.05 megajoules to their target, which subsequently released 3.15 megajoules of energy output. The reaction has been replicated many times since its first discovery in December 2022. Experts say this could pave the way to a future with near-limitless clean energy.

Source: Nature

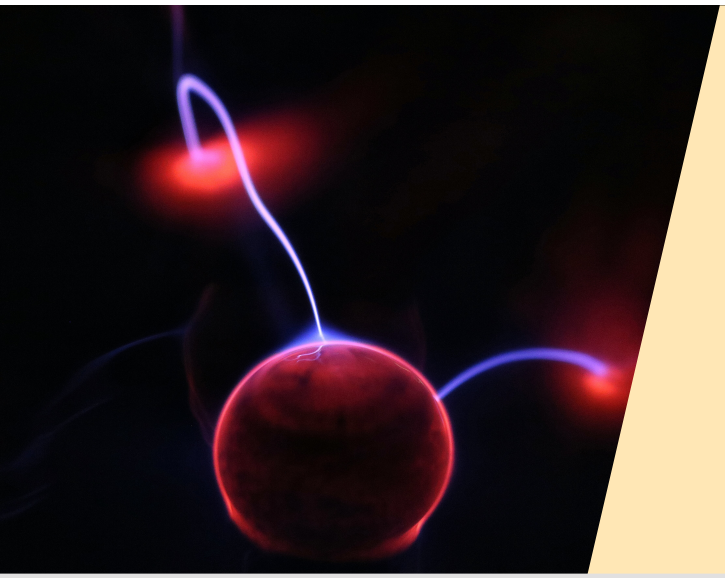
Lithium-ion batteries break energy density record

A team of researchers led by Xiqian Yu and Hong Li of the Institute of Physics have succeeded in manufacturing rechargeable pouch-type lithium batteries which boasts a gravimetric energy density of 711.3 Wh/kg. Currently, it is the highest in rechargeable lithium batteries based on an intercalation-type cathode and has set a new record. These devices can be used to power long-range electric vehicles and electric aviation, both of which require high battery energy density.

Source: Physicsworld



Physics Bulletin



Entanglement and Classical mechanics related by a link

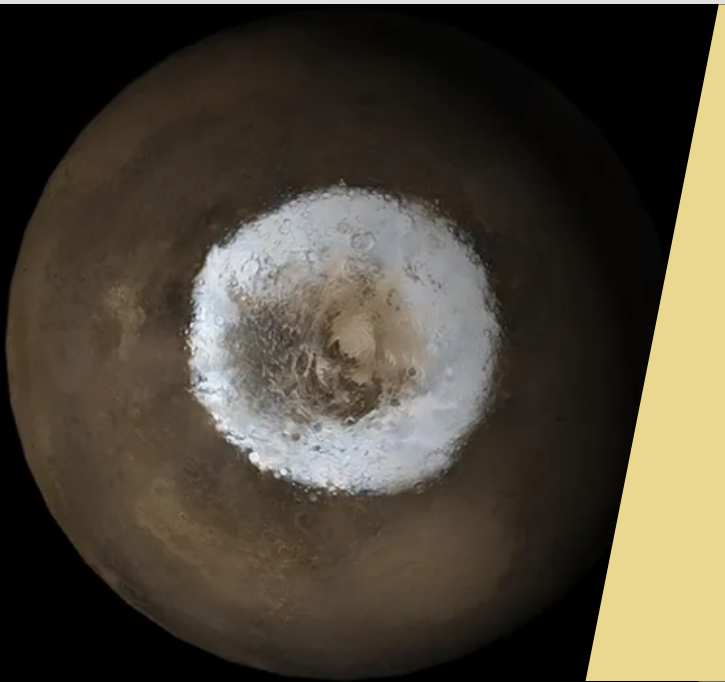
Physicists at Stevens Institute of Technology have discovered a link between the wave properties of light and the mechanical properties of point masses, bridging the gap between classical mechanics and optics. They found that polarization and entanglement properties of light are quantitatively related to the center of mass and moment of inertia of rigid bodies through the Huygens-Steiner theorem. This finding could potentially help simulate the behavior of light wave entanglement using mechanical masses.

Source: Physicsworld

Reionization of early universe by galaxies discovered

Using the James Webb Space Telescope (JWST), astronomers have found evidence that early galaxies contributed to the reionization of the early universe. Reionization is the process by which neutral hydrogen atoms are ionized, making the universe transparent to certain wavelengths of light. The research was conducted by the EIGER collaboration, which used the JWST's Near Infrared Camera to study light from quasars in the early universe. The team discovered a correlation between the locations of ancient galaxies and patches of reionized gas, suggesting that something within these galaxies, possibly young stars, ionized the surrounding space.

Source: Physicsworld



Mars' Rotation is speeding up each year

Scientists have found that Mars is rotating slightly faster with each passing year, causing the length of a Martian day to shorten by fractions of a millisecond annually. This discovery was made using data from NASA's InSight mission, which measured the planet's spin by bouncing radio waves into space and analyzing their return time. The cause of the acceleration is still uncertain, but researchers suggest it could be due to ice accumulation at the poles or post-glacial rebound. Additionally, the study revealed that Mars's core is not uniform and has regions of varying density, which could contribute to the accelerated spin.

Source: Live Science

PIEAS ACHIEVEMENTS

Pakistan Institute of Engineering and Applied Sciences (PIEAS) has been re-designated as International Atomic Energy Agency (IAEA) Collaborating Centre for the second term of four years. In this momentous occasion, Chairman of the Pakistan Atomic Energy Commission (PAEC), Dr. Raja Ali Raza Anwar, graced the premises of PIEAS to preside over the ceremony marking the re-designation of the IAEA Collaborating Center PIEAS. Chairman PAEC officially handed over the Re-designation Plaque to Dr. Naseem Irfan, Rector PIEAS, and as a symbol of this significant milestone, also unveiled a commemorative plate in the Department of Nuclear Engineering at PIEAS. As an IAEA Collaborating Centre, PIEAS will support the IAEA's programmatic activities by implementing an agreed work plan.

Two faculty members of PIEAS, Dr. Rehan Ahmad faculty member of Department of Electrical Engineering and Dr. Faisal Shehzad faculty member Department of Metallurgy and Materials Engineering, have been named top 2% scientists of the world in the list published by Stanford University. PSP on the behalf of Department of Physics and Applied Mathematics (DPAM) would like to extend its heartfelt congratulations to both professors for their remarkable achievements, as their dedication and hard work have brought great honor to our institution.

EVENTS

In keeping up with the World Space Week 2023, PSP organized an outreach event in collaboration with Dr. Shoaib Ahmed (former Member Science at PAEC) and the PAEC Model College for Girls (Nilore), The exciting event attracted students all the way from high school to kindergarten. With the help of school's science faculty, PSP student volunteers organized numerous hands-on activities and interesting talks, from measuring Earth, making rockets, to star formation and expansion of Universe. Dr Ahmad's telescope session was a huge hit which attracted hundreds of students of all ages.

Center for Mathematical Sciences hosted two captivating talks that delved into the realm of Artificial Intelligence (AI). On November 29th, Dr. Ahmad Ahsan Nawaz delivered a thought-provoking lecture titled "AI at the Heart of Healthcare Transformation." This enlightening session discussed the potential of AI in revolutionizing the field of medicine. Founder PIEAS, Dr. Inam-ur-Rehman presence brought significance to the occasion. Then on December 20th, Dr. Asifullah Khan took the stage to explore the introduction of ChatGPT and its growing popularity in his talk titled "Unlocking the AI Revolution: Exploring the Ascendance of ChatGPT and Its Popularity." His discussion shed light on fascinating world of AI-powered chatbots and their transformative role in various industries. The talk was also attended by three Chinese professors on the visit to PIEAS. Both sessions attracted significant attention from a diverse audience.

Pinboard

ICRAC 24

The Department of Mathematics at CUI, Lahore Campus is organizing an International Conference on Relativistic Astrophysics and Cosmology (ICRAC-2024). This conference aims to bring together researchers, scientists, and scholars to discuss and exchange ideas on Gravitation, Astrophysics, and Cosmology. The two-day event will attract key players in these fields from around the world and provide a platform for sharing and exploring knowledge.

Date: 1-2 February

STEM Career Program

STEM Careers Program is a joint venture of HEC and PIEAS to inspire the potential youth of the nation to pursue careers in STEM. Besides, STEM teams also represent Pakistan in International Science Olympiads (ISOs) in Biology, Chemistry, Mathematics, and Physics organized worldwide, exhibiting the country's natural talent in these competitions.

Deadline: 18 February 2024

Inertia 24

The grand annual event dedicated to introducing the PIEAS Society for Physics (PSP). This event aims to showcase our objectives, activities, and provide you with an opportunity to become a part of our community. Get ready to immerse yourself in fascinating talks and engage in stimulating conversations with like-minded peers,. Join us for an unforgettable evening of knowledge, camaraderie, and endless possibilities!

Date: 21 February (tentative)

Fullbright Scholarship

The Fulbright Student Program enables graduate students from abroad to study & conduct research in the US. Fulbright encourages applications from all fields. The Fulbright Foreign Student Program operates in more than 160 countries worldwide. Approximately 4,000 foreign students receive Fulbright scholarships each year.

Deadline: February 28, 2024

International School on Physics & Allied Disciplines 2024

The National Centre for Physics (NCP) and International Centre for Theoretical Physics (ICTP), are jointly organizing the International School on Physics & Allied Disciplines (ISPAD) in Islamabad. The purpose of ISPAD is to provide a platform to participants to exchange scientific knowledge and to generate enthusiasm for science and innovation.

Duration: 04 - 08 March, 2024

School of Physics and Mathematics Without Frontiers

The aim of this project by ICTP is to inspire and engage students' on different subjects in theoretical physics and mathematics. The school is an interdisciplinary activity: it includes lectures in theoretical physics and mathematics and it consists of interactive lectures centered around exercises. Our ultimate goal is to help the students to engage with the material in a more active and inspiring way.

Date: 11 - 23 March

CERN Technical Student Programme

At CERN physicists and engineers are probing the fundamental structure of the universe. For student looking to complete practical training in domains related to Applied Physics, CERN brings this opportunity to work at the cutting edge of technology, contribute and broaden knowledge in disciplines like detector physics, analysis and simulation, radiation studies, optics, lasers, cryogenics and many more.

Deadline: 11 March 2024

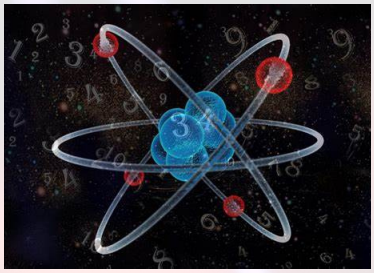
Joint ICTP-IAEA School

This joint IAEA-ICTP School on Data for Modelling Atomic and Molecular Processes in Plasmas is a 5-day series of lectures and computing practical exercises to help early-career plasma physicists develop an understanding of the techniques used to model and simulate the radiative and collisional properties of plasmas at the atomic level.

Date: 18 - 22 March

Physics Problems

> What is the physical meaning and significance of magic numbers of nucleons?



> If we were to exist in a 2D world, how would perception of the depth and objects differ from our experience in our 3D reailty?

> What will happen when double slit experiment is performed with electron rather than light?

> Will two mirrors facing each other produce infinite relfections?

Answer to Physics Problems in Zenith (Aug-Sep 2022)

1. The discovery that the expansion of the universe is accelerating came from observations of several dozens supernovae in the late 1990s. The 2011 Nobel laureates by comparing the brightness of distant, far-away supernovae with the brightness of nearby supernovae discovered that the far-away supernovae were about 25 percent too faint. For almost a century, the Universe has been known to be expanding but this discovery proved that it is also accelerating.
Link 1 | Link 2

2. The important contributions by John Hall and Theodor Hänsch (winners of 2005 Physics Nobel Prize) have made it possible to measure frequencies with an accuracy of fifteen digits. Lasers with extremely sharp colours can now be constructed and with the frequency comb technique precise readings can be made of light of all colours. This technique makes it possible to carry out studies of, for example, the stability of the constants of nature over time and to develop extremely accurate clocks and improved GPS technology.
Link 1

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