www.indapt.org.in

Scan to Read IAPT Bulletin online

ISSN 2277-8950

International Year of Quantum Science and Technology

Bulletin of THE INDIAN ASSOCIATION OF PHYSICS TEACHERS

A MONTHLY JOURNAL OF EDUCATION IN PHYSICS & RELATED AREAS

VOLUME 17 | NUMBER 8 | AUGUST 2025

In this photo released on April 14, 2025, NASA's James Webb Space Telescope revealed the gas and dust ejected by a dying star at the heart of NGC 1514. Using mid-infrared data showed the "fuzzy" clumps arranged in tangled patterns, and a network of clearer holes close to the central stars shows where faster material punched through. This scene has been forming for at least 4,000 years — and will continue to change over many more millennia. At the center are two stars that appear as one in Webb's observation, and are set off with brilliant diffraction spikes. The stars follow a tight, elongated nine-year orbit and are draped in an arc of dust represented in orange.

One of these stars, which used to be several times more massive than our Sun, took the lead role in producing this scene. "As it evolved, it puffed up, throwing off layers of gas and dust in in a very slow, dense stellar wind," said David Jones, a senior scientist at the Institute of Astrophysics on the Canary Islands, who proved there is a binary star system at the center in 2017.

Link: https://www.nasa.gov/image-article/fuzzy-rings-of-a-dying-star

Bulletin of The Indian Association of Physics Teachers

http://www.indapt.org.in

The Bulletin is the official organ of the IAPT. It is a monthly journal devoted to upgrading physics education at all levels through dissemination of didactical information of physics and related areas. Further, the Bulletin also highlights information about the activities of IAPT. All communications should be addressed to:

Chief Editor (IAPT Bulletin), Dept. of Physics, P.U., Chandigarh – 160 014

Email: iapt@pu.ac.in

Editorial

Physics Education Eco-System in IAPT

This year I had the opportunity to participate in some very interesting events in both offline and online modes, three of which I would like to highlight: these are

1. Science Education Eco System (SEE) Conference organised jointly by Homi Bhabha Centre Science Education and TIFR where brainstorming sessions and lectures were held to identify what needs to be done to improve the quality of science education, IAPT was one of the important participants as a stakeholder and put forward its view point in changed which are needed for teaching, learning and research in Physics which is learner centric with a proactive role by physics educators both in and outside the scope of curriculum.
2. I attended an annual workshop specially organised for Undergraduate and Postgraduate students by IAPT in collaboration with S.N. Bose National Centre for Basic Sciences, Kolkata dedicated to the memory of one of the eminent condensed matter Physicist of the country Prof. CK Majumdar. This is a unique event in which students are given an exposure in frontier areas of Physics by eminent Physicists from this national center and members of RC 15 Kolkata. This workshop offers an Unique opportunity to the participants to interact with researchers in offline mode. Visits to the research laboratories is an important part of this workshop. It was a satisfying experience to be there and interact with the participants, resource persons and team RC 15 West Bengal. This programme is what makes IAPT work with commitment and dedication of its members sticking with an idea worth pursuing.
3. Initiation of capacity building workshops by IAPT, first workshop of this year was a two week online workshop on Design of Cognitively Aligned Question Items by a set of eminent resource persons from among the IAPT members. This workshop also aligns with the needs of National Standard Examinations conducted for selecting the teams for participation in international Olympiads in Physics, Chemistry, Biology, Astronomy and Junior Science. This also builds capacity among the teachers in creating assessments and generates a resource pool of trained question items designers. The workshop was open to teachers from schools, colleges and universities. Forty eight participants attended this workshop. It was organised through an initiative of one of the Zonal Vice Presidents of IAPT with a dedicated team to brainstorm the content of the workshop.

In one of the initiatives for the first time by IAPT, we have opened up opportunities for international collaborations. IAPT signed a memorandum of Understanding with GIREP, a group of physics educators and researchers working in Europe for collaborative programs. It was signed on 1st July 2025 by President GIREP, Eilish McLoughlin and President IAPT through an online meeting. We hope to have positive collaborative outcomes for the benefit of physics education. Prof. Rekha Ghorpade and I attended this meeting of the Co-operative Bodies organized as part of GIREP Conference 2025 in Lieden.

In IAPT'S calendar of the year conventions, conferences and symposia play very important role of engagement with the stake holders. This year besides these IAPT events, we have an important international event lined up: International Conference of Physics Education 2025, supported by C14 Commission on Physics Education co-hosted by Indian Institute of Technology, Ropar, Indian Institute of Science Education and Research, Mohali and Indian Association of Physics Teachers. Organisers are working hard to give a very rich experience to the participants of the conference through a bouquet of events in the conference which include plenary lectures, invited talks, workshops, panel discussions, oral presentations, poster presentations and workshop presentations. I believe this is an important opportunity for the physics and science community in the country for an international exposure and can help add lot of value in implementing National Education Policy particularly in STEM.

For ICPE, we have the advantage of three leading mentors from IUPAP: Prof Manjula Sharma, Chair C 14 Commission, Prof. Arun Grover Member C14 Commission and President Designate Prof. Sunil Gupta. Prof. Rajeev Ahuja Director IIT Ropar and Prof. A K Tripathi Director IISER Mohali, are the Patrons of the conference. They have brought great insights to make this international conference a memorable learning experience. Prof. Pushpender Singh, IIT Ropar and Prof. Arvind from IISER Mohali are Joint Chairs for the meeting. IIT Ropar is situated in an area of great archeological importance corresponding to Indus Valley Civilization. It has world class state of the art infrastructure. Both IISER and IIT Ropar are leading research institutions of the country and have carved out a name for themselves.

Our two flagship programs are being organised at two beautiful cities. Annual convention 2025 is being organised in Goa in collaboration with Physics Department Goa University and National Student Symposium in Physics is lined up at Physics Department Chandigarh. RC Goa and RC Chandigarh teams have given calls for these two events. Good luck to them. Chalo Goa, Chalo Chandigarh, Chalo Ropar (Part of Chandigarh, Mohali, Panchkula tri City).

This time one of the very different event is making Buzz around the country which a Physics Road Show, namely IAPT Anveshika Physics Bharat Yatra. It started in the month of May and is going to visit schools, colleges and Universities through lectures, stage shows and hands on minds in experiences for students in variety of ways. The best to notice in this Yatra is emergence of talented physics communicators who are making waves on the way. Participation is very inclusive with all regional Councils coming forward to conduct this huge outreach initiative of National Anveshika Network of IAPT.

Recently, Prime Minister on 27th August 2025 in his monthly radio broadcast underlined the success Indian teams in International Olympiads, IAPT thanks honorable Prime Minister for congratulating the medalists and the team of mentors. Behind this success story is a long outstanding collaborative effort of IAPT with TIFR-HBCSE starting with conduct of National Standard Examinations in the subjects of Physics, Chemistry, Biology, Astronomy and Junior Science followed by orientation and selection camps. At every step IAPT members work as a team to script the success stories. In 2024, in Junior Science Olympiad, Indian team was the country winner. This is the commitment of IAPT in contributing significantly to science education eco system in the country. Participation of IAPT members in Olympiad programs has made sure that students from the remotest corners of the country are able to avail this opportunity.

In the last two years two new research based competitions have been initiated one for high school students namely Indian National Young Physicists Tournament (INYPT) and other for UG and PG students namely Indian Physicists Tournament. The format of these program is based on International Young Physicists Tournament and International Physicists Tournament. These programs have all the elements of research oriented approach to solve open ended problems declared an year in advance to work as research projects. We hope this set of tournaments will help Indian participation in the international Events.

From the 2024, IAPT has taken over the full responsibility of publishing the IAPT Journal of Physics Education and soon it will appear as open journal system. Physics Community in the country was sorely missing this only research journal for Physics Education. Thankfully, this Journal has been provided financial support from Board of Research in Nuclear Sciences, Department of Atomic Energy which is gratefully acknowledged on behalf of the entire community. Chief Editor Prof. OSKS Sastri and team of executive editors are working hard on generating the issues corresponding to the gap period by processing the submitted articles. Effort is also being made for digitizing past print issues and made available in the online archives.

Indian Association of Physics Teachers Bulletin has a new team of editors and the content of the bulletin has seen started seeing a renewed interest in its content, attracting quality content. For the last forty two years it has come out without break showing the resilience of IAPT as a committed organization to its vision and Mission. Every month IAPT Bulletin has been reaching about 4000 members of the IAPT in e-format besides its print version.

This editorial conveys heartfelt gratitude to all the stake holders for creating this robust eco system. In the last 42 years IAPT has built upon the dedicated work and commitment of its passionate members, who were not deterred by lack of facilities, they laid the path as they moved for us to appreciate and inspire us to work for this great eco-system.

Cooperation with GIREP

Indian Association of Physics Teachers (IAPT) and the Group International de Recherche sur l'Enseignement de la Physique (GIREP) agree to cooperate to promote physics education and physics education research. In particular, IAPT and GIREP will exchange information through websites and newsletters and send informational posters about each organization's conferences to each other.

Signed by

P K Ahluwalia, President of IAPT

Date: 01/07/2025

Eilish McLoughlin, President of GIREP

Date: 01/07/2025

Keep visiting the IAPT official website www.indapt.org.in for more updated information and a peep at photo galleries posted there of each event. We solicit your feedback on all the activities which we do. New innovative ideas are most welcome. Keep contributing Keep enjoying.

P K Ahluwalia
President IAPT

Physics News

Simulating the Hawking effect and other quantum field theory predictions with polariton fluids

Quantum field theory (QFT) is a physics framework that describes how particles and forces behave based on principles rooted in quantum mechanics and Albert Einstein's special relativity theory. This framework predicts the emergence of various remarkable effects in curved spacetimes, including Hawking radiation. Researchers at Sorbonne University recently identified a new promising experimental platform for simulating QFT and testing its predictions. The researchers found that they were able to precisely manipulate the polariton fluid they created to produce different horizon geometries. This is a remarkable and unprecedented achievement, which allows theoretical physicists to test QFT predictions with different horizon configurations. Measuring entanglement generation by the Hawking effect is a major goal for their future research. In the future, they would also like to create rotating black hole geometries to see how entanglement between the Hawking pairs behaves when other amplification phenomena occur as well.

Read more at: https://phys.org/news/2025-07-simulating-hawking-effect-quantum-field.html

Original Paper: Physical Review Letters (2025). DOI: 10.1103/t5dh-rx6w

Famous double-slit experiment holds up when stripped to its quantum essentials

MIT physicists have performed an idealized version of one of the most famous experiments in quantum physics. Their findings demonstrate, with atomic-level precision, the dual yet evasive nature of light. They also happen to confirm that Albert Einstein was wrong about this particular quantum scenario. Ketterle's group at MIT experiments with atoms and molecules that they super-cool to temperatures just above absolute zero and arrange in configurations that they confine with laser light. The group reasoned that with this arrangement, they might shine a weak beam of light through the atoms and observe how a single photon scatters off two adjacent atoms, as a wave or a particle. This would be similar to how, in the original double-slit experiment, light passes through two slits. From the intensity of the detected light, the researchers could directly infer whether the light behaved as a particle or a wave. Working at the level of single photons required repeating the experiment many times and using an ultrasensitive detector to record the pattern of light scattered off the atoms. From the intensity of the detected light, the researchers could directly infer whether the light behaved as a particle or a wave.

Read more at: https://phys.org/news/2025-07-famous-quantum-essentials.html

Provided By: Physical Review Letters (2025). DOI: 10.1103/zwhd-1k2t

Physicists show tensor mesons play important role in light-on-light scattering

Usually, light waves can pass through each other without any resistance. According to the laws of electrodynamics, two light beams can exist in the same place without influencing each other; they simply overlap. Nevertheless, quantum physics predicts the effect of "light-on-light scattering." It has been observed at the CERN particle accelerator. Virtual particles can literally emerge from nothing for a short time, interact with the photons and change their direction. A team at TU Wien has now been able to show the contribution of so-called tensor mesons. When photons interact with photons, virtual particles can be created. They cannot be measured directly, as they disappear immediately. Tensor mesons did appear in earlier calculations, but with very rough simplifications. In the new evaluation has a different sign than previously thought, thus influencing the results in the opposite direction. These analyses are important for one of the biggest questions in physics: How reliable is the Standard Model of particle physics?

Read more at: https://phys.org/news/2025-07-physicists-tensor-mesons-play-important.html

Original paper: Physical Review Letters (2025). DOI: 10.1103/dxwr-gps

Soumya Sarkar
IISER PUNE

August: The Month in the History of Physics

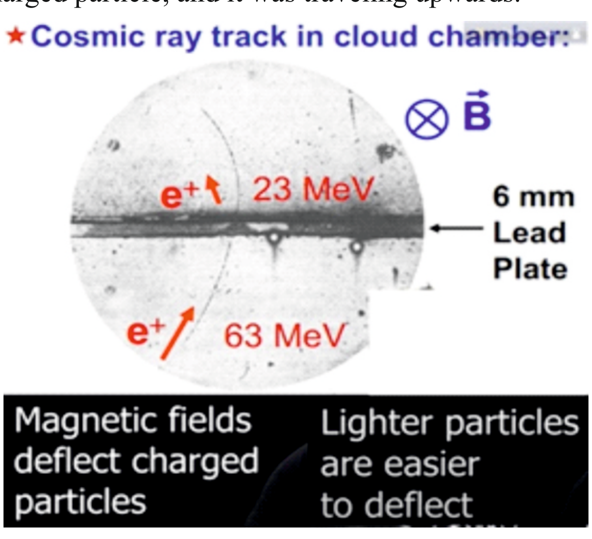
August 02, 1932 : Discovery of the Positron by Carl David Anderson

In 1928, British physicist Paul Dirac theoretically showed that Einstein's theory of relativity implied that every particle in the universe has a corresponding antiparticle, each with the same mass as its twin, but with the opposite electrical charge.

The hunt was on for the experimental verification of this hypothesis; a Caltech postdoc named Carl D. Anderson would win the race.

Anderson built his own, improved version of a cloud chamber, incorporating a piston so that he could get the pressure to drop very rapidly. He also used a mixture of water and alcohol in the chamber. And he obtained much better photographs than his colleagues. The resulting photographs revealed that cosmic rays produced showers of both positively and negatively charged particles, and the positive charges could not be protons (the only known positively charged particle known at that time), as one might expect, because the track radius would specify a proton stopping distance much shorter than the length of the observed track.

In August 1932, Anderson recorded the historic photograph of a positively charged electron (now known as a positron) passing through a lead plate in the cloud chamber. It was definitely a positively charged particle, and it was traveling upwards.



His discovery gave Anderson a Nobel Prize in Physics in 1936, at the age of 31—one of the youngest persons to be so honoured.

August 1948: Maria Goeppert Mayer and the Nuclear Shell Model

Maria Goeppert Mayer, who made important discoveries about nuclear structure, is one of only two women to have won the Nobel Prize in physics in the entire twentieth century. In August 1948, Goeppert Mayer published her first paper detailing the evidence for the nuclear shell model, which accounts for many properties of atomic nuclei – particularly stability of certain nuclei.

In 1946, Mayer started working at Argonne National Laboratory with Edward Teller (regarded as 'father of Hydrogen Bomb') on a project to determine the origin of the elements. The work involved creating a list of isotope abundances. While making this list, it became clear to Goeppert Mayer that nuclei with so-called “magic numbers,” 2, 8, 20, 28, 50, 82, or 126 protons or neutrons were especially stable. This observation led her to suggest a shell structure for nuclei, analogous to electron shell structure in atoms.

It so happened that Hans Jensen and Goeppert Mayer ended up publishing very similar results in successive issues of Physical Review in June 1949. They shared the Nobel Prize in 1963 for their work on the shell model along with Eugene Wigner, for an unrelated work.

August 10, 1915: Henry G.J. Moseley Killed in Action in the war field

The month of August is not only recorded the breakthroughs in physics but a great loss both for n physics and chemistry was observed during the month in 1915. Science students everywhere are familiar with the modern periodic table, which organizes the chemical elements based on their properties and atomic numbers. In the earliest significant version, Dmitri Mendeleev provided a better framework in

1869 with his precursor to our modern periodic table of elements, organizing them according to the sequence of atomic masses.

With discovery of the existence of chemical isotopes, it was realized that atomic weight was not the optimal criterion for ordering the periodic table. A young British physicist named Henry Moseley provided a more scientifically rigorous classification scheme. Around 1910, Moseley combined recently introduced x-ray spectrometry with Bragg's law of diffraction to measure the various x-ray spectra associated with specific elements. In the process, he arrived at an empirical mathematical relationship between frequencies of well-defined lines in an element's x-ray spectrum and its atomic number. Today we know this as Moseley's law.

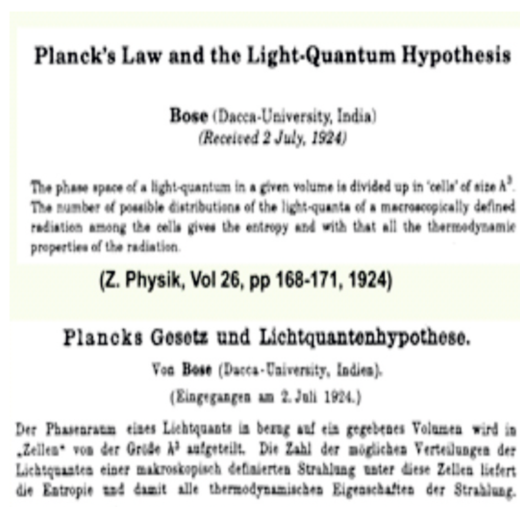
H.G.J. Moseley

In 1914 Moseley, instead of shifting from Rutherford's Manchester laboratory to Oxford to pursue his physics research, decided to enlist himself in the Royal Engineers of the British Army, serving as a technical officer of communications during World War I. On August 10, 1915, Moseley was sending a military order when a sniper's bullet caught him in the head and killed him. He was only 27. Given all that he had accomplished at such a young age, Isaac Asimov noted that Moseley's death “might well have been the costliest single death of the War to mankind generally.” Indeed, because of it, the British government established a new policy barring the country's most prominent scientists from engaging in active combat duty. Now we know that Moseley was nominated for the Nobel Prize for both physics and chemistry in the year 1915.

August 1924: Paper by Satyendra Nath Bose on light quantum hypothesis

The famous path breaking paper of S N Bose on 'Planck's law and light quantum hypothesis,' recommended by Einstein, was published in the August 1924 issue of Z. Phys (Zeitschrift fur Physik). Seeing the significant content of the paper, Einstein took immediate action in response to a hand-written letter sent by Prof Bose. He translated the paper in German and arranged for its quick publication in Z. Phys. The paper led to the emergence of Bose-Einstein statistics, the first quantum statistics to describe the behaviour of subatomic particles.

References



Planck's Law and the Light-Quantum Hypothesis

Bose (Dacca-University, India)
(Received 2 July, 1924)

The phase space of a light-quantum in a given volume is divided up in 'cells' of size h^3. The number of possible distributions of the light-quanta of a macroscopically defined radiation among the cells gives the entropy and with that all the thermodynamic properties of the radiation.

(Z. Physik, Vol 26, pp 168-171, 1924)

Plancks Gesetz und Lichtquantenhypothese.

Von **Bose** (Dacca-University, Indien).
(Eingegangen am 2. Juli 1924.)

Der Phasenraum eines Lichtquants in bezug auf ein gegebenes Volumen wird in „Zellen" von der Größe h^3 aufgeteilt. Die Zahl der möglichen Verteilungen der Lichtquanten einer makroskopisch definierten Strahlung unter diese Zellen liefert die Entropie und damit alle thermodynamischen Eigenschaften der Strahlung.

1. Different entries from the APS journals https://www.aps.org

Achintya Pal

A Quantury of Quirks

From Haas and Hilbert to Horodecki and Hyperentanglement

Dr. Mrittunjoy Guha Majumdar

National Institute of Advanced Studies, Bengaluru; Amrita Vishwa Vidyapeetham, Delhi NCR

Abstract: The transition from classical deterministic physics to quantum mechanics represents one of the most profound conceptual revolutions in the history of science. This article traces the intellectual trajectory from early 20th-century proto-quantum theories through contemporary developments in hyperentanglement and quantum machine learning. We examine the epistemological shift from visualizable mechanical models to abstract operator formalism, highlighting key theoretical milestones and their experimental validation. The analysis encompasses the evolution from Haas's early quantization attempts to modern implementations of quantum walks with hyperentangled states, demonstrating how foundational quantum principles continue to drive technological innovation in the quantum information era.

The early decades of the twentieth century saw physics undergo a metamorphosis more radical than anything science had witnessed before. What started as a routine effort to patch a few cracks in classical physics turned into a full- blown revolution—one that redefined our understanding of matter, energy, and even reality itself. The confident worldview of the Victorian era, where Newton's laws ruled the heavens and Maxwell's equations tamed electricity and magnetism, began to wobble under the weight of strange experimental results. In 1894, Albert A. Michelson famously declared that all that remained in physics was to refine the decimals—believing the great discoveries had already been made. Little did he know that the ground was about to shift beneath the feet of science.

This quantum revolution didn't explode onto the scene overnight. It crept in quietly, anomaly by anomaly, until the old guard could no longer ignore it. What followed was a dramatic intellectual transformation, unfolding in stages: the proto-quantum era (1900–1913), filled with bold guesses and hesitant hypotheses; the old quantum theory (1913– 1925), where semi-classical models tried to keep up with bizarre new findings; the burst of modern quantum mechanics (1925–1930), which rewrote the rulebook entirely; and finally, the contemporary quantum age we now inhabit, where entanglement, teleportation, and quantum computing are not science fiction but scientific frontiers.

Proto-Quantum Foundations

The genesis of quantum theory can be traced to Max Planck's investigation of black-body radiation, a problem that had confounded theoretical physicists for decades. Gustav Kirchhoff's thermal radiation law (1859) had established the theoretical framework, but classical electromagnetic theory predicted the catastrophic result that infinite energy would be radiated at short wavelengths—the infamous "ultraviolet catastrophe." Planck's solution, presented to the German Physical Society on December 14 1900, introduced the revolutionary hypothesis that electromagnetic energy could only be emitted or absorbed in discrete quantities, or "quanta," proportional to the frequency: $E=h\nu$. This quantization condition, while mathematically successful in reproducing the observed black-body spectrum, was initially viewed by Planck himself as a mathematical convenience rather than a fundamental physical principle. In his letter to Robert W. Wood, he writes,

"It was clear to me that classical physics could offer no solution to this problem, and would have meant that all energy would eventually transfer from matter to radiation. ...This approach was opened to me by maintaining the two laws of thermodynamics. The two laws, it seems to me, must be upheld under all circumstances. For the rest, I was ready to sacrifice every one of my previous convictions about physical laws. . . . [One] finds that the continuous loss of energy into radiation can be prevented by assuming that energy is forced at the outset to remain together

in certain quanta. This was purely a formal assumption and I really did not give it much thought except that no matter what the cost, I must bring about a positive result."

The profound implications of Planck's quantum hypothesis became apparent only through subsequent theoretical developments. The introduction of a fundamental constant h (Planck's constant) suggested that nature possessed an intrinsic graininess at microscopic scales, fundamentally different from the smooth continuity assumed in classical physics. This discretization would later prove to be not merely a property of radiation but a universal characteristic of physical systems at quantum scales.

Einstein's Photon Hypothesis

Einstein's 1905 paper on the photoelectric effect transformed Planck's mathematical artifice into a physical reality by proposing that light itself consisted of discrete energy packets—photons. This bold interpretation directly challenged the wave theory of light, which had been convincingly established through Young's double-slit experiment and Maxwell's electromagnetic theory. The photoelectric effect presented clear experimental evidence that electromagnetic radiation exhibited particle-like properties: the kinetic energy of emitted photoelectrons depended on light frequency rather than intensity, and no electrons were emitted below a threshold frequency regardless of intensity. Einstein's photon hypothesis provided a complete explanation: $E_{\text{kinetic}} = h\nu - \varphi$, where represents the work function of the material. Jeremy Bernstein writes, in Quantum Profiles (1991),

"In contemplating the papers Einstein wrote in 1905, I often find myself wondering which of them is the most beautiful. It is a little like asking which of Beethoven's symphonies is the most

beautiful. My favorite, after years of studying them, is Einstein's paper on the blackbody radiation. [...] Part of being a great scientist is to know— have an instinct for—the questions not to ask. Einstein did not try to derive the Wien law. He simply accepted it as an empirical fact and asked what it meant. By a virtuoso bit of reasoning involving statistical mechanics (of which he was a master, having independently invented the subject over a three-year period beginning in 1902), he was able to show that the statistical mechanics of the radiation in the cavity was mathematically the same as that of a dilute gas of particles.

As far as Einstein was concerned, this meant that this radiation was a dilute gas of particles—light quanta. But, and this was also characteristic, he took the argument a step further. He realized that if the energetic light quanta were to bombard, say, a metal surface, they would give up their energies in lump sums and thereby liberate electrons from the surface in a predictable way, something that is called the photoelectric effect. [...] In the first place, not many physicists were even interested in the subject of blackbody radiation for at least another decade. Kuhn has done a study that shows that until 1914 less than twenty authors a year published papers on the subject; in most years there were less than ten. Planck, who was interested, decided that Einstein's paper was simply wrong."

Einstein's bold proposal that light behaved as a stream of particles clashed directly with its well-established wave behavior, setting the stage for one of quantum theory's most profound revelations: that light—and later matter—exhibits both particle-like and wave-like properties, depending on how we look. The particle-wave duality would become a central theme in quantum mechanics, challenging classical notions of complementary properties being mutually exclusive. The tension between wave and particle descriptions would later be resolved through the Copenhagen interpretation and the principle of complementarity, but Einstein's early recognition of quantum discreteness established the conceptual foundation for this development.particle descriptions would later be resolved through the Copenhagen interpretation and the principle of complementarity, but Einstein's early recognition of quantum discreteness established the conceptual foundation for this development.

The Old Quantum Theory

Before Bohr's celebrated atomic model, Arthur Erich Haas made significant contributions to early quantum theory through his 1910 attempt to explain the hydrogen spectrum. Haas combined classical electrodynamics with quantized angular momentum, proposing that electrons orbited the nucleus in circular paths with specific, discrete energy levels. Although Haas's model proved quantitatively inaccurate, it was historically significant for introducing quantization principles into atomic theory before Bohr's more successful formulation. His approach demonstrated the growing recognition that classical mechanics required modification at atomic scales, foreshadowing the systematic development of quantum mechanics. Haas's work exemplifies the transitional nature of early quantum theory, attempting to preserve classical visualization while incorporating quantum constraints. This tension between classical intuition and quantum requirements would characterize the entire period of the old quantum theory, ultimately leading to the abandonment of classical pictures in favor of abstract mathematical formalism.

Niels Bohr's 1913 atomic model represented a crucial advancement in quantum theory by successfully explaining the hydrogen spectrum while introducing fundamental quantum concepts. Bohr's model incorporated three key postulates: (1) electrons occupy discrete, stationary orbits without radiating energy; (2) angular momentum is quantized according to $L = nh$; and (3) radiation occurs only during transitions between stationary states with frequency $v = (E_1 - E_1)/h$. The success of Bohr's model in predicting the Rydberg constant and explaining spectroscopic observations provided compelling evidence for quantum principles. However, the model's semi-classical nature— combining classical orbital mechanics with quantum restrictions— revealed fundamental inconsistencies that would require resolution through more sophisticated theoretical frameworks. Bohr's correspondence principle, which required quantum predictions to approach classical results in the limit of large quantum numbers, provided a crucial bridge between quantum and classical physics. This principle would later influence the development of matrix mechanics and the establishment of quantum mechanics as a consistent theoretical framework.

The Bohr-Kramers-Slater (BKS) theory of 1924 represented the final major attempt to reconcile wave theories with quantum phenomena without invoking photon reality. This theory proposed statistical conservation of energy and momentum, with individual atomic processes potentially violating conservation laws while maintaining statistical compliance. Although the BKS theory was experimentally refuted by the Bothe-Geiger and Compton-Simon coincidence experiments, its theoretical framework proved crucial for subsequent developments. The theory's introduction of "virtual oscillators" operating at atomic resonance frequencies provided the mathematical foundation that directly inspired Heisenberg's matrix mechanics. The failure of the BKS theory paradoxically catalyzed the birth of modern quantum mechanics by demonstrating the inadequacy of semi- classical approaches and necessitating a complete departure from classical visualization. This transition marked the end of the old quantum theory and the beginning of the modern quantum mechanical era.

From 'What Is' to 'What is Observed'

Werner Heisenberg's 1925 paper "Über quantentheoretische Umdeutung kinematischer und mechanischer Beziehungen" initiated the modern quantum mechanical era by completely abandoning classical electron trajectories in favor of observable quantities and transition amplitudes. Working in isolation on the island of Heligoland, Heisenberg focused exclusively on measurable transition frequencies, rejecting the unobservable electron orbits that had characterized previous atomic models. Heisenberg's insight was to represent physical quantities as matrices rather than classical variables, with matrix elements corresponding to transition amplitude between quantum states. This approach naturally incorporated the discrete nature of atomic spectra while providing a consistent mathematical framework for quantum calculations. The development of matrix mechanics by Born, Heisenberg, and Jordan established quantum mechanics as a complete theoretical framework based on abstract mathematical structures rather than classical mechanical analogies. The non-commutative nature of quantum observables, expressed through the canonical commutation relation $[x, p] = ih$, revealed fundamental differences between quantum and classical physics at the mathematical level.

Yet even as matrix mechanics took root, an alternative formulation was taking shape—one that embraced the wave-like nature of particles rather than abstract algebra. Erwin Schrödinger's development of wave mechanics in 1926 provided an alternative formulation of quantum theory based on wave equations rather than matrix algebra. Schrödinger's time- dependent and time-independent wave equations offered a more intuitive approach to quantum problems while maintaining mathematical rigor. He famously said,

"What we observe as material bodies and forces are nothing but shapes and variations in the structure of space."

The demonstration of mathematical equivalence between matrix mechanics and wave mechanics by Dirac and others established quantum mechanics as a unified theory with multiple equivalent formulations. This equivalence revealed the deep mathematical structure underlying quantum phenomena and provided flexibility in choosing appropriate methods for specific problems. Schrödinger's wave function provided a complete description of quantum systems, with $\psi|^2$ representing the probability density for finding particles at specific locations. This probabilistic interpretation, developed by Max Born, marked a fundamental shift from deterministic classical predictions to statistical quantum descriptions.

Paul Dirac's interpretation of Heisenberg's matrices as "q-numbers" and his development of operator formalism provided the mathematical framework that remains central to modern quantum mechanics. Dirac's approach unified matrix and wave mechanics while establishing the abstract mathematical structure that would accommodate subsequent developments in quantum field theory. The Dirac notation $|\psi>$ for quantum states and the concept of operators acting in Hilbert space provided elegant mathematical tools for quantum calculations. This formalism naturally incorporated quantum superposition, entanglement, and measurement processes within a consistent mathematical framework. Dirac's relativistic wave equation and prediction of antimatter demonstrated the power of quantum mechanical principles when combined with special relativity. These developments established quantum mechanics not merely as a theory of atomic phenomena but as a fundamental framework for understanding all physical processes at microscopic scales.

Einstein's Challenge of Spookiness

Einstein's discomfort with quantum mechanics' probabilistic interpretation culminated in the 1935 EPR paper (Einstein, Podolsky, Rosen), which challenged the completeness of quantum theory through a thought experiment involving spatially separated, correlated particles. The EPR argument contended that quantum mechanics must be incomplete if physical reality possessed definite properties independent of measurement. The EPR paradox highlighted the non-local correlations inherent in quantum mechanics, where measurements on one particle instantaneously affect the state of distant, entangled particles. Einstein's characterization of this phenomenon as "spooky action at a distance" reflected his commitment to local realism and his belief that complete physical theories should provide definite predictions for all measurable quantities. Schrödinger's response to the EPR paper introduced the term "Verschränkung" (entanglement) and emphasized that quantum correlations represented the essence of quantum mechanics rather than an uncomfortable side effect. Schrödinger's famous thought experiment involving a superposed cat further illustrated the conceptual challenges posed by quantum superposition at macroscopic scales.

John Bell's 1964 derivation of Bell's inequalities provided a quantitative framework for testing the predictions of local hidden variable theories against quantum mechanics. Bell's theorem demonstrated that no physical theory based on local hidden variables could reproduce all quantum mechanical predictions, establishing a fundamental distinction between classical and quantum descriptions of reality. The experimental tests of Bell's inequalities, beginning with Freedman and Clauser (1972) and achieving definitive results through Aspect's experiments (1982), consistently demonstrated violations of local realism in favor of quantum mechanical predictions. These experiments confirmed that quantum correlations exceed the bounds imposed by local realistic theories, establishing non- locality as a fundamental feature of quantum mechanics. The 2022 Nobel Prize in Physics awarded to Aspect, Clauser, and Zeilinger recognized their foundational contributions to understanding quantum entanglement and its applications. These developments transformed entanglement from a philosophical curiosity into a practical resource for quantum information processing and communication.

Higher - Dimensional Correlations for Info dynamics

Entanglement is an invaluable resource in quantum information processing. In the 1990s, it was harnessed for quantum cryptography, quantum teleportation and quantum communication protocols. But the question is: what if we were able to make a number of entangled logical carriers of information for a single quantum particle? This can be done! With hyperentanglement and hybrid entanglement. Hyperentanglement represents the simultaneous entanglement of particle pairs across multiple degrees of freedom (DoFs), including polarization, spatial mode, orbital angular momentum, time-bin, and frequency. This multidimensional entanglement enables the encoding of multiple qubits per particle and provides enhanced resilience against decoherence processes that might affect individual degrees of freedom. Hybrid entanglement is entanglement across the degrees-of-freedom.

The experimental generation of hyperentangled states typically employs spontaneous parametric down-conversion (SPDC) in nonlinear crystals such as periodically poled potassium titanyl phosphate (ppKTP). These processes can simultaneously produce entanglement across multiple degrees of freedom, creating high-dimensional quantum states with rich correlation structures. Recent experimental implementations have demonstrated hyperentanglement across four or more degrees of freedom simultaneously, enabling the creation of quantum states that exist in Hilbert spaces of dimension 2^n where represents the number of entangled degrees of freedom. These high-dimensional states provide enhanced information capacity and improved security for quantum communication protocols. Since SPDC can be somewhat inefficient in producing entangled particles, newer forms of generating entanglement have arisen, including excitonic entanglement generation.

Hyperentangled states have found applications across multiple domains of quantum information science. In quantum key distribution (QKD), the use of multiple degrees of freedom provides enhanced security through increased information capacity and improved resistance to eavesdropping attempts. The BB84 protocol and its variants benefit significantly from high-dimensional quantum states that reduce the probability of successful interception. Superdense coding protocols utilizing hyperentangled states can achieve information transmission rates exceeding the classical Shannon limit by exploiting quantum correlations across multiple degrees of freedom. These applications demonstrate the practical advantages of quantum mechanical principles for information processing tasks. Quantum teleportation protocols have been enhanced through hyperentanglement, enabling the faithful transmission of unknown quantum states across arbitrary distances. The use of multiple entangled degrees of freedom provides redundancy and error correction capabilities that improve the fidelity of teleportation processes.

Hybrid entanglement, combining continuous and discrete variables or photonic and atomic systems, represents a promising architecture for scalable quantum networks. These systems

leverage the advantages of different physical platforms while mitigating their individual limitations through quantum interfaces and conversion protocols. In this regard, quantum transduction is an important element of bridging these disparate systems, such as with opto-electromechanical transducers. Atomic ensemble-photon interfaces enable the conversion between stationary qubits (stored in atomic states) and flying qubits (encoded in photonic states), providing the foundation for quantum repeaters and distributed quantum computation. These hybrid systems require careful engineering of interaction. Hamiltonians and decoherence management to maintain quantum coherence across different physical platforms. The development of quantum networks based on hybrid architectures promises to enable distributed quantum computation, secure quantum communication over global distances, and the creation of quantum internet infrastructure. These applications require advances in quantum error correction, network protocols, and hardware interfaces to achieve practical implementation.

Walking, Probably

Imagine a particle that doesn't just move left or right, but explores all possible paths at once— this is the essence of a quantum walk. Quantum walks represent a quantum mechanical analog of classical random walks, exhibiting fundamentally different statistical properties due to quantum superposition and interference effects. Discrete-time quantum walks utilize a quantum "coin" to determine the walker's direction at each time step, creating coherent superpositions of spatial positions. The implementation of quantum walks with hyperentangled coins enables high- dimensional encoding and enhanced computational capabilities. By utilizing multiple degrees of freedom for coin states, these systems can explore larger Hilbert spaces and exhibit richer interference patterns than conventional quantum walks. Recent experimental implementations have demonstrated quantum walks using polarization-path-frequency entangled states in interferometric setups. These systems enable the optimization of quantum dialogue protocols and the implementation of quantum algorithms with improved efficiency compared to classical counterparts.

Theoretical proposals involving frequency- tagged qubits enhance addressability in large Hilbert spaces by enabling selective conditional operations based on spectral characteristics. These approaches utilize controlled-phase gates conditioned on frequency tags to achieve precise manipulations of high-dimensional quantum states. The implementation of frequency-tagged quantum operations typically employs interferometric setups with frequency shifters and wavelength-division multiplexing techniques. These systems create entangled states where specific frequency modes are correlated with auxiliary degrees of freedom such as polarization or spatial path. Applications of frequency-tagged quantum systems include compact, multiplexed quantum processors that utilize spectral diversity for parallel quantum computation. These architectures promise to enable scalable quantum computers with reduced hardware complexity compared to conventional approaches requiring individual control of large numbers of physical qubits.

Intelligence is Quantum Now

In the age of exploding data and artificial intelligence, the next leap in learning may come not from faster silicon, but from the strange logic of quantum mechanics. Quantum Machine Learning (QML) explores the integration of quantum computing principles with learning algorithms to achieve computational advantages for complex data processing tasks. Quantum algorithms such as Quantum Support Vector Machines (QSVM) and Quantum Approximate Optimization Algorithm (QAOA) leverage quantum superposition and entanglement for enhanced optimization and pattern recognition. The quantum feature mapping provided by quantum circuits enables the exploration of exponentially large feature spaces that are classically intractable. These quantum- enhanced feature spaces can capture complex correlations in data that exceed the capacity of classical machine learning approaches. Hybrid classical-quantum systems combine the strengths of classical preprocessing and quantum computation, utilizing quantum circuits for computationally intensive tasks while employing classical algorithms for optimization and post-processing. These hybrid approaches represent the most promising near-term applications of quantum machine learning.

The no-free-lunch theorem in machine learning applies equally to quantum algorithms, highlighting the necessity of problem-specific quantum models rather than universal quantum advantages. Correlation- based feature selection (CFS) and other classical techniques remain essential for identifying appropriate applications for quantum machine learning algorithms. Current quantum hardware limitations, including limited qubit counts, short coherence times, and high error rates, constrain the practical implementation of quantum machine learning algorithms. Near-term quantum devices operate in the Noisy Intermediate-Scale Quantum (NISQ) era, requiring algorithms that are robust to quantum noise and decoherence. The development of quantum error correction and fault-tolerant quantum computation remains essential for realizing the full potential of quantum machine learning. Current research focuses on variational quantum algorithms and quantum approximate optimization methods that are suitable for NISQ devices.

The Quest for Quantum Supremacy

Google's Sycamore processor achieved quantum supremacy in 2019 by performing a specific sampling task faster than classical supercomputers. This milestone demonstrated that quantum computers could outperform classical computers for carefully chosen problems, marking a significant achievement in quantum computation. The University of Science and Technology of China's Jiuzhang photonic quantum computer (2020) demonstrated quantum computational advantage for Gaussian boson sampling, providing an alternative approach to quantum supremacy using photonic systems rather than superconducting qubits. These demonstrations, while limited to specific computational tasks, established the reality of quantum computational advantages and validated decades of theoretical predictions about quantum computation's potential.

IBM's Quantum System Two (2023) represents advances in modular quantum computing architecture, enabling the construction of larger quantum systems through the integration of multiple quantum processors. These developments address scalability challenges in quantum computation by providing pathways to fault-tolerant quantum computers. Microsoft's topological Majorana qubit prototypes (2025) explore alternative approaches to quantum computation based on topologically protected quantum states. These systems promise enhanced stability against environmental decoherence, potentially providing superior error rates compared to conventional qubit implementations. Quantinuum's work on entropy generation and quantum randomness demonstrates applications of quantum computation beyond traditional algorithmic tasks, exploring fundamental questions about information theory and thermodynamics in quantum systems.

The control of decoherence in multiqubit networks involving heterogeneous degrees of freedom represents a significant challenge for scaling quantum information systems. The coupling between different physical degrees of freedom can lead to complex decoherence patterns that require sophisticated error correction strategies. Advances in quantum interfaces and real-time feedback systems are essential for maintaining coherence in large- scale hyperentangled systems. Current research focuses on nitrogen-vacancy (NV) centers in diamond, trapped ions, and photonic crystal cavities as platforms for implementing these capabilities. Quantum error correction protocols, including surface codes and bosonic cat codes, are being adapted to hyperentangled systems, though achieving fault tolerance across multiple degrees of freedom remains an aspirational goal requiring significant theoretical and experimental advances.

Calibration drift, environmental coupling, and readout errors in hybrid architectures complicate the long-term operation of quantum systems involving multiple physical platforms. The integration of different quantum technologies requires careful engineering of interfaces and control systems to maintain coherence across platform boundaries. Research in Cryogenic inter-connects and photonic routing continues to push the frontier toward viable large-scale quantum networks. These developments must address fundamental challenges in quantum state preservation during transmission and conversion between different physical encoding schemes. The realization of practical quantum advantage for commercially relevant problems requires continued advances in hardware development, error correction, and algorithm design. Current research focuses on identifying application domains where quantum computers can provide clear advantages over classical approaches.

Conclusion

The intellectual journey from Haas's proto- quantum insights through contemporary hyperentanglement research illustrates the profound conceptual evolution that has characterized quantum mechanics over more than a century. David Hilbert's Sixth Problem concerning the axiomatization of physics provided the mathematical framework that would eventually encompass quantum mechanics within the structure of Hilbert spaces and operator theory. The transition from Heisenberg's abandonment of visualizable orbits to modern implementations of quantum walks with hyperentangled states demonstrates the continuous interplay between fundamental theoretical insights and technological applications. Bohr's principle of complementarity, Schrödinger's coherent states, and the Horodecki classification of entangled states represent milestones in humanity's evolving understanding of quantum reality. The contemporary era of quantum information science validates the prescient insights of quantum mechanics' founders while revealing new applications that extend far beyond their original conceptual framework. The development of quantum computers, quantum networks, and quantum machine learning demonstrates that the quantum revolution continues to reshape our technological capabilities and scientific understanding.

The philosophical implications of quantum mechanics—from the abandonment of classical determinism to the acceptance of non-local correlations represent a fundamental shift in scientific epistemology that continues to influence our understanding of physical reality. As we advance deeper into the quantum information age, the foundational insights of quantum mechanics continue to drive innovation while revealing new mysteries about the nature of information, computation, and reality itself. The International Year of Quantum 2025 marks the turn of a *quantury* – quantum century, of quirks, and provides an opportunity to reflect on this remarkable intellectual journey while anticipating future developments that will further extend our understanding and utilization of quantum mechanical principles. The century-long evolution from classical certainty to quantum possibilities demonstrates the transformative power of scientific inquiry and the continuing potential for fundamental discoveries that reshape our understanding of the universe.

References

1. Planck, M. (1900). "Zur Theorie des Gesetzes der Energieverteilung im Normalspektrum." *Verhandlungen der Deutschen Physikalischen Gesellschaft*, 2, 237-245.
2. Einstein, A (1905). "Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt." *Annalen der Physik*, 17(6), 132-148.
3. Heisenberg, W. (1925). "Über quantentheoretische Umdeutung kinematischer und mechanischer Beziehungen." *Zeitschrift für Physik*, 33(8-9), 879-893.
4. Schrödinger, E. (1926). "Quantisierung als Eigenwertproblem." *Annalen der Physik*, 79(4), 361-376.
5. Einstein, A., Podolsky, B., & Rosen, N. (1935). "Can quantum-mechanical description of physical reality be considered complete?" *Physical Review*, 47(10), 777-780.
6. Bell, J. S. (1964). "On the Einstein Podolsky Rosen paradox." Physics Physique Физика, 1(3), 195-200.
7. Aspect, A., Grangier, P., & Roger, G. (1982). "Experimental realization of Einstein-Podolsky-Rosen-Bohm Gedankenexperiment: a new violation of Bell's inequalities." *Physical Review Letters*, 49(2), 91-94.
8. Barreiro, J. T., Wei, T. C., & Kwiat, P. G. (2005). "Beating the channel capacity limit for linear photonic superdense coding." *Nature Physics*, 4(4), 282-286.
9. Deng, F. G., Ren, B. C., & Li, X. H. (2017). "Quantum hyperentanglement and its applications in quantum information processing." *Science Bulletin*, 62(1), 46-68.
10. Majumdar, M. G., & Chandrashekar, C. M. (2022). "Quantum dialogue using hyperentangled photons." *Journal of Physics B: Atomic, Molecular and Optical Physics*, 55(4), 045501.
11. Arute, F., et al. (2019). "Quantum supremacy using a programmable superconducting processor." *Nature*, 574(7779), 505-510.
12. Zhong, H. S., et al. (2020). "Quantum computational advantage using photons." *Science*, 370(6523), 1460-1463.

The physics of laser driven electron plasma accelerators: necessity, principles, and applications

Arghya Mukherjee
Asst. Professor, Amity School of Physical Sciences,
Amity University Punjab, Mohali

1. Introduction

Particle accelerators refer to such devices that produce a controlled amount of accelerated beams of charged particles, such as electrons, protons and ions. The key idea is the employment of external electromagnetic (EM) fields and an efficient conversion of field energies to the kinetic energy of the particles which eventually propel them to a very high speed. But, why do we need these accelerators ? Because, highly energetic charged particles hold a wide range of applications in present day science and technology. They are used not only in fundamental research, which primarily includes a closer inspection of matter on the atomic and subatomic level; energetic beams, with distinct characteristics, are also desired in a plethora of socio economic platforms. These platforms include health, environmental monitoring, food technology, energy and aerospace engineering, to name a few [1].

The first linear particle accelerator, also known as a linac, was conceived by Gustav Ising in the year 1924 [2]. Linac was designed by utilizing a series of accelerating regions containing time-varying voltages. Inspired by Ising's work, Rolf Widerøe built a two-stage linear accelerator and verified the above principle. After this experiment the entire accelerating mechanism became more prominent. In principle, the ions travel through a series of metal tubes/cavities in synchronism with an oscillating electric potential applied alternately to the tubes such that the electric field between the tubes is always in a direction to accelerate the ions as they pass from the interior of one tube to the interior of the next. Following this principle, an acceleration up to a desired energy level can be obtained. Subsequently, the possibility of accelerating particles by passing

them several times through the same accelerating region, rather than once through many different regions, was discovered by Ernest Orlando Lawrence and M. Stanley Livingston in the early 1930s [3]. This invention, known as cyclotron, was a remarkable step in the development of particle accelerators - employing an accelerating field of radiofrequency (RF) range. Thereafter, a surge in developing sophisticated RF based accelerators to generate charged particles with higher and higher energies has been geared up.

Physically, the performances of RF based accelerators are governed by the amplitude of the accelerating field strength and also by the number of acceleration stages (tubes/cavities). Although a stronger electric field results in greater acceleration; however, here the field strength is limited, owing to the thermionic emissions of the metallic tubes. On the other hand, implementation of a large number of metal tubes requires a colossal space. For example, the longest linear accelerator in the world is located at SLAC National Accelerator Laboratory in Menlo Park, California, which covers more than 3 kms. Another facility is the very well-known Large Hadron Collider (LHC) at CERN, which is presently the world's largest, and highest-energy charged particle accelerator. It lies in a tunnel 27 kms in circumference and as deep as 175 metres beneath the earth surface.

From the above discussion we can deeply feel that formulaic RF accelerators actually require gigantic physical space to operate. Naturally, the development, fabrication and maintenance of conventional RF accelerators turn out to be strenuous as well as expensive. Thus, from the very beginning there was a quest for fruitful ways to reduce the length of the accelerating device while simultaneously increasing the accelerating field strength.

Now, the characteristics of an energetic charged particle beam are measured by certain physical parameters, viz. its energy, total charge, energy spread and its size & temporal shape. Naturally, while designing an accelerator, at the outset, one seeks such accelerating mechanisms which are relatively compact, easy to employ, and also where a precise control of the aforementioned beam parameters can be performed more effortlessly.

In this situation, the amelioration in laser science and technology, specifically generating ultrashort super intense pulses in the multi-terawatt and petawatt power ranges, offers a number of very compact, straightforward, even commercially viable acceleration mechanisms where some of the above harden requirements could be relaxed [4, 5]. Now, it also becomes worthwhile to mention that, since the last four decades, laser driven acceleration processes have drawn a great deal of attention not only owing to its compactness, but also due to the occurrence of additional options for the beam parameter control [5, 6].

The aim of this article is to acquaint the readers with some of these acceleration processes. Physically, when a laser, having sufficient intensity, falls on a matter, it ionizes the medium and creates a plasma. Therefore, in most of the laser assisted acceleration experiments a plasma medium is automatically produced, and the nature of the plasma medium governs the entire acceleration process. Thus, the contents of the article start with a brief description of plasmas - the fourth state of matter.

2. What is a plasma?

A plasma is an ionized gas containing mainly electrons and ions [7]. 99% of the universe is in the plasma state. By custom, a plasma is primarily characterized by its density (electron density) and its temperature (electron temperature). In laser driven plasma based accelerators, another plasma parameter controls the physics of laser-plasma interaction, and it is called the plasma frequency. This is the eigen frequency of the oscillating electrons which occur when electrons are displaced from their equilibrium positions, and thus creating a restoring force that causes them to oscillate back and forth about their respective equilibrium positions. A handy formula for the calculation of the plasma frequency, measured in Hz, can be expressed as $f_{pe} = 8980\sqrt{n_e}$ where n_e is the plasma density measured in c.c. In laser-plasma acceleration studies very short pulse lasers, having pulse duration of few tens of femtoseconds with peak intensities above 10^{18} $Watt/cm^2$ are usually employed [7]. In most of the cases, the wavelengths of the lasers vary between 800 nm - 1200 nm. Now, if the plasma density is such that the associated plasma frequency is higher than the frequency of the incident laser, then the laser can't propagate through the plasma, and the plasma is said to be overdense. Plasmas generated from high density solid targets are generally overdense and accelerations of ions are usually performed by means of overdense plasmas. On the other hand, for electron acceleration, one needs an underdense plasma medium, where the plasma frequency is much lower than the incident laser frequency. Plasmas generated via ionization of low density gas jet targets are usually under dense.

Given the above physical scenario, naturally, the physics of laser driven accelerations of electrons and ions are distinctly different from each other as the underlying plasma parameters are completely non-identical for these two cases. This article is devoted only to discussing the physics of laser driven plasma based electron accelerators using gaseous targets, and their applications [5].

3. The physics of laser Wakefield acceleration of electrons

Here, we start by studying the motion of a test electron in an electrostatic plane wave. The trajectory can be obtained by solving the Lorentz force equation using higher secondary mathematics. The trajectory of an initially rest electron over the background applied field has been depicted in figure 1. The trajectory is a

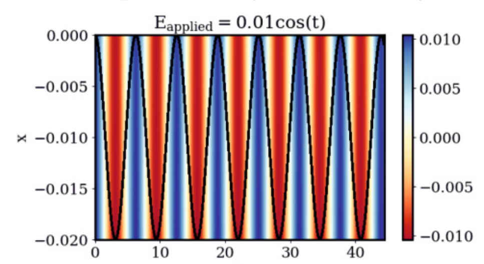


Figure 1: electron trajectory in a plane electrostatic wave. The distribution of the field has been shown by the colormap.

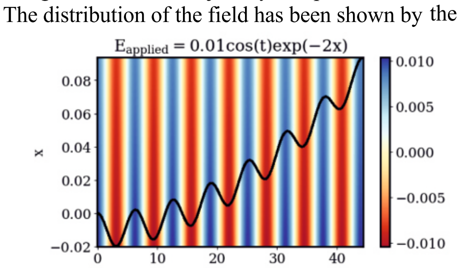


Figure 2: electron trajectory in a plane electrostatic wave with slowly varying amplitude.

sinusoidal variation of the distance with time [8], following the applied field. Now suppose the electric field has an amplitude that varies smoothly in space (say, along x-direction). From figure 2 we see that, in this case, the net result is a displacement along the positive x direction, where the electric field amplitude is weaker. In this figure, when the field amplitude is relatively higher to the bottom - at the first half of the oscillation the particle is brought back into a stronger field region, where the particle can get a stronger push in the upward direction in the next half cycle. But, when the field turns around (blue patches) the particle is in a weaker field, and hence, experiences a weaker downward push, which finally leads to a net upward displacement [8].

Now, physically we can decompose the above motion into two parts [8]: (a) slowly varying component (displacement of the oscillating centre towards the weaker field), and (b) rapidly varying fast component. The force behind the displacement towards the weaker field can be calculated by averaging over the fast oscillating time period of the applied field. This time-averaged force is called the ponderomotive force, and mathematically can be expressed as $F_p = -\frac{e^2}{4m_e\omega_L{}^2}\frac{d<E^2>}{dx}$ where, e, m_e and ω_L respectively be the electronic charge, its mass and the frequency of the applied field [7, 8]. We can notice two important characteristics of this force. Firstly, the force is charge independent, and secondly, this force acts much more strongly on electrons than on ions, owing to their lighter mass.

Although the above discussion has been made for an applied electrostatic field, similar force is applied to a charged particle when it interacts with an electromagnetic field, having slowly varying amplitude [7]. A real example of such a field is a short pulse (femtoseconds) laser, where the field can be expressed by the product of a slowly varying envelope (Gaussian, in general) and a very fast oscillating carrier wave [7].

Let us now focus on the propagation of an ultrashort laser in an underdense plasma medium. When a pulsed Gaussian laser enters the plasma medium the ponderomotive force pushes the electrons to the weaker field regime. As a result, the electrons drift radially outward, away from the laser's axis of propagation, as the intensity is maximum on the axis of propagation. The expelled electrons leave behind a net positively charged ion background which acts like a restoring force on the displaced electrons and pulls the electrons towards the laser axis. The ions remain stationary because of their inertia. Finally, the resulting structure forms a propagating space charge wave at the rear of the incident laser, and bears a name laser Wakefield accelerator (LWFA) [9]. This situation is analogous to the motion of a high speed boat creating wakes on the surface of the water. The concept of LWFA was invented in 1979 by Tajima and Dawson [9] and it was shown that such wake waves are capable of producing longitudinal accelerating fields of ~100 GV/m, leading to accelerated electrons with energies of the order of 100 MeV over a distance of 1 mm [5, 9]. Thus, accelerations with improved field strength can be possible within much compact arrangements as compared to the conventional RF accelerators. The maximum strength of the longitudinal accelerating field driven by LWFAs is given by (measured in V/m) $E_{acc} = 96\sqrt{n_e}$, where n_e is the plasma density expressed per c.c [10]. Thus, for a plasma density of $\sim 10^{18}/cm^3$ a longitudinal field strength of *100 GV/m* can be reachable. Now, by principle, an electron can ride on these wake waves, staying in-phase with the longitudinal electric field and being accelerated to high energies. Here, the acceleration of the electrons on these waves can be seen as "wakesurfing" , a very popular water sport in which a person surfs the wake that is created on the water surface by a preceding high speed boat. Here, in figure 3, the generation and evolution of the wakefields obtained from one-dimensional computer simulations [11] have been shown.

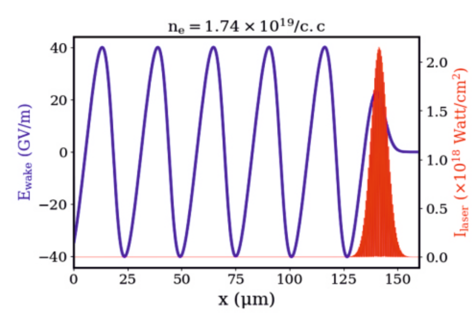


Figure 3:generation and evolution of the wake waves, traveling along the positive x-axis.

4. X-ray radiation from the accelerated electrons in LWFAs

In the previous section, we have mentioned about the maximum field that can be achieved from LWFAs.

This maximum amplitude can be attained if one gradually increases the peak intensity of the laser, keeping the plasma density and the other plasma parameters fixed. In this section, we focus on such scenarios where laser intensities are more than required to achieve the maximum field amplitude. Such parameter regimes are often called "bubble-regime" of LWFAs [12]. Here, the purpose of mentioning the bubble-regime lies in the fact that the present day laser technology demands to perform experiments in this regime [4, 5]. Moreover, performing accelerations in this regime offers the generation of compact tunable radiation sources [13]. Here by radiation, we mean the x-ray radiation generated from the accelerated electrons in the LWFAs.

Instead of periodic wake waves, the bubble regime is characterized by the formation of an ion cavity free from the plasma electrons behind the laser pulse [12]. The formation of such bubbles have been depicted in figure 4, where the laser is pointed out by the red ellipse. The colormap represents the electron charge density in terms of the background density, mentioned on the title of the figure. These results are generated from high performance computer simulations [11], performed in a Linux based cluster.

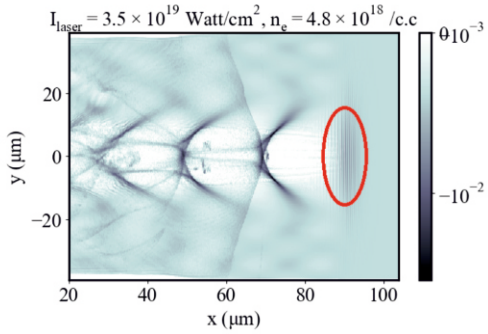


Figure 4:generation and evolution of the wake waves in the bubble regime

The properties of the emitted electromagnetic radiation from an accelerated charged particle crucially depends upon its trajectory [14]. In figure 5 we have cartooned the trajectory of an accelerated electron in the bubble regime. In the bubble regime of LWFA, the radial force that pushes the electrons toward the optical axis causes them to oscillate around it. These oscillations are called Betatron oscillations. As a result, during their excursion within the wake, the oscillatory motions of the electrons lead to the emission of radiation. The energy of the emitted radiation lies in the x-ray range, owing to the relativistic energies of the accelerated electrons [13].

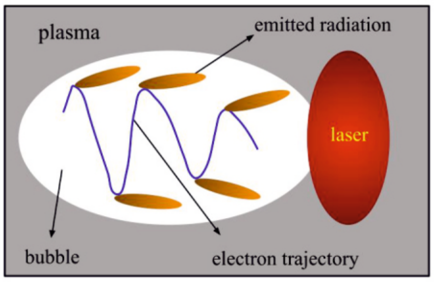


Figure 5:betatron oscillations and x-ray radiation generation in the bubble regime

Noticeably, Betatron radiation has similar duration as the laser pulse, i.e. in the fs regime [15]. Here, we would like to emphasize that the above application holds a paramount interest in the generation of conventional fs x-ray sources, which is challenging to build [15]. These bright short pulses, generated via LWFA, are also desired in x-ray tomography, phase contrast imaging etc [13, 15].

5. Conclusion

In conclusion, the necessity, working principle and some major applications of plasma based laser driven electron acceleration (LWFA) have been outlined in this article. It has been shown that LWFA offers a promising mechanism to build table-top accelerators as well as compact x-ray radiation sources.

6. References

[1] PSuzie Sheehy, arXiv:2407:10216 [2024].
[2] Gustaf Ising, Arkiv för Matematik, Astronomi och Fysik, Band 18 (1924).
[3] Lawrence et. al., Phys. Rev. 40, 19 (1932)
[4] Mourou et. al. Rev. Mod. Phys. 78, 309 (2006)
[5] Esarey et. al., Rev. Mod. Phys. 81, 1229 (2009)
[6] Macchi et. al., Rev. Mod. Phys. 85, 751 (2013)
[7] Paul Gibbon, Short Pulse Laser Interactions with Matter: An Introduction, Imperial College Press (2005)
[8] D. R. Nicholson, Introduction to Plasma Theory, Wiley and sons (1983)
[9] Tajima et. al., Phys. Rev. Lett.43, 267 (1979)
[10] Katsouleas et. al., Phys. Rev. Lett. 61, 90 (1988)
[11] Derouillat et. al., Comput. Phys. Commun., 222, 352 (2018)
[12] Pukhov et. al., Appl. Phys. B 74, 355 (2002)
[13] Felicie Albert, Phys. Plasmas 30, 050902 (2023)
[14] John David Jackson, Classical Electrodynamics, Wiley India (2002)
[15] Cornellia Gustafsson, Electron and X-ray Beam Control in Laser Wakefield Acceleration (PhD thesis, 2025)

Article

Visualising the 'UNDEFINED' through physics experiments

Bhupati Chakrabarti
Formerly of Department of Physics, City College, Kolkata 700009
chakrabhu@gmail.com

Abstract
The term 'undefined' in different branches of mathematics and possibly in some situations in physics is a familiar one. The concept of 'undefined' often remains an abstract idea to the students and occasionally, they mix it up with the concept of 'infinity.' The fact that 'infinity' and undefined are two different concepts may be communicated to the students with some suitable physics experiments that can actually be performed by the teacher or by the students in the classroom itself. Here some suitable physics experiments have been described and discussed so to speak for the 'visualization' of the concept of the 'undefined.'

Introduction
In mathematics we do come across some of the mathematical operations that we try to carry out hand us over what is known as 'undefined.' The term 'undefined' essentially implies that we cannot assign any suitable number or any suitable expression or any known or defined quantity to it. It often emerges from our attempt to division by zero. This happens in different fields of mathematics that includes arithmetic, geometry, trigonometry etc. However, it often remains as a mathematical concept and the students do not appreciate its significance easily and tend to consider it as a purely theoretical idea. However, the concept known as 'undefined' may be handled also through experimental situations that possibly make it easier for the students to understand it. Here, we have tried to present a few simple experiments through which the students are likely to visualize what 'undefined' exactly implies in a rather straightforward way.

In physics we do come across situations where the division by zero becomes imminent. But we handle these cases with the arguments from physics and in a way do not allow the 'undefined' to appear. But a look from a different angle helps us to come across the undefined in quite a few experiments.

Oscillation of a bar pendulum

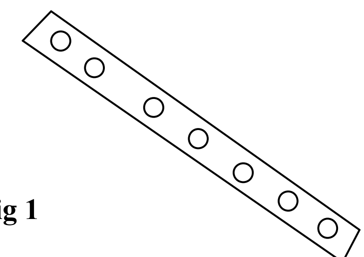


Fig 1

Figure 1 shows a bar pendulum and it can be assumed to be executing simple harmonic oscillation with small amplitude when it oscillates about one of the drills. The time-period T of this oscillation is given by

$$T = 2\pi\sqrt{\frac{I}{mgh}} \qquad (1)$$

where I is the moment of inertia of the bar about the point of oscillation and 'h' is the distance of the centre of mass from the point about which the oscillations are taking place. The formula in (1) shows 'h' can be made to be equal to zero when the bar is made to oscillate about its centre of mass. This makes the centre of mass the point of oscillation. One can see from (1) that the time-period T becomes undefined.

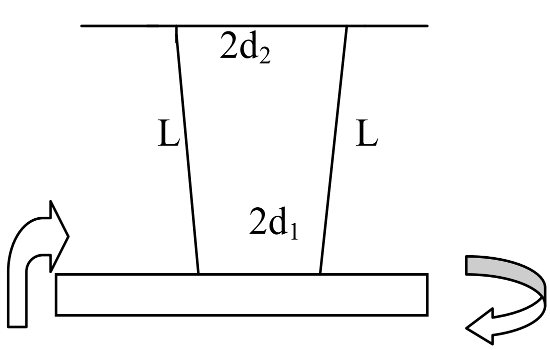
While performing the experiment what do we observe in such a situation? The bar does not show any oscillation. If the bar is shifted from its equilibrium position it just remain there. So, there is no question of having a time-period from the physics point of view. When we try to make the bar oscillate about its centre of gravity by disturbing it from its stable equilibrium position there is no rise in the position of the centre of mass and hence no storage of gravitational PE can take place. So, there is no question of continuous interchange of PE and KE to keep the oscillation happen or keep that going.

This can be seen from another point of view. When the bar pendulum oscillates about a point 'h' away from the centre of mass; a restoring couple develops that tries to bring it back to its equilibrium position. But with 'h' = 0 this restoring couple cannot develop. So, the bar remains at any position it has been taken and no oscillation takes place. Since there is no oscillation the question of defining the T (time-period) does not arise. In the process T becomes undefined.

Angular oscillation of a bifilar pendulum

In a bifilar pendulum the oscillating body is suspended from two strings and can execute angular oscillation under gravity. A wooden metre scale hung horizontally about its mid-point can be a suitable bifilar pendulum. Similar situation may emerge with a bifilar pendulum shown in the Figure 2 where the time-period of oscillation T depends on several parameters and is given by

Fig 2



$$T = 2\pi\sqrt{\frac{IL}{mg\ {}_1d_2}} \qquad (2)$$

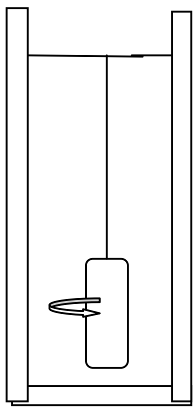
Where 'm' is the mass of the bar under oscillation and 'I' is the moment of inertia of the suspended bar about an axis passing through its centre of gravity and is perpendicular to the plane of oscillation and 'g' is the acceleration due to gravity. The other symbols have been explained through the diagram. As one can see that most of these parameters can be changed easily keeping the symmetry of the system undisturbed.

If in a bifilar pendulum we make either d_1 or d_2 equal to zero we shall not be able to make the pendulum oscillate. From physics point of view, we shall not be able to store any gravitational potential energy into the bar simply by applying a torque on it if either d_1 or d_2 is zero. In fact, the system will also move to neutral equilibrium from stable equilibrium. And no restoring couple will develop to bring it back to its equilibrium position giving rise to angular oscillation when some external torque is applied. So, there will not be any oscillation. The formula tells us in a situation like this the time-period is undefined. However, from physics point of view one could see that there is no storage of gravitational PE when one disturbs the pendulum by applying an external torque keeping d_1 or d_2 equal to zero.

Torsional oscillation of a solid cylinder suspended from a metal wire

The time-period of the torsional oscillation of a cylindrical mass depends on several factors and has been used in the UG laboratory for the determination of the rigidity modulus of the materials of the wire of suspension by the so called 'dynamical method.' This is, in contrast to the other method known as 'statical method' where the angle of twist to the wire is measured.

Fig 3



Now the time-period of this oscillation is given by

$$T = 2\pi\sqrt{\frac{I}{c}} \qquad (3)$$

where I is the moment of inertia of the cylinder about the vertical axis of rotation and 'c' is the torque per unit angle and is given by c= $\frac{\pi n r^4}{2L}$ where n is the rigidity modulus of the material of the wire, L its length and 'r' is its radius. Using the value of 'c' in the expression of the T we get

$$T = 2\pi\sqrt{\frac{I\,2L}{\pi n r^4}} \qquad (4)$$

This indicates when 'n' i.e. the rigidity modulus of the wire is zero (n=0) i.e. the wire cannot offer any resistance to any attempt to change its shape then the time-period T becomes undefined. Since a metal wire can try to retain its shape 'n' has a significant value for it and the time-period of oscillation can be defined and measured. However, if we replace the metal wire by, say, a torsion free nylon thread, i.e. the cylinder is suspended from a strong thread the time-period of oscillation will become undefined as 'n' becomes equal to zero. Or in other words we cannot expect any oscillation to take place in this situation.

From physics point of view when we use a suitable metal wire for suspension and apply a torque on the cylinder the wire gets twisted and an elastic PE is stored and a restoring torque is developed. When the cylinder is released, this restoring torque tries to take back the cylinder to its equilibrium position and the oscillation starts. With a torsion free string is used for suspension then 'n' becomes zero and there cannot be any oscillation at all. This is being indicated with T turning into 'undefined' status.

Angular oscillation of a magnet on earth's magnetic field

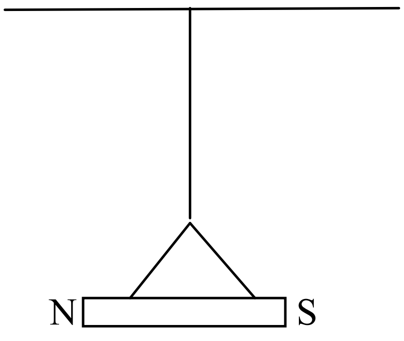
The oscillation of a small magnet suspended from a torsion free string under the influence of the earth's magnetic field is well known. The time-period of this oscillation is given by

$$T = 2\pi\sqrt{\frac{I}{MB_H}} \qquad (5)$$

Where '*I*' is the moment of inertia of the magnet about the axis of oscillation, '*M*' is the moment of the bar magnet and 'B_H' is the horizontal component of the earth's magnetic field.

Here the magnet remains aligned with the magnetic meridian when undisturbed. Now if we apply an external torque on the magnet a restoring couple develops that tries take it back to its original equilibrium position where the magnetic potential energy is minimum. Now, if we can make the effective B_H to zero i.e. by placing the oscillating magnet in a suitable magnetic field to the cancel the horizontal component of the earth's magnetic field in that location or create a neutral point or neutral area and the T turns out to be undefined as per the above formula.

Fig 4



In reality, we shall not see any oscillation even if we apply some external torque. In other words, the time-period T would be undefined. In fact, on the surface of the moon where there is no magnetic field the $B_H = 0$ i.e. a magnet will show no oscillation of this type. This is because its time- period becomes undefined there in the absence of any magnetic field.

This also explains why a piece of a metal which is not a magnet does not oscillate in the earth's magnetic field when suspended in the way shown in figure 4. In that case the magnetic moment M of that metal piece that occurs in the denominator of the expression under the radical sign turns out to be zero since that is not a magnet. So, that also makes the time-period of oscillation undefined or in other words it does not show any oscillation or gives rise to an undefined time-period T.

Discussion with some other situations in physics

There are some of the other possible situations in physics that may lead to the emergence of 'undefined.' However, these may not prove to be easy to show in a UG laboratory. In these situations, we can underline the possible existence of 'undefined' theoretically.

For a simple pendulum if we can make acceleration due to gravity 'g' to be equal to zero in a specially created situation then there will be no oscillation of the pendulum or in other words the time-period will become undefined. For example, if we think about a place like International Space Station or the inside of an artificial satellite orbiting round the earth where the zero- gravity situation is prevailing, then the time-period of the simple pendulum becomes undefined as 'g' turns out to be zero. Similar situation may be observed for a bar pendulum or bifilar pendulum even when $h \neq 0$.

Concluding remarks

Since most of the experiments described here are quite simple and are very well-known, possibly the teachers of mathematics can also make use of them and all these activities can be done in a classroom situation. We know that for the passage of a light ray falling normally on a rectangular glass block and passing undeviated through it, the refractive index can be defined using the velocity ratio but not with Snell's law. This is because Snell's law leads to an undefined situation. And that is why, it is mentioned that Snell's law is not applicable for a normal incidence. The variation of the value of $\tan\theta$ with θ when θ changes from 0 to π/2 is another example that can be used in mathematics. Here the value of $\tan\theta$ goes on increasing with θ until it has touched π/2 where it turns out to be undefined. One can also look at it as the ratio of $\sin 90^0$ and $\cos 90^0$.

Since an undefined quantity essentially implies that we cannot define it; students may tend to think that the various undefined observed in different situations are different from each other. Or, sometimes the students feel that all the undefined are equal. Neither of these is correct because undefined refers to something that cannot be defined. And it is not a number, big or small. So, there is no question of comparison among them. We just do not know what it is or we cannot assign any number to them. All of them are known by the same nomenclature 'undefined' and should be considered as belonging to one separate, may be, a special category.

References

1. https://en.wikipedia.org/wiki/Undefined_(mathematics)

Artificial Intelligence: The Neural Network Approach

Vipin Srivastava
Former Professor of Physics
at the University of Hyderabad

The whole world is going gaga over Artificial Intelligence (AI). There are discussions about the impact it will have on our lives in the years to come, its merits and demerits, how it will affect creative activity or lead to job losses and so on.

How many of us know the genesis of AI? I guess, very few. AI has evolved in a highly ramified manner though different branches trace back to Alan Turing's[1] ideas of computability or machine intelligence. Here, I aim to give a glimpse, in simple terms, of one particular line of evolution – the Neural Network approach – which has had the widest applicability. This preliminary exposure will be interesting for those who may be just curious. It may also give a direction to those who wish to be initiated into this multidisciplinary subject with endless scope for research, both fundamental and applied.

[1] **Alan Turing** (1912-54) is considered the father of the present-day computers. He invented a hypothetical device now known as 'Turing' machine, that carried out logical operations. A computable function was one that could be computed with this machine. Going beyond Turing computability is a subject of research. Do quantum algorithms or quantum computers surpass Turing or advanced Turing machines in this respect; also do they tackle 'computational complexities' more effectively than Turing machines?

At its core, AI is about making a computer learn, memorize and retrieve information from its memories much like the brain does. It mimics the brain in processing information so that it is able to make 'decisions' on its own and perform various cognition like tasks.

The efforts in this direction started in the 1940s but did not take us far because the physiology of learning and memory was not known so well. In 1949, a Canadian psychologist Donald Hebb found a crucial clue. He discovered that when we are learning something, the synapses that connect the fundamental constituents of the brain viz. the neurons, change their effectiveness or efficacy in a more or less irreversible or permanent manner. This is now known as synaptic 'plasticity'.[2] This stirred up a lot of research activity, but a turning point came in 1982 when John Hopfield, a Caltech physicist turned computer scientist, gave a model for neural network that seemed biologically quite viable. It was favoured by both the physicists and computer scientists and research activities escalated manifold thereafter.

[2] **Neuronal network and synaptic plasticity:** In a normal brain, about 100 billion neurons form an entangled network. A neuron communicates with 100's of 1000's of other neurons by exchanging electrical impulses, called action potentials, via synaptic connections. The action potentials trigger release of neurotransmitters across the synaptic gaps between neighbouring neurons. In this course, the electrical potential of the post-synaptic neuron goes up or down, and if it exceeds that neuron's inherent threshold, it fires and sends out an action potential, otherwise it stays quiescent. The details of the underlying electrochemical mechanism are fascinating and are described in textbooks.

The above mechanism is triggered every time an information comes to be recorded in the brain and the efficacy of synaptic connections i.e., their character – whether excitatory or inhibitory – and strength, changes irreversibly or plastically. Such plastic changes lie at the core of the brain's learning and memory.

What is generally not known is that Hopfield's model of cognitive learning and memory was inspired by a physical system called 'spin-glass'[3]. A 'spin-glass' is characterized by a small concentration of 'atomic spins'[3] frozen in a lattice in random directions and at locations few and far between. They interact in a very special manner that 'frustrates'[3] their relative orientations. The frustrated 'spins' give rise to a huge number (technically, 'exponentially' large number) of minimum energy states of a 'spin-glass' (for somewhat involved technical reasons they are called 'meta-stable ground states') -- each one corresponds to a particular configuration of randomly oriented 'spins' in the System. This means that a 'spin-glass can be simultaneously stabilized by a huge number of random configurations of magnetic spins.

---

[3]**Spin-glass** are alloys in which certain magnetic elements (Iron, Manganese, or Chromium) randomly replace – in very small proportions (< 10%) – the non-magnetic host elements (Gold, Copper or Silver), which are typically arranged as a lattice. They are termed 'glass' because the magnetic elements are frozen in random locations along with their spins[a], also oriented randomly. And this is the key to their special properties. Curiously, these magnetic atoms interact (or communicate) with each other over long ranges in a very special way – depending on the separation, two distant magnetic atoms can interact with each other either ferromagnetically (in which a spin compels the other to align parallel to it) or anti-ferromagnetically (with anti-parallel alignment of spins). This contradictory nature of interactions **frustrates** the orientation of magnetic spins.

[a][(i) The negatively charged electrons, revolving around a nucleus of an atom, produce tiny magnetic fields in random directions. They cancel each other out in atoms of non-magnetic elements, but produce net 'magnetic moments' or 'atomic spins' in magnetic elements. (ii) The common glass or glassy materials (also called non-crystalline) do not have underlying lattice structures. Because of the irregular or random network of atoms in them the term 'glass' has become synonymous with randomness.]

This concept along with its Mathematics was mapped on to the brain's neural network in which each configuration of randomly oriented 'spins' was identified as a memory. The special interaction described above was adapted mathematically to represent Hebb's synaptic plasticity by Leon Cooper, a Physics Nobel laureate from Brown University. This is popularly known as "Hebb's learning rule" following which memories are inscribed in the network as cumulative changes in synaptic efficacies and are distributed over large parts of the brain. Then there is a mechanism to recall a memory selectively by association – when a known information is encountered a widespread exchange of action potentials[2] sets in via the synapses that are modified plastically in the course of inscribing memories; this settles down with a pattern of firing/quiescent neurons, and recall is marked by its matching, neuron by neuron, with the presented pattern.

Notwithstanding the success of the Hopfield-model with Hebb's rule incorporated and conjoined with the prescription for recall, there is still tremendous scope for improvement. Efforts are constantly on to improve this model or construct new ones to mimic cognition as closely as possible. These include some efforts by this author's group together with his Cambridge collaborators namely an eminent physicist from Cavendish, Sir Sam Edwards and a neuroscientist David Parker. In future articles, we will explore fundamentally new insights into the physiology of learning that will not only make inscription and recall of information more capacious and efficient but also make the model brain more intelligent.

Incidentally, together with a Physics Nobel laureate Phil Anderson from Bell Labs, Sir Sam Edwards gave the first mathematical theory for 'spin-glass' in 1975 that apparently paved the way for Hopfield to frame his neural-net model. Thus, the origin of AI can be traced to 'spin- glass' and late Sir Sam can be acknowledged to be one of the progenitors of Artificial Intelligence.

Report (RC-06)

Felicitation of Prof. Jainendra Jain and Public Lecture on Quantum Physics

A prestigious academic event was organized on July 14, 2025**,** by the Department of Physics, IIS (Deemed to be University), Jaipur in collaboration with the RC-06**,** to felicitate Prof. Jainendra Jain for receiving the Wolf Prize in Physics 2025 and to host his public lecture. The event was held at the campus of MNIT Jaipur**.**

Prof. Jainendra Jain, a world-renowned physicist and Distinguished Professor at Penn State University, has been honored with the Wolf Prize for his seminal work on the theory of **composite fermions**, which has provided deep theoretical insights into the fractional quantum Hall effect and other exotic quantum phenomena.

The event commenced with a formal welcome and introduction of Prof. Jain by Prof. K.S. Sharma, President, RC-06 and Prof. Y.K. Vijay, Former President RC-06, followed by the **presentation of a citation** jointly by IIS (Deemed to be University) and RC-06. Dignitaries from various institutions, senior faculty members, researchers, and students were in attendance, making the occasion academically vibrant and celebratory.

Prof. Jain's lecture on **"A Strange New Universe: Where Bizarre Quantum Particles Rule"** captivated the audience with its elegant explanations of quantum mechanics beyond the standard textbook treatment. He illuminated the concept of emergent particles, such as composite fermions, and how they give rise to entirely new forms of quantum matter under extreme conditions. His presentation struck a fine balance between scientific depth and accessibility, engaging both students and seasoned researchers alike.

The audience responded with enthusiasm, raising several thoughtful questions during the interactive session. The event successfully fulfilled its twin goals: to celebrate scientific achievement at the global level and to bring cutting-edge physics closer to young minds in India.

Prof. Ritu Jain, Secretary, RC-06 presented a formal Vote of thanks to Prof. Jainendra K. Jain for accepting the citation and for delivering an enlightening lecture. The organizers expressed their gratitude to **MNIT Jaipur** for providing the venue and to RC-06 for their continued efforts in promoting physics education and outreach in the region.

Ritu Jain
Secretary

Report (Sub RC-08 F)

First Invited Talk under the Lecture Series

Celebration of International Year of Quantum Mechanics (IYQ-2025)

To commemorate the **International Year of Quantum Science and Technology (IYQ 2025)**, the Sub-RC 08F, (Marathwada Region), organized a lecture series highlighting significant milestones and emerging frontiers in quantum science and physics.

The inaugural lecture of this series was conducted on 24 July 2025 via Google Meet (7.00 pm to 8.35 pm).

The event commenced with a warm welcome and was hosted by Dr. R. G. Vidhate, Secretary, Sub-RC-08F. Dr. D. R. Sapate, President, Sub RC-08F, introduced the speaker, Emeritus Professor Dr. K. M. Jadhav, a highly esteemed academician and researcher with decades of contributions to materials science and condensed matter physics.

In his lecture, entitled **"Contribution of Physicists in the Development of Science"**, Prof. Jadhav guided the audience through a comprehensive exploration of both historical and contemporary contributions made by physicists to the advancement of human knowledge and technology. The talk began with an insightful discussion on the intersection of *adhyatma* and science, emphasizing the harmony between these domains. Prof. Jadhav highlighted the cultural and scientific significance of the famous **Pandharpur Vitthal Wari** in Maharashtra state. The talk concluded with highlighting the importance of **Guru Purnima**, underscoring the vital role of mentors and teachers in both spiritual and scientific journeys.He discussed the groundbreaking achievements of figures such as Isaac Newton, Albert Einstein, Marie Curie, Georg Simon Ohm, Robert Hooke, etc. who have significantly advanced our understanding of the physical universe.

The lecture adeptly bridged classical physics with modern innovations, including nuclear energy, laser technology, space research, and, notably, the burgeoning field of quantum technologies. **He explained the BCS theory in a simple manner, which was a landmark in quantum physics earning Nobel Prize in 1972.** Prof. Jadhav emphasized the profound ways in which these advancements are transforming industries and society at large.

The session was marked by enthusiastic participation from students, teachers, and researchers. The subsequent interactive Q&A session fostered engaging discussions and thoughtful questions, all of which Prof. Jadhav addressed with remarkable clarity and depth.

The event concluded with a vote of thanks proposed by Dr. Siddram Dongarge, a senior member of Sub RC- 08F,

Highlights of the Lecture:

- Chronological presentation of key physicists' contributions
- Emphasis on Indian scientists and their global impact
- Relevance of physics in interdisciplinary scientific development
- Emerging quantum technologies and their future implications
- Active audience engagement during Q&A

R G Vidhate

Report (Kerala)

"Magic of Lenses" – A Hands-on Physics Programmme

The IAPT, Kerala Chapter, successfully conducted a **workshop-cum-training programme** titled "**Magic of Lenses"** for Class X students following the Kerala state syllabus. The event was organised as a part of the KERALA RC (Regional Centre) initiative on promoting hands-on science learning through active learning techniques.

The programme was held at Excel Public School, New Mahe, from 10:00 a.m. to 1:30 p.m., with an enthusiastic participation of **80 students**. The programme was inaugurated by the Principal Madam Sathi M Kurup in the presence of Vice Principal Mr Sudheesh V K

The central objective of the workshop was to demystify the behavior of light through various optical elements using direct experimentation, thereby reinforcing textbook learning with real-world observations. Each participant was provided with a complete experimental kit, ensuring every student had an opportunity to explore independently.

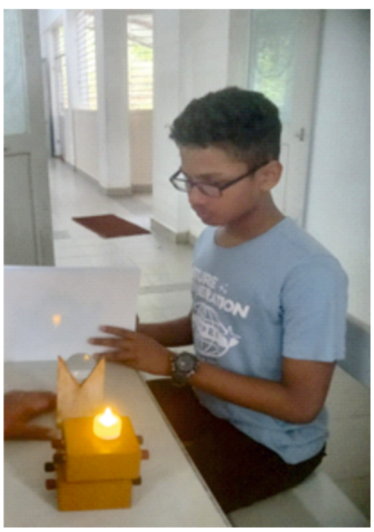
The session began with **a** simple demonstration using a glass slab, where students observed that light bends slightly when it enters and exits a medium of different optical density, establishing the basic concept of refraction. This was followed by experiments using prisms, where the students could visibly witness how light undergoes greater deviation due to the triangular geometry of the prism, thus deepening their understanding of angular dispersion and light paths.

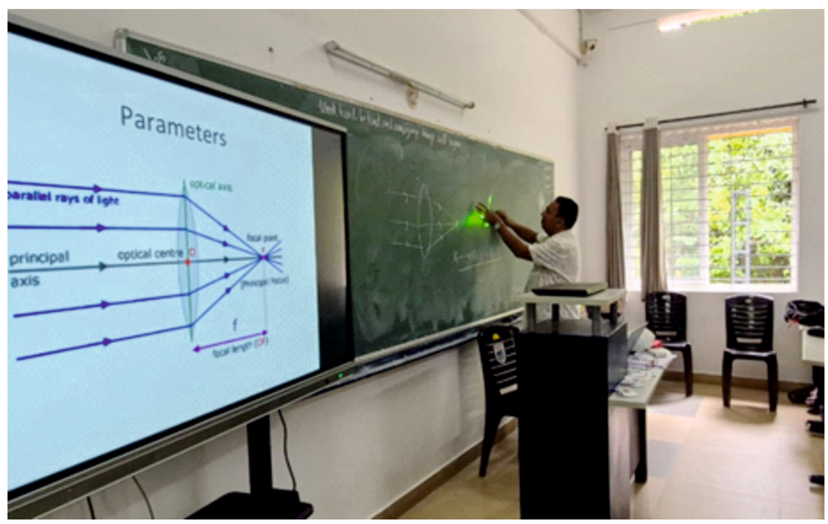
The core part of the workshop focused on convex and concave lenses. Through a guided discussion and hands-on activities, students were introduced to the idea that lenses can be understood as a combination of prisms and glass slabs. With this conceptual framework, they conducted experiments to find the position and nature of the images formed by lenses for different object distances.

Students learnt to measure the image distances systematically and tabulate results using the Cartesian sign convention, which was introduced during the session. They recorded their observations, compared real and virtual images, and discussed focal length estimation from their measurements. This approach not only clarified the textbook concepts of image formation but also laid a foundation for experimental physics and critical thinking.

The feedback from both students and teachers was overwhelmingly positive, with many appreciating the opportunity to explore and experiment freely under the mentorship of trained resource persons. Students raised many interesting and thoughtful questions, leading to lively discussions that further deepened their understanding.

The programme was coordinated by Dr K M Udayanandan, Mr M C Linu Kumar, Mr Ajith Kumar P and Dr Nishanth P.





K M Udayanandan

Report (NASNI)

Building a Bridge between Curiosity and Cosmos

National Astronomy Network of IAPT

At the **38th Annual Convention of IAPT,** held in **Dharamshala in November 2024,** a collective desire emerged among astronomy educators and enthusiasts: the need for a **dedicated interactive platform** for sky gazers across the country. This vision gave birth to **NASNI – the National Astronomy Network of IAPT,** officially launched with its first virtual meeting on **January 1, 2025,** attended by twelve founding members.

What is NASNI ?

NASNI is a national platform under the umbrella of the Indian Association of Physics Teachers (IAPT) aimed at promoting interactive, inclusive, and sustained engagement in astronomy for all. Whether one is a beginner looking at the Moon for the first time or an amateur enthusiast tracking Messier objects, NASNI offers a structured path of guidance and growth.

Why NASNI ?

The motivation behind NASNI is to **foster curiosity, deepen understanding, and promote collaborative learning** in astronomy. It seeks to fill the gap between eager learners and experienced professionals by building a vibrant community that thrives on shared observations, ideas, and knowledge.

How Does NASNI Operate?

The group organizes bi-monthly virtual talks, held on the first and third Wednesdays of each month. These sessions feature distinguished experts in astronomy and astrophysics — from directors of observatories to passionate sky watchers and educators. The recorded versions of these talks are available on the NASNI YouTube Channel **https://www.youtube.com/@NASNI25**, with links also accessible via the IAPT website, ensuring on-going learning for all.

Purpose and Activities (Jan–July 2025)

Since its inception, NASNI has hosted the following talks:

- **Prof. Hemant Kumar,Rtd. Director SCERT, HP** (Jan 22): *Polaris to Messier Objects*
- **Dr. Bharat Adur ,** Director, Akash Ganga Center for Astronomy, Badlapur, Thane (Feb. 5): *Observing Meteors and Meteorites*
- **Ar. TusharPurohit** , IUUCA Pune (Feb 9): *Searching the Heavens*
- **Dr.AnandaHota, Rad@home, Mumbai** (Mar.5):*Multi-wavelength Understanding of Black Hole Galaxy Co-evolution*
- **Ar. Kaustuv Chaudhary**, Kolkata Asttronomy Center (Mar 19): *Wonders of the Night Sky*
- **Er. Dorje Angchuk, Indian Astronomy Observatory, Leh** (Apr.2): *Indian Astronomical Observatory, Leh*
- **Dr.Gourav Bannerjee, PDF, IIA Bangalore** (Apr 16): *India's Journey to Space: Current Status and Future Prospects*
- **Prof. Hum Chand** ,Deptt of Physics, CUHP (May 7): *Stardust and Us – Life Cycle of Stars and Evolution of Humans*
- **Mr.Neelesh Rana** ,Community Science Center, Rajkot (May 21): *The Joy of Sky Watching*
- **Dr.Nitu Borgohain** , Global University Guwahati, Assam (June 4): *From Stardust to Supernova*
- **Mr.Gopal Mandal,Galileo Astronomical Observatory, Kolkata** (June 18): *Scientific Experiments with a Small Telescope at Home*
- **Dr.Sarang Shah, Jyotirvidya Parisanstha, Pune** (July 2): *Stellarium and Software Tools for Amateur Astronomers*
- **Dr.Arun Singh, Assistant Professor, Department of Physics, Faculty of Science,The ICFAI University, Raipur, Chhattisgarh** (July 16): *Effects of Microgravity on Human Physiology and Future Space Missions*

Each session has drawn active participation from school students, college teachers, amateur astronomers, and members of the public.

Looking Ahead: Vision for the Next Six Months

NASNI plans to:

- Launch **regional astro-clubs** in schools and colleges.
- Host a **National Sky-Watching Challenge** for students.
- Introduce **mentorship programs** linking beginners with experienced astronomers.
- Collaborate with planetariums and observatories for **on-ground exposure**.

Why It Matters

NASNI empowers learners with:

- Access to credible and diverse experts.
- Structured learning experiences beyond textbooks.
- A sense of belonging in a national-level scientific community.
- The inspiration to transform curiosity into informed observation and discovery.

Our Motto:

"Bridging Curiosity with the Cosmos"

Connect with NASNI

Stay updated with upcoming talks, resources, and astronomy activities via the NASNI YouTube Channel and the IAPT official website.

Hemant Kumar
Coordinator, NASNI

Report (RC-07)

Summer School in Physics – 2025

Sir P. T. Sarvajanik College of Science (Autonomous), in collaboration with RC – 07, successfully organized a 'One-week Summer School in Physics" from 23^{rd} to 28^{th} June 2025. The program was specifically designed to provide in-depth exposure to three fundamental areas of Physics, namely, Thermodynamics, Electromagnetism and Quantum Mechanics, with emphasis on analytical thinking and problem-solving skills.

A total of 11 students of the VNSGU region participated in the program. The relatively small cohort allowed for one-to-one interaction, personalized guidance and effective mentoring throughout the program.

This academic initiative was aimed at creating stimulating environment for students to engage them deeply in theoretical framework, while simultaneously developing practical approach to solving complex problems. The Summer School served as an enriching platform for knowledge sharing between the participants and the well-experienced resource persons from academia.

Academic Sessions:

The Summer School comprised of problem-solving lessons and interactive sessions with three distinguished resource persons:

Prof. Michael D'Souza– Thermodynamics

Prof. Michael D'Souza conducted an intensive module on Thermodynamics, covering classical aspects. The sessions included deep dives into the laws of thermodynamics, entropy and thermodynamic potentials. Particular attention was paid to real-world applications and derivation-based problem-solving; encouraging students to apply their theoretical knowledge to practical situations.

Prof. Atul Modi – Electromagnetism

Prof. Atul Modi led the sessions on Electromagnetism, beginning with Maxwell's equations and extending to boundary conditions. The sessions were complemented by well-curated problem sets that challenged students to think critically and connect physical intuition with mathematical rigor.

Prof. Kiran Kolwankar – Quantum Mechanics

Prof. Kiran Kolwankar offered an engaging series of lectures on Quantum Mechanics; focusing on both, the foundational principles and modern interpretations. Topics such as second order differential equation and its solution, the Schrödinger equation and operator formalism were explored. The sessions, emphasizing on conceptual clarity and rigorous problem analysis and solving, enabled the students to navigate abstract ideas with confidence.

All the three topics were approached with a strong focus on problem-solving techniques, equipping students with tools to tackle computational problems.

Daily assignments and practice problems were provided to reinforce learning outcomes. Some sessions also included presentations by students, fostering critical thinking and effective communication.

Student Experience and Feedback:

Students expressed high levels of satisfaction with the quality of sessions and the opportunity they had to interact closely with the experts in the field. Many of them found the problem-solving focus particularly beneficial, as it helped bridge the gap between the textbook knowledge and the real-world applications. Participants appreciated the small-group format, which allowed for personalized mentoring, frequent clarification of doubts, and peer collaboration.

Several students noted that the summer school significantly boosted their confidence in handling complex topics and inspired them to pursue further studies or research in Physics.

Viresh Kumar H. Thakkar

Announcement for the Selection of Coordinators for Various Activities of the Indian Association of Physics Teachers

As per the decision of the Executive Council of IAPT in its meeting held on May 05, 2024, the guidelines were notified for the selection of various coordinators and chief editor of the IAPT Bulletin. These guidelines were approved by Executive Committee and General Body during the 38th Annual Convention at Dharamshala in October 2024. Following is the Table of various coordinators:

S. No.	Activity	Name of the Coordinator	Year of Appointment	No. of Years Completed
1.	CCE	Prof. B. P. Tyagi	2019	7
2.	NSE	Prof. Anand Singh Rana	2019	7
3.	NSEJS	Prof. D. Uthra	2023	3
4.	NGPE	Prof. Pradip Kumar Dubey	2023	3
5.	APhO	Prof. Vijay Kumar	2021	5
6.	JSO	Prof. B. S. Achutha	2024	2
7.	NCEWP	Prof. S. K. Joshi	2021	5
8.	NCIEP	Prof. Geetha R. S.	2022	4
9.	NCICP	Prof. Pradipta Panchadhyayee	2022	4
10.	NPECP	Prof. Govind Lakhotiya	2024	2
11.	INYPT	Prof. Gyaneshwaran Gomathinaygam	2024	2
12.	NANI	Prof. H. C. Verma	2011	14
13.	Chief Editor	Prof. Manjit Kaur	2024	2

According to the guidelines the terms for Chief Coordinator of Exams (CCE), Coordinators of NSE, APhO, JSO and Chief Editor of Bulletin is 5 years.

For the other competitions the term of any coordinator is of 3years with an extension of another 3 years if EC approves.

At present we announce the selection process for the coordinators of following activities:

1. Chief Coordinator of Exams [CCE]
2. National Standard Exam [NSE]
3. Asian Physics Olympiad [APhO]
4. National Anveshika Network of India [NANI]

The detailed process was published in the December 2024 issue of IAPT Bulletin and is also available on our website **indapt.org.in**

The application forms and other detail with the timeline will be published in the September issue of IAPT Bulletin.

We request our sincere and devoted members to come forward to serve our association and community with full dedications.

Rekha Ghorpade
General Secretary, IAPT

FIRST STEP TOWARDS

INTERNATIONAL SCIENCE OLYMPIADS

NATIONAL STANDARD EXAMINATION IN PHYSICS	: NSEP 2025 - 26
NATIONAL STANDARD EXAMINATION IN CHEMISTRY	: NSEC 2025 - 26
NATIONAL STANDARD EXAMINATION IN BIOLOGY	: NSEB 2025 - 26
NATIONAL STANDARD EXAMINATION IN ASTRONOMY	: NSEA 2025 - 26
NATIONAL STANDARD EXAMINATION IN JUNIOR SCIENCE	: NSEJS 2025 - 26

These are the only examinations that lead to participation of Indian students in the National and International Science Olympiads. No other examination is recognized for this purpose.

Organized by

INDIAN ASSOCIATION OF PHYSICS TEACHERS (IAPT)

206, Adarsh Complex, Awas Vikas - I, Keshavpuram, Kalyanpur, Kanpur-208017

In co-ordination with
ASSOCIATION OF CHEMISTRY TEACHERS (ACT) &
ASSOCIATION OF TEACHERS IN BIOLOGICAL SCIENCES (ATBS)

Step II Toppers from these NSEP, NSEC, NSEB, NSEA & NSEJS from each State/Union Territory will be eligible for II stage i,e Indian National Olympiads (INOs) 2026 in respective subjects. For details see the website: www.iapt.org.in and the student's brochure.

Step III About 40 toppers in each of INPhO, INChO, INBO, 50 of INAO and 35 of INJSO will qualify for the Orientation Cum Selection Camp (OCSC) in respective subjects for two weeks at Homi Bhabha Centre for Science Education (HBCSE), Mumbai or Banglore Indian teams to participate in International Olympiads – 2026 will be selected on the basis of performance of students in respective OCSC.

In addition, about 8 toppers from INPhO and NSEP may get an opportunity to participate in **Asian Physics Olympiad (APhO)**. The APhO will be held in May 2026.

Language: **Question Papers are in English, Hindi, Gujarati, Bangla, Kannada, Tamil and Telugu or any Indian Language provided 300 students OPT for it**

Awards: Students attending OCSC will be awarded Gold medals and a merit certificate in all subjects. Certificates shall be awarded to Toppers (National & State) of National Standard Examination.

Syllabus: **NSEP, NSEC, NSEB:** Upto CBSE class XII; **NSEA:** Physics & Mathematics upto CBSE class XII along with basic Astronomy; **NSEJS:** Physics, Chemistry & Biology upto CBSE class X.

Programme:

Centre registration: Aug 1 to Aug 20, 2025.

Student enrolment: Aug 21 to Sep 14, 2025

1. **Enrollment at Centre:** Pay fee to Centre In-charge.
2. **Direct Online Enrolment:** A student can enroll directly online at www.iapt.org.in; He/She will pay fee by online payment.

DATE AND TIME OF EXAMINATION: SUNDAY 23.11.25

NSEP : 8:30 AM to 10:30 AM
NSEC : 11:30 AM to 1:30 PM
NSEB : 2:30 PM to 4:30 PM
NSEJS: 2:30 PM to 4:30 PM

SATURDAY 22.11.2025

NSEA : 2:30 PM to 4:30 PM

Fee Rs. 300.00 per student per subject

PREVIOUS 10 YEARS QUESTION PAPERS BOOKLET WITH ANSWERS IN EACH SUBJECT IS AVAILABLE FOR Rs. 150/- EACH FROM IAPT OFFICE KANPUR (iaptknp@rediffmail.com)

Prof. BP Tyagi
Chief Coordinator (Examination)
23 Adarsh Vihar, Raipur Road,
Dehradun - 248001
Ph: 9837123716, E-mail: bptyagi@gmail.com
Visit Website: www.iapt.org.in

Dr. Anand Singh Rana (9412954316) Coordinator NSE
Dr D Uthra (8610886474) Coordinator NSEJS
IAPT Examination Office:
15, Block II, Rispana Road, DBS College Chowk, Dehradun-248001
Email: iapt.nse@gmail.com
Helpline: 9632221945, 8310281694, 8533993332

For all queries regarding the examination: Student may contact local centre in-charge else the Helpline.

12th IAPT NATIONAL STUDENT SYMPOSIUM ON PHYSICS

INDIAN ASSOCIATION OF PHYSICS TEACHERS
&
DEPARTMENT OF PHYSICS, PANJAB UNIVERSITY, CHANDIGARH

10-12 OCTOBER, 2025

To foster a culture of innovation and creativity among the young students, IAPT has instituted the annual National Student Symposium on Physics (NSSP). The yearly series started in 2013 in collaboration with the Department of Physics, Panjab University, Chandigarh.

The Symposium provides a national forum to young students, to present their new ideas and innovative work at an early stage of academic career. 12th in the series, NSSP-2025, will be held during October 10-12, 2025.

NATIONAL ADVISORY COMMITTEE

RenuVig (Patron)
VC, Panjab University, Chandigarh
Vijay Singh (Mumbai)
S.D. Mahanti (USA)
L. Satpathy (Bhubaneswar)
Bhupati Chakrabarti (Kolkata)
Tankeshwar Kumar (Mahendragarh)
Arvind (Mohali)
Manjit Kaur (Chandigarh)

NATIONAL ORGANISING COMMITTEE

P.K. Ahluwalia (Shimla), President, IAPT
Rekha Ghorpade (Mumbai)
Satya Prakash (Chandigarh)
U.S. Kushwaha (Chandigarh)
K.N. Joshipura (Vallabh Vidyanagar)
H.C. Verma (Kanpur)
B.P. Tyagi (Dehradun)
P.C. Deshmukh (Bengaluru)
Y.K. Vijay (Jaipur)
Meenakshi Sayal (Jalandhar)
Ranjita Dekha (Guwahati)
V. Rajeshwar Rao (Karimnagar)
Vipul Rastogi (Haridwar)
A.M. Srivastava (Bhubaneswar)
P.K. Panigrahi (Bhubaneswar)

- **Invited Talks by Subject Experts**
- **Oral Presentations by the Students**
- **Poster Presentations by the Students**
- **Visit to Research Laboratories**

The undergraduate and postgraduate students with physics background can apply for the symposium latest by August 30, 2025 Local hospitality and accommodation shall be provided to students. Limited travel support (bus or sleeper class by train) may be given to few selected participants.

Register at
https://sites.google.com/view/iaptnssp2025/home
or
Scan this QR code

LOCAL ORGANISING COMMITTEE

S.K.Tripathi (Convener NSSP 2025)
(Chairperson, Dept. of Physics)
C.N. Kumar (Coordinator)
Ranjan Kumar (Secretary)
Sanjay Kr. Sharma
N. Goyal
D. Mehta
S. Sahijpal
Rajesh K. Baboria
R.P.N. Tripathi
Ram Gopal
B.C. Chaudhary
Vivek Kumar
Sheojee Singh
Bimal Rai
Rama Arora
Amit Goyal
Rajesh Sharma
Ranber Singh
Saroj Bala
Mumtaz Oswal

For more information, contact
Prof. C.N. Kumar
Department of Physics
Panjab University, Chandigarh
nssp@pu.ac.in

Department of Physics,
Panjab University, Chandigarh

Indian Association Of Physics Teachers
(Registered under Section XXI of Societies Act 1860, Reg. No. K-1448)
Regd. Office : Flat No. 206, IInd Floor, Adarsh Complex,
OPR-4, Awas Vikas-1 Keshavpuram, Kalyanpur, Kanpur-208017
Email: iaptknp@rediffmail.com Ph.: 9415404969, 9839035685, 9935432990

NATIONAL COMPETITION FOR INNOVATIVE EXPERIMENTS IN PHYSICS (NCIEP) – 4th-7th October 2025, Goa University, Goa

FINAL REMINDER

Last Date to receive entries 31st August 2025

1. **The following categories are included:**

   (A) The participant can be a teacher at any level or M. Phil. / Ph. D. awarded /Ph.D. pursuing student or a Scientist from national laboratories or a science communicator working in science centers, etc. He/she need not be an IAPT member.

   (B) The participant can be a student pursuing UG/PG course

   (C) The participant can be a High School student Studying in 9-12 standard.

   For all categories participants themselves have to demonstrate the experiment.

2. The experiment should be an original one, designed by the participant himself/ herself. It can be even a demonstration type experiment. As 2025 had been declared as the year of Quantum Science and technology participants are most welcome to design experiments in that topic.

   For category B and C, students can work under the guidance of a **mentor**.

3. The top 3 experiments from each category A, B and C are awarded cash prizes.

Selected entries from each category will be invited for a demonstration at the 39th IAPT convention to be held from 4thto 7th October 2025 at Goa. The invited participants will be paid railway fare from the workplace to the convention place as per IAPT rules. In case of joint authors, only one of the participants is eligible to receive TA (as per IAPT rules). Top ten student participant entries (for category B and C) may be given an amount of Rs 1000/- each towards expenditure incurred in setting up the experiment. Please submit the write-up of experiment as an email attachment (both word & PDF file is a must) to the coordinator at the email id: **nciepiapt03@gmail.com** The selected participant must come with his/her own setup for final demonstration.. Decision of the judges will be final. **Detailed announcement can be viewed in the IAPT June 2025 Bulletin page 184-186.**

Closing date to receive the entries is 31st August , 2025. Please feel free for any query at e- mail: **nciepiapt03@gmail.com** **or WhatsApp number 8088812890**

Dr Geetha R S, Coordinator, NCIEP 2025

39th

ANNUAL NATIONAL CONVENTION OF INDIAN ASSOCIATION OF PHYSICS TEACHERS - 2025

5th to 7th October, 2025

Venue: Goa University

Organized by IAPT Goa RC - 21 and School of Physical and Applied Sciences Goa University

About the Convention

National Convention of Physics Teachers brings together educators, researchers, and innovators from across the country to explore new trends, challenges and opportunities in Physics teaching.

THEMES AND SUB THEMES

Empowering Physics Education

Quantum Science & Technology
- Quantum Computing
- Quantum Materials and Devices
- Quantum Simulation
- Quantum Optics & Photonics

Space Research Achievements
- Indian Space Mission
- Satellite Technology
- Indian astronomical observatories
- Astronomy public outreach

Physics Education Research
- Learning Physics through outreach
- Technology in Physics Education
- Pedagogical learning in Physics
- Use of AI in Physics Education

Challenges in Physics Education
- Laboratory infrastructure
- Diversity and inclusion
- Research &innovation in Physics
- Integrated & Holistic education

Email to submit abstract : iaptgoarc@gmail.com

Highlights

- Eminent Talks
- Project Exhibition
- Awards
- Pre Convention
- Workshops
- Poster Presentations
- Oral Presentations
- Networking
- Visit to CSIR-NIO
- River Cruz

Registration Details

IAPT Members and participants

- **A - Participation:** Rs. 2500/-
  (Includes: Kit, Lunch, convention Dinner)
- **B - Participation:** Rs. 6500/-
  (Includes: A + 4 nights sharing accommodation, breakfast, dinners)
- **C -Accompanying person:** Rs. 4500/-
  (4 nights sharing accommodation, breakfast, lunch and dinner)

Industry & Sponsorship

- **D - Industries:** Rs. 6000/- (Includes: A)
- **E - Sponsor:** Rs. 25000/-
  (Includes: A + Logo display)
- F- Sponsor: Rs. 50000/-
  (Includes: A + Logo display + Stall)

Contact Information

Email: iaptgoarc@gmail.com
reshma@unigoa.ac.in

Abstract Submission Guidelines

Maximum Length: Maximum 250 words (Upto 1 page)

Formatting: Times New Roman, font size 12, single line spacing, justified alignment, word format.

Bank Details for Payment

Name: INDIAN ASSOCIATION OF PHYSICS TEACHERS RC 21

A/C Number: 100710200017630

IFSC Code: BKID0001007

Bank Name: Bank of India, Panaji

Registration Form Link

https://forms.gle/GAJL155tRb7neyzXA

Important Dates

Commencement of online registration: 10th July 2025
Deadline for online Abstract Submission: **16th August 2025**
Communication of Acceptance of Abstract: 25th August 2025
Deadline for online Registration: **10th September 2025**

About IAPT

Indian Association of Physics Teachers (IAPT) was established in the year 1984 by late Dr. D.P. Khandelwal. It has grown since then with over 10,000 members. Which includes educators, researchers and students worldwide, working to improve physics teaching. Builds a vibrant network of passionate physics enthusiasts. It runs Scientific Culture Centers for graduate, postgraduate projects, research in physics education, organizes national exams in Physics, Chemistry, Biology, Astronomy, Junior Science and the Graduate Physics Examination across India.

IAPT Goa RC came into existence in 1999. It actively promotes quality Physics Education in the region through workshops, teacher training programs, student enrichment activities, and Science outreach.

About Goa University

Goa University, established on 1985, is located on the scenic Taleigao Plateau and offers a range of graduate and postgraduate programs across various disciplines including Konkani, Portuguese, Marine Sciences, Data Science, and AI. It has adopted the NEP-2020 policy, offering flexible degree options with multiple entry and exit points through the Academic Bank of Credits. The university is home to ten schools formed from traditional departments, offering a range of undergraduate, master's, and Ph.D. programs, as well as certificate and diploma courses.

SPAS- School of Physical and Applied Sciences, formed by merging Physics, Mathematics, and Electronics departments. Also offers interdisciplinary M.Sc. Biophysics, Computational Physics. The departments are well-funded by DST, UGC, and other national agencies, supporting advanced teaching and research.

Advisory Committee

Prof. H. B. Menon, Vice-Chancellor Goa University (Chief Patron)
Prof. P. K. Ahluwalia, President IAPT (Patron)
Prof. Sunder N. Dhuri, Registrar Goa University
Prof. Sunil Kumar Singh, Director CSIR-NIO
Prof. Prasad Naik, Emeritus Professor BITS Pilani KK Birla Goa
Shri. Bhushan Savoikar, Director Directorate Higher Education Goa
Shri. Shailesh Zingade, Director Directorate of Education Goa
Shri. Bhagirath Shetye, Chairman GBSHSE, Govt. of Goa
Ms. Meghna Shetgaonkar Director SCERT, Govt. of Goa
Prof. P.C. Deshmukh, Vice President, IAPT
Prof. Rekha Ghorpade, General Secretary, IAPT
Prof. Sanjay Kr. Sharma Secretary IAPT
Dr. D. C. Gupta, Treasurer IAPT
Prof. Ramesh Pai, Dean, SPAS Goa University
Prof. K. R. Priolkar, Sr. Prof. SPAS Goa University
Dr. V. Girish, Dy Director Science Program office ISRO HQ
Prof. Satish Keluskar, President IAPT Goa RC
Prof. Meenakshi Sayal, Vice president North Zone
Prof. Ranjita Deka, Vice President East Zone
Prof. Y. K. Vijay, Vice President West Zone
Dr. V. Rajeshwar Rao, Vice President South Zone
Prof. Vipul Rastogi, Vice President Central Zone
Prof. B. P. Tyagi, Chief Coordinator Exams
Prof. Manjit Kaur, Chief Editor IAPT Bulletin
Prof. C. N. Kumar, Editor IAPT Bulletin
Prof. G. V. Kelkar, Former President IAPT Goa RC
Prof. A V Heblekar, Former President IAPT Goa RC
Prof. S N Pai Raiturkar, Former President IAPT Goa RC
Prof. Erwin Desa, Former President IAPT Goa RC
Prof. A.V. Kulkarni, Former President IAPT Goa RC
Prof. R. Tangsali, Former President IAPT Goa RC
Prof. Vithal Tilvi, Professor Goa State Higher Education Council

Organizing Committee

Dr. Reshma Raut Dessai, Secretary IAPT Goa RC (Convenor)
Shri. Manoj Sawaikar, Vice President IAPT Goa RC
Shri. Roger C A Ferrao, Treasurer IAPT Goa RC
Dr. Sudipta Kanungo, EC member IAPT Goa RC
Shri. Atul A Naik, EC member IAPT Goa RC
Shri. Pradeep Morajkar, EC member IAPT Goa RC
Smt. Shubhangi Agni, EC member IAPT Goa RC
Shri. Amey Shirodkar, EC member IAPT Goa RC
Shri. Yeshwant Gaonkar, EC member IAPT
Dr. Feroz Kadar Badesab, Scientist NIO Goa
Ms. Vandana C C, EC member IAPT Goa RC
Ms. Mruga Dhabolkar, EC member, IAPT Goa RC
Prof. Rajendra Gad, Vice Dean SPAS Goa University
Prof. Jivan Parab, Vice Dean SPAS Goa University
Dr. Venkatesha R Hathwar, SPAS Goa University
Dr. Rajeshkumar S Hyam, SPAS Goa University
Dr. Sudhir Cherukullappurath, SPAS Goa University
Dr. Bhargav K Alavani, SPAS Goa University
Dr. Pallavi P Gawade, SPAS Goa University
Dr. Jessica Fernandes e Pereira, SPAS Goa University
Dr. Mridini Gawas, SPAS Goa University
Dr. Mudraj Pagi, SPAS Goa University
Dr. Narayan T Vetrekar, SPAS Goa University
Dr. Aniket A Gaonkar, SPAS Goa University
Dr. Sandeep Gawali, SPAS Goa University

Rising Above the Gathering Storms….

The above phrase is part of the title of a 2007 report published by the National Academy of Sciences, Engineering, and Institute of Medicine, USA urging the different stakeholders to take heed of the then growing challenges in science and technology education and prepare the country to stay ahead. The advancements and challenges have grown manifold since then. The storm has intensified, pushing science education into an existential crisis and necessitating a radical overhaul of its ecosystem. It is no exaggeration to say that much of what we are teaching today runs the risk of becoming obsolete in the near future, if it's not already. In this article, we discuss some papers which will help familiarize with the related literature and the ongoing discussions surrounding these issues.

Broadly, a radical redesign and revamp of the science education ecosystem are necessitated by:

i) The rapidly changing nature of scientific research practices, exacerbated by the advent of technologies such as machine learning.

ii) The changing nature of the world and the complex problems looming over humanity such as climate change, pandemics and sustainability.

As far as India is concerned there is a third dimension - our changing aspirations as a nation, embodied in ideals such as *Viksit Bharat* and global leadership. The DAE Maha Chintan Shivir - Vision 2047 hosted by TIFR, Mumbai delved into some aspects of these issues. For more details, refer to the accompanying presentation and white paper:

https://www.tifr.res.in/mcs2024/talks/AI/Education and Human Resource.pdf

DAE Maha Chintan Shivir: Vision 2047 - White Paper on Education and HRD

The white paper maintains that the rapidly increasing gap - between what is taught in our schools and colleges and what scientists and professional practitioners do - is among the most significant educational challenges of our times. It then outlines a model to study scientific practices and human learning in tandem, to translate cutting edge scientific practices into novel educational practices of compelling quality. This requires a new culture of interaction between science practitioners, science education researchers and educators. The white paper stresses that the traditional educational machinery with its ad hoc approaches to educational reforms may not be able to deliver us out of the present crisis. It underscores the necessity of new systems and structures to come into being. Though the discussion is situated within the context of DAE institutions, the outlined model is generic and applicable to other scientific establishments in the country.

There are related discussions which focus on the larger socio-ecological challenges and their implications for science education. The below editorial, in the latest issue of the journal *Research in Science Education,* discusses various aspects of them. The authors reflect on the nature of the multiple, entangled challenges and uncertainties of the current age characterized as `anthropocene'. Socio- ecological issues of grave significance such as the climate crisis and biodiversity loss, concerns pertaining to mis/disinformation are also explored in connection with efforts to formulate a futuristic orientation to science education.

White, P., & Tytler, R. (2025). Science Education: Fit for the Future. *Research in Science Education*, 1-10.

https://link.springer.com/content/pdf/10.1007/s11165-025-10277-7.pdf

K K Mashood
HBCSE - TIFR, Mumbai

Postal Regd. No. Kanpur City-28/2024-26 Date of printing 01-08-2025 Date of posting 08-08-2025 RNI No. UPENG/2009/29982 ₹ 25/-

BULLETIN OF THE INDIAN ASSOCIATION OF PHYSICS TEACHERS

FOUNDED BY (LATE) DR. D.P. KHANDELWAL

VOLUME 17 NUMBER 8 AUGUST 2025

IN THIS ISSUE

If undelivered please return to :

Dr. Sanjay Kr. Sharma

Managing Editor

Flat No. 206, Adarsh Complex,

Awas Vikas-1, Keshavpuram, Kalyanpur, Kanpur-208017

Published by Dr. Sanjay Kr. Sharma on behalf of Indian Association of Physics Teachers. For circulation amongst IAPT members/subscribers only.
Flat No. 206, Adarsh Complex, Awas Vikas-1, Keshavpuram, Kalyanpur, Kanpur-208 017, Mob. 9415404969.
Printed at Sharda Graphics Pvt. Ltd., 123/766, Factory Area, Fazalganj, Kanpur-208012, Ph. 9336845329
Chief Editor: Prof. Manjit Kaur