INTERNATIONAL CONFERENCE-CUM-ROUND TABLE ON TRANSLATIONAL RESEARCH AND INNOVATION IN BEAM TECHNOLOGIES (ICTRIBT-2026)

Report of Contributions

Contribution ID: **1** Type: **not specified**

Optimization of a Dielectric Barrier Discharge Cold Atmospheric Plasma for Safe and Selective Skin Cancer Treatment

Recent advances in molecular biology and biomedical research have led to the development and utilization of new techniques and agents for treating diseases. One such technique is Cold Atmospheric Plasma (CAP), which is increasingly adopted in healthcare. Over the last two decades, CAP has attracted the attention of many biomedical scientists due to its ability to generate reactive species [1]. CAP is a non-thermal plasma that operates near room temperature and has the capacity to produce reactive oxygen and nitrogen species, enabling CAP to benefit experimental applications in wound healing, microbial inactivation, cancer treatment, and many more [2,3]. Apart from the reactive species, CAP also generates UV radiation, an electric field, charged species, and heat during its production. The plasma parameters and concentration of reactive species are device-dependent. Therefore, the design of a CAP device, its optimization, and validation are of utmost importance before biomedical applications [4].

In this study, we evaluated the pre-clinical safety and efficacy of CAP generated by an indigenously developed dielectric barrier discharge (DBD) setup. Electrical and optical characterization of the DBD-CAP device confirmed stable plasma discharge and consistent production of reactive oxygen and nitrogen species. Safety assessments were performed on mouse peritoneal cells (*ex vivo* study) and the skin of Wistar rats (*in vivo* study). Mice peritoneal cells are the primary cells used to assess safety in *ex vivo* studies. A safety study on mouse peritoneal cells was conducted at 24 kV with treatment times ranging from 0 to 120 seconds, and cell viability was assessed following a 24-hour incubation. A safety study was conducted on Wistar rats at 18 kV, with a treatment time of 15-45 seconds. Various blood parameters and histology of the treated skin tissue were analyzed. In contrast, treatment of human melanoma skin cancer cells (G-361) was performed as part of an anticancer study. The CAP treatment of human melanoma skin cancer cells at 24 kV with a treatment time of 0-45 s. Cell viability, intracellular ROS, and apoptosis were analyzed following 24-hour incubation. The CAP treatment on G-361 cells resulted in a substantial reduction in cell viability, an increase in apoptosis, and an increase in intracellular ROS, with increasing treatment time. Cell mortality after treatment is driven by ROS-mediated apoptosis. Together, these findings demonstrate the selective profile of the DBD-CAP device, safety in normal skin cells, and strong anti-cancer efficacy in melanoma, supporting its translational potential as a minimally invasive therapeutic option for skin malignancies.

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Magnetic Field–Assisted Thermal Arc Plasma Synthesis of Core/Shell Fe-based Nanoparticles and Their Magnetic Properties

Core/shell Fe-based nanoparticles were synthesized using a thermal arc plasma technique. To investigate the influence of an external magnetic field, synthesis was carried out in a helium atmosphere at an arc current of 50 A and atmospheric pressure, both in the presence and absence of a transverse magnetic field of approximately 100 G applied perpendicular to the plasma plume.

Transmission electron microscopy revealed well-defined core–shell architectures with predominantly spherical nanoparticles, whose size distribution was noticeably influenced by the applied magnetic field. Structural phase formation and elemental composition were verified using X-ray diffraction and elemental mapping. Magnetic measurements performed at 300 K showed a clear reduction in saturation magnetization (from ~69 to ~44 emu/g) and remanent magnetization (from 18 to 12 emu/g) for samples synthesized under magnetic field conditions. Additionally, variations in zero-field-cooled and field-cooled magnetization behavior further highlight the role of the magnetic field during nanoparticle formation.

These findings demonstrate that magnetic field–assisted thermal plasma synthesis provides an effective route for tuning the structural characteristics and magnetic properties of Fe-based core–shell nanoparticles, offering potential for applications in data storage, biomedical technologies, and energy-related systems [1-2].

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PULSE FORMING NETWORK- A NOVEL EXCITATION SYSTEM TO STUDY WHISTLER DYNAMICS AND MAGNETIC RECONNECTION PHENOMENON IN LVPD-U

We discuss the design and performance of a pulse-forming network (PFN)–based pulsed power supply developed for whistler wave excitation in the Large Volume Plasma Device (LVPD-U). The LVPD-U produces a quiescent argon plasma with a typical density of ˜3 × 10^{17} m^{-3} and an electron temperature of ˜4–5 eV, immersed in an axial magnetic field of 6.2 G. The pulsed power system is based on the discharge of a 50Ω characteristics impedance of PFN on a 50Ω Loop Antenna, capable of storing up to 12 C at a maximum charging voltage of ≤ 20 kV for ≤ 200A antenna current, through triggered switching of Hydrogen Thyratron. The PFN output is coupled with an electrical galvanic isolation to the loop antenna inside the device through a wide band ferrite-core transformer with inherent impedance matching. A novel current amplitude clipping feature is ensured by playing with BH curve of the ferrite core transformer by raising ferrite core magnetization through a feeble DC biasing loop to the transformer core. The performance of the exciter system is characterized through the excitation of electromagnetic hydrodynamic (EMHD) structures in LVPD plasma and the pulse has been detected by a 3-axis magnet probe. The system provides a controlled and flexible experimental platform for laboratory investigations of whistler wave dynamics, magnetic reconnection, and related space plasma phenomena. Additionally, several experimentally observed features of physical relevance are discussed with results from LVPD experiments.

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Contribution ID: **4**	Type: **not specified**

Investigation on photon sphere radius of Kerr black hole within plasma environment

Black hole is a large compact object, where the existence of gravity is so strong that any particle or electromagnetic wave cannot escape out of it. Again, no-hair theorem states that a black hole can be characterized by only three parameters: mass, charge and angular momentum. On the other hand, 99% of the visible Universe is composed of plasma, a state of matter dominated by charged particles. The presence of plasma in the region of black holes may affect the equations of motion of photons and charge particles which leads to the modification of the black holes shape and size. In the present study, we basically focus on the behavior of plasma surrounded uncharged rotating black hole (Kerr black hole). In this environment, we have analyzed the variation of photon sphere radius with the rotational parameter and plasma frequency for the Kerr black hole. Here we found that the presence of the plasma increases the photon sphere radius. Again, our findings indicate that the growth for photon sphere radius is less for prograde orbit than the retrograde case. Also, we have noted that for a given plasma frequency, the photon sphere radius of the Kerr black hole decreases when we increase the rotating parameter.

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Contribution ID: **5** Type: **not specified**

Quantum Edge Detection: A Technical Survey of Methods and Approaches

Abstract
Context: Edge detection is critical in image-based diagnostics where intensity variations must be resolved under low resolution and noisy conditions. Quantum image processing, using superposition and interference, offers alternative approaches to classical gradient-based methods.
Purpose: This study surveys quantum Hadamard-based and classical edge detection techniques, explicitly motivated by diagnostic tasks where accurate boundary identification from detector images is essential.
Methods: A classically simulated quantum model is applied to 8×8 binary images using amplitude encoding, single-qubit Hadamard operations, and permutation unitaries to highlight intensity transitions. Classical methods (Canny, Sobel, Laplacian) are applied independently. The workflow—image selection, quantum encoding, circuit simulation, and post-processing—is implemented in Python using Jupyter Notebook, Google Colab, and IBM Quantum simulators.
Findings: Quantum detection captures subtle boundaries via interference, even at low resolution. Orthogonal scans provide complementary features forming coherent edge maps. Canny detection localizes edges precisely with noise suppression, Sobel captures general patterns, and Laplacian highlights rapid changes but introduces spurious responses. Quantum simulations require moderate resources; classical methods are efficient on standard hardware.
Significance: Quantum and classical methods have complementary strengths, suggesting hybrid approaches could enhance edge continuity, robustness, and interpretability in precision imaging. This provides a foundation for future hybrid pipelines and large-scale, error-mitigated quantum-assisted analysis.
Keywords: Quantum image processing; quantum edge detection; hybrid quantum–classical methods; interference-based imaging; diagnostic image analysis

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Contribution ID: **6** Type: **not specified**

A Hybrid Quantum–Classical Framework for Image Analysis and Facial Expression Recognition

Abstract
Context: Image analysis and boundary detection are critical in diagnostic and monitoring systems where intensity variations must be resolved under noise and limited resolution. Quantum image processing, using superposition and interference principles, offers novel representations and operations for structured analysis, which can complement classical approaches in imaging-intensive experimental setups.
Purpose: This study investigates a hybrid quantum–classical framework for facial image analysis and facial expression recognition, explicitly motivated by applications where accurate detection of spatial patterns is crucial for experimental diagnostics and monitoring.
Methods: Facial images are enhanced using histogram equalization and adaptive thresholding to maximize contrast and improve separability prior to quantum-inspired processing. The enhanced images are then encoded using a gridding-based representation analogous to block-based quantum image models, enabling localized subsystem analysis. Facial expressions are characterized through graph-based observables derived from facial landmark points, and classification is performed using classical and quantum-inspired classifiers.
Findings: Thresholding-based preprocessing improves image quality by enhancing contrast and segmentation boundaries, while gridding-based segmentation enables localized analysis and stable feature extraction. Experiments conducted on a subset of the FFHQ dataset achieve approximately 90% accuracy in small-scale evaluations. The workflow demonstrates potential for reliable pattern recognition in image-intensive diagnostic environments.
Significance: The results demonstrate that hybrid quantum–classical frameworks can effectively bridge classical image processing and quantum-inspired algorithms, providing scalable and robust tools for monitoring, diagnostics, and structured analysis in imaging-intensive experimental systems.
Keywords: Quantum image processing; hybrid quantum–classical frameworks; quantum-inspired models; image gridding; experimental diagnostics; pattern recognition
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Galaxy 2D to 3D Depth Visualization –Cosmic Eye (NGC 2566) using MiDaS and Accuracy Evaluation using SSIM

Abstract
Context: Accurate 3D reconstruction from 2D images is vital for both astronomical studies and imaging-intensive experimental systems, where structural identification under limited resolution and noise is crucial.
Purpose: This work evaluates the MiDaS DPT-Large model on synthetic galaxy images with ground truth depth maps, motivated by applications requiring precise structural detection for monitoring and alignment in experimental setups.
Methods: Synthetic datasets simulating galaxies with bulges and rings were generated. Depth maps predicted by MiDaS were compared to ground truth using SSIM, and Canny edge detection was applied to assess structural correspondence.
Findings: Direct SSIM averaged 0.4508, while edge-based SSIM reached 0.9253, showing strong preservation of morphological boundaries. Batch testing over ten images yielded SSIM from 0.3370 to 0.5337. 3D visualizations highlighted accurate recovery of global structures, though fine ring details remain challenging.
Significance: Monocular depth estimation demonstrates potential for structural analysis and real time monitoring in imaging-intensive experimental systems, including beam diagnostic and alignment applications.
Keywords: Galaxy 3D reconstruction; monocular depth estimation; MiDaS; SSIM; synthetic galaxy images; imaging diagnostics.
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Contribution ID: **8** Type: **not specified**

Plasma-Activated Water: Transforming Food Safety Through Reactive Species - Synergistic Effect on Microbial Decontamination, Antioxidant Boosting, and Pesticide

Plasma-Activated Water (PAW) has emerged as a promising technology for food processing applications, demonstrating effectiveness in surface sanitation, produce blanching, and fruit decontamination. Its ability to reduce microbial load, prolong shelf life, and maintain nutritional value has drawn significant research interest. PAW contains reactive oxygen and nitrogen species (RONS), which possess strong antimicrobial properties against various foodborne pathogens, including bacteria, molds, and viruses. This study examined the impact of PAW on enzymatic browning, microbial inhibition, and pesticide degradation in fresh-cut apples. PAW was produced with activation times of 5, 10, and 15 minutes, and apple slices were treated by immersion in PAW for 10 minutes before room-temperature storage. Results showed that PAW activated for 15 minutes (PAW15) exhibited the lowest peroxidase activity, indicating superior enzymatic inhibition. PAW immediately reduced polyphenol oxidase activity, with PAW15 showing the most pronounced effect. Antioxidant capacity, assessed via ABTS and DPPH assays, was significantly enhanced in PAW-treated samples on the first day of storage ($P < 0.05$), though differences diminished after 8 days. Microbial analysis confirmed that PAW effectively suppressed microbial proliferation without negatively affecting apple quality. Moreover, PAW reduced pesticide residues and minimized browning while maintaining antioxidant levels. Among the treatments, PAW15 demonstrated the highest efficacy in pesticide removal and bacterial reduction, likely due to its elevated RONS concentration, which enhances antimicrobial and detoxifying effects.
These findings highlight PAW's potential as a sustainable, chemical-free method for enhancing food safety and shelf life, supporting its adoption in the food industry as an eco-friendly decontamination solution. This research contributes to advancing PAW applications in food preservation and safety.

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Multilayer titanium-based thin films for photocatalytic dye degradation

A titanium-based multilayer thin-film system fabricated via magnetron sputtering represents a highly promising architecture for visible-light-driven photocatalytic applications. In this heterostructured design, each constituent layer is deliberately engineered to perform a distinct yet synergistic role in enhancing light absorption, charge transport, and surface redox reactions. The multilayer consists of a TiN base layer, an intermediate Ag layer, and a top TiON layer, collectively forming a functional TiN/Ag/TiON [1,2] architecture optimized for efficient photocatalytic activity under solar irradiation.
The TiN base layer, with a thickness of approximately 100 nm, serves as a highly conductive electron migration and collection layer. Owing to its metallic or semi-metallic nature, TiN facilitates rapid electron transport and acts as an electron sink, effectively suppressing charge carrier recombination within the photocatalytic system. Additionally, TiN provides mechanical stability and promotes improved interfacial adhesion for the subsequent layers, thereby enhancing the overall structural integrity of the multilayer film.
A thin silver (Ag) interlayer, typically in the range of 5–10 nm, is introduced between the TiN and TiON layers to further improve charge separation and optical performance. Silver plays a crucial role as a plasmonic and charge-mediating layer, where localized surface plasmon resonance (LSPR) effects can enhance visible-light absorption and local electromagnetic fields at the interface. Moreover, Ag acts as an efficient electron bridge, promoting directional charge transfer from the photoactive TiON layer toward the TiN base, while also serving as a recombination barrier that prolongs charge carrier lifetimes.
The top TiON layer, with a thickness of approximately 50 nm, functions as the primary photoactive component of the multilayer system. Titanium oxynitride exhibits a tunable and narrowed bandgap in the range of ˜2.0–3.5 eV, depending on oxygen and nitrogen content, making it highly responsive to visible light. Upon illumination, the TiON layer efficiently absorbs photons and generates electron–hole pairs. Its mixed anionic composition provides abundant surface defect states and active sites that are favorable for photocatalytic redox reactions, particularly at the solid–liquid interface.
A type-II band alignment at the TiN/Ag/TiON interfaces plays a critical role in facilitating effective charge separation. This alignment enables photogenerated electrons to migrate from the TiON conduction band toward the Ag interlayer and subsequently into the TiN layer, while holes remain in the TiON valence band. Such spatial separation of charge carriers is driven by favorable band offsets, interfacial electric fields, and the formation of Schottky or quasi-Schottky junctions at the metal–semiconductor interfaces. These effects collectively minimize electron–hole recombination losses and enhance the availability of long-lived charge carriers for surface reactions.
The optimized thicknesses of the individual layers are crucial for maximizing photocatalytic efficiency. The relatively thick TiN layer ensures efficient electron transport and surface reaction kinetics, while the thin Ag layer balances plasmonic enhancement and charge transfer without excessive optical shielding. The TiON top layer thickness is carefully chosen to provide sufficient light absorption while maintaining efficient charge extraction at the interfaces. Together, these parameters enable enhanced generation of reactive oxygen species (ROS), such as superoxide radicals ($O_2\bullet^-$) and hydroxyl radicals (•OH), which are essential for organic pollutant degradation, antimicrobial activity, and water-splitting reactions.

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Intermittent Ion Beam Sputtering with Temperature Variation for Controlled Nanopatterning of Silicon Surfaces

Self-organized nanopattern formation on solid surfaces through low-energy ion beam sputtering has emerged as a versatile technique for nanoscale surface engineering. While continuous ion irradiation has been extensively investigated [1–6], the effects of intermittent (pulsed) ion exposure, particularly when coupled with controlled substrate temperature variation, remain comparatively less explored [7].
In this study, we examine the evolution of nanoscale surface morphologies on silicon (Si) subjected to low-energy (500 eV) Ar^+ ion irradiation applied in an intermittent (pulsed) mode, while maintaining a constant total fluence. The substrate temperature is systematically varied during the intermittent sputtering process to assess its influence on surface pattern development. The ion beam, incident at an oblique angle of 67°, promotes the formation of anisotropic triangular features riding on nanoripples.
The investigation focuses on understanding how ON/OFF sputtering cycles, in conjunction with thermal modulation, affect the ordering, orientation, and roughness of the resulting nanopatterns. The results indicate that intermittent irradiation enhances morphological control by enabling surface relaxation and adatom diffusion during the OFF phases, while temperature variation facilitates stress relaxation and structural stabilization.
These findings are expected to provide deeper insight into the thermally assisted evolution of surface morphologies under non-continuous ion bombardment, establishing a novel pathway for achieving high-precision nanoscale patterning. The outcomes will contribute to the development of advanced fabrication techniques for applications in optics, sensing, and nanoelectronics [8-9], while also contributing to the refinement of continuum theoretical models describing surface dynamics under dynamic ion irradiation.
Keywords: Ion Beam Irradiation, Intermittent Sputtering, Nanopattern Formation, Temperature-Dependent Morphology, Atomic Force Microscopy

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Contribution ID: **11** Type: **not specified**

Non-Thermal Plasma Engineered Mn-Ferrite Quantum Dots Embedded Polydopamine for Biosensing Applications

Micro discharge plasma (MDP) is a non-thermal, non-equilibrium technique that offers precise control over nanomaterial synthesis. By adjusting MDP operating parameters, enables effective control of particle size, structure, and morphology through plasma driven chemical reactions that control the properties of nanomaterials. In this work, manganese ferrite quantum dots (MFQDs) were synthesized and were embedded in situ within the polydopamine (PDA) matrix to form hybrid nanostructures using MDP with oxygen as the plasma gas. The role of PDA in particle size, phase formation, and morphology was systematically investigated. Optical emission spectroscopy was employed to monitor the reactive plasma species during the synthesis which confirms the presence of hydroxyl radical (OH•) and atomic oxygen (O). XRD showed that PDA added system produced phase pure spinel $MnFe_2O_4$, while FTIR identified characteristic PDA functional groups (C-N, C=C, N=H) along with metal oxygen bonds. XPS revealed the coexistence of mixed Mn^{2+}/Mn^{3+} and Fe^{2+}/Fe^{3+} oxidation states as well as carbon related bonds (C-O, C-C, C-N, C=C, C-H), indicating strong MFQD–PDA interaction. HRTEM showed MFQDs of 6 to 9 nm, embedded within PDA spheres and layered structures, with reduced aggregation and the formation of hybrid structure. The peroxidase-like activity of MFQDs–PDA hybrid nanostructures was evaluated using a TMB–H_2O_2 colorimetric assay, showing distinct blue colour development with significantly higher absorbance at 652 nm. The corresponding kinetic parameters ($V_(max)$ & K_m) were evaluated which was found to be superior to that of pristine $MnFe_2O_4$, indicating enhanced catalytic activity after PDA incorporation. These results demonstrate that PDA significantly improves peroxidase-like catalytic performance, making the MFQDs–PDA hybrid nanostructure a promising platform for enzyme free biosensing.

Keywords: Micro discharge plasma, $MnFe_2O_4$, Polydopamine, hybrid nanostructure, peroxidase mimetic.

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Coupled Surface-Wave Dynamics and Acoustic Wave propagation in a Microwave Atmospheric Pressure Plasma Jet

The interaction of surface waves with atmospheric-pressure plasmas critically governs plasma stability, energy transport, and wave–matter coupling [1]. In this study, we investigate surface-wave interactions and their role in acoustic emission generation in a microwave atmospheric pressure plasma jet (MW-APPJ) operated in continuous-wave mode. Audible acoustic emissions were reproducibly observed within two microwave power regimes, 220-360 W and 570-620 W. Experiments were performed under well-controlled conditions, including different gas flow rates, mixture of gases, and an air swirl flow of 45 lpm, a water-cooling flow rate of 6 lpm, and variable sliding-short positions, to systematically analyze plasma-wave coupling. Acoustic signals were acquired using a calibrated microphone and analyzed via Fast Fourier Transform (FFT) in MATLAB to determine dominant frequency components and their dependence on operating parameters. Concurrently, plasma column fluctuations were characterized using optical emission spectroscopy to estimate variations in electron number density (ne) and electron excitation temperature (Texc). Gas temperature fluctuations were measured with a K-type thermocouple, while high-speed imaging captured the spatiotemporal dynamics of the plasma plume.

The results demonstrate a strong correlation between surface-wave interference, plasma instabilities, and acoustic wave generation. Interference between counter-propagating surface waves near the applicator induces periodic modulation of plasma parameters, producing pressure perturbations that manifest as acoustic emissions. This work provides direct experimental evidence of surface-wave-driven acoustic generation in MW-APPJs and advances the understanding of coupled wave plasma acoustic phenomena, with implications for plasma diagnostics, source optimization, and plasma-assisted applications [2].

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Numerical Stability Analysis Of The Edge Harmonic Mode In Boundary Region Of Magnetized Fusion Plasmas

Computational framework implemented for simulation of low frequency three dimensional electrostatic edge harmonic mode observed near the vicinity of the plasma boundary region of tokamak configuration. The underlying driven mechanism associated with this particular mode identified. In addition, several distinct forms of stabilization mechanism has also been recognized. Two-fluid based model for this mode solved analytically in linear limit to obtain the growth rate. In the computational analysis, the full 3-D model was systematically reduced to 2-D and later to 1-D by applying appropriate symmetry, dimensionality and scale separation assumptions. These simplified models were rigorously compared with the respective modes to confirm that they accurately captured the dominant features of the original system. The system also evolved numerically with the specific background profiles and with different initializations to obtain numerical growth rate which compared with the analytical growth rate.

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Contribution ID: **14** Type: **not specified**

Influence of Process Parameters on the Thermal Plasma Driven Aluminothermic Processing of Manganese Ore

Manganese (Mn) is a critical component in the production of ferrous and non-ferrous alloys. It is primarily sourced from high-grade ores (>40% Mn) typically containing Fe, Al, and Si oxides [1]. While conventional hydrometallurgical and carbothermal reduction methods generate toxic secondary waste, the aluminothermic process offers an environmentally friendly alternative. However, standard aluminothermic reduction often requires significant external energy to initiate the reaction and achieve efficient metal–slag separation. This study investigates the recovery of Mn and associated metals using a thermal plasma-assisted aluminothermic process. The starting ore composed of $MnAl_2(SiO_4)_3$, SiO_2, and Fe_3O_4 phases with oxide concentrations of MnO (36%), SiO_2 (21%), Al_2O_3 (22%), and FeO (17%). TG-DSC analysis revealed that the aluminothermic reaction between molten Al and solid metal oxides initiates at approximately 960 ℃. Consequently, the thermite mixture was treated using a transferred arc plasma (at 3, 5, and 7 kW) under Ar, Ar + H2, and air atmospheres to optimize recovery. The plasma successfully initiated and sustained the reaction, generating a molten product that facilitated clean separation between the metal and oxide phases. The resulting products included a Mn-rich metal fraction that containing Fe, Si, and Al, suitable for steelmaking applications and a slag fraction that composed of Al_2O_3, Mn_2SiO_4, $FeSiO_3$, and Al_2SiO_5, with potential utility as a refractory material in the cement industry. Residual Mn in the slag suggests insufficient aluminium addition or high slag viscosity. These limitations can be mitigated by reducing ore particle size, improving the wettability between liquid Al and the ore, or adding fluxes to decrease viscosity. With further parameter optimization, this scalable, non-toxic approach may provide a commercially viable pathway for large-scale Mn ore processing.

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Contribution ID: **15** Type: **not specified**

APPEL Linear Device: A Test-bed for Tokomak plasma studies

The APPEL (Applied Plasma Physics Experiments in Linear) device is a versatile linear plasma facility that can support a wide range of experiments, such as plasma-wall interaction studies, pre-ionization start-up experiments, and ion heating investigations, making it an ideal test bed for both fundamental and applied plasma research. The device operates over a wide gas pressure range, from 10-4 mbar to 10−2 mbar, and can sustain steady-state axial magnetic fields of up to 0.41 T with high radial uniformity. Recent experiments have demonstrated particle fluxes on the order of 10ˆ22 mˆ-2sˆ−1-10ˆ22mˆ−2sˆ−1, enabling effective studies of plasma material interactions. The linear configuration provides a controlled environment for examining plasma generation, RF power coupling, and plasma uniformity under conditions relevant to tokamak plasma. Pre-ionization studies conducted in the APPEL device using a spiral antenna achieved a density of the order of 1016 m^{-3}.

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Contribution ID: **16** Type: **not specified**

Numerical Simulation of Obstacle-Induced Solitons in Strongly Coupled Plasmas

Nonlinear wave structures (solitons) in strongly coupled Plasmas arise from the interplay of dispersion, nonlinearity, screening, and interparticle correlations [1-3]. Depending on the Mach number, a moving or localized source can excite upstream precursor solitons or pinned solitons that remain locked to the source [4]. In this study, precursor and pinned solitons are first analyzed within the Quasi-Localized Charge Approximation (QLCA) framework, which provides useful insights but exhibits limitations when applied across broad ranges of the coupling parameter Γ and screening parameter κ. To overcome these restrictions, we develop a unified fluid framework [2] with a realistic equation of state and a forced Korteweg–de Vries formulation, enabling a consistent description over an extended parametric space [3]. A central outcome is the identification of the boundary separating precursor and pinned soliton regimes in Yukawa systems. We demonstrate that this transition is governed primarily by screening, with only weak dependence on coupling strength. The theoretical predictions are validated using pseudo-spectral fluid simulations and molecular dynamics.

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(2) Prince Kumar, D. Chakraborty and Devendra Sharma, Contribution to plasma physics, (2025)
(3) Prince Kumar and Devendra Sharma, Journal of plasma physics (2025)
(4) P. Bandyopadhyay and A. Sen, Reviews of Modern Plasma Physics 6 (2022): 28

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Contribution ID: **17** Type: **not specified**

Synthesis of Zinc Oxide Nanoparticles from Spent Battery Wastes via Laser Ablation Technique for Photocatalytic Dye Degradation Application.

The recycling of waste materials into reusable resources plays a crucial role in environmental sustainability and waste reduction. Rapid industrialization and urbanization have led to the large-scale accumulation of electronic waste, among which spent batteries represent a valuable secondary source of functional materials [1]. In addition to that, among various forms of pollution, water pollution is regarded as the most hazardous to the environment due to large amount of effluents discharged from textile and dyeing industries that leads to a serious ecological threat. Production of efficient catalyst to degrade the dyes from waste materials reduces the environmental pollution, resources scarcity and production costs. In recent years, metal oxide nanoparticles (MO NPs) have emerged as promising candidate for dye degradation. Among MO NPs, zinc oxide nanoparticles (ZnO NPs) exhibit excellent photocatalytic activity, because of their physico-chemical properties, chemical & thermal stability and non-toxicity [2,3]. Conventional nanoparticle synthesis methods are often constrained by complex processing requirements and huge processing time. Laser ablation provides a straightforward and environmentally sustainable alternative for the one-step synthesis of high-purity nanoparticles without the use of chemical reagents or stabilizing agents. Compared to other laser ablation techniques, continuous wave fibre laser (CWFL) provides steady energy density, ensures rapid and controlled ablation [4]. Bearing this in mind, an attempt was made to synthesize ZnO NPs from spent battery waste using CWFL ablation technique. Structural, elemental, and functional group analyses evidenced the formation of ZnO NPs. The photocatalytic performance of the synthesized ZnO NPs was evaluated through the degradation of methylene blue (MB) and rhodamine B (RhB) dyes under UV and solar irradiation. The results demonstrated a progressive decrease in dye concentration with increasing irradiation time, achieving a maximum degradation efficiency of~ 99% under solar and UV light. These findings highlight the potential pathway for sustainable resource utilization by converting spent battery waste into high-purity ZnO NPs with superior photocatalytic activity.

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Contribution ID: **20** Type: **not specified**

On the Electromagnet set up for Compact Plasma System (CPS) at Ravenshaw University and measurement of transverse velocity of argon plasma, "Blob"moving in a magnetic topology

Coherent plasma structures, "Blobs"are responsible for cross field transport in magnetically confined plasmas. Washer plasma gun is a robust device to produce plasma blobs. The transport of matter and energy in magnetically confined devices are an important area of current research in plasma physics. We have designed a washer stacked plasma gun which is a very robust device to produce moving plasma structures, "Blobs ". We have created a magnetic topology inside the experimental chamber by using electromagnet. The magnetic strength at different axial and radial positions are measured using magnetic pick-up coil duly calibrated. The same is compared with the theoretical value. The magnetic topology inside the CPS device is reported in this communication. The transverse velocity of argon plasma blob, produced from a washer stacked plasma gun, moving in magnetic topology is measured and reported in this communication.

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Contribution ID: **21** Type: **not specified**

Revisiting Newton's 340-year-old Third Law: A Generalized or Extended Form within Newtonian Mechanics.

Revisiting Newton's 340-year-old Third Law: A Generalized or Extended Form within Newtonian Mechanics.

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Abstract

Newton's law asserts the equality and simultaneity of action–reaction force pairs. The law is examined within the Newtonian framework under realistic interaction conditions, extending its applicability to real-world systems relevant to contemporary theoretical and experimental investigations. Newton primarily applied the law qualitatively in Principia, illustrating it through three examples involving macroscopic interactions. Simple rebound experiments show that spherical bodies can retrace their original line of fall and rebound to comparable heights under suitable conditions, whereas asymmetrical or flat bodies exhibit reduced rebound heights and oblique rebound trajectories. The original formulation neglects several interaction-dependent factors, including material properties of bodies, rotation, spin, orientation, contact geometry, and deformation during interaction. Consequently, the law is treated as independent of these factors and is therefore held universally. In horizontal motion the characteristics of the surface are also significant. The prevailing descriptions based on impact force and the coefficient of restitution are inadequate for quantitatively explaining the rebound heights of bodies with varying shapes and material compositions. Motivated by the above qualitative experimental trends and supported by historical and conceptual analysis, a generalized form of Newton's third law is proposed in which the reaction force is modified or extended by dimensionless coefficients accounting for shape, composition, target surface, and other interaction parameters, and expressed as
Reaction (FBA) = − [Kshape × Kcomposition × Ktarget × Kother] Action (FAB)
The generalized form reduces to the original form under suitable conditions of parameters and provides an experimentally testable framework for quantitative confirmation at the macroscopic level. Over time, applications of Newton's third law have been extended to diverse systems, including aerodynamics and aerospace propulsion, each of which requires separate quantitative analysis.

Key Words. Third law, falling and rebounding bodies, shape, composition, and rocket.

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Contribution ID: **22** Type: **not specified**

A Time-Dependent Study of Radio-Frequency Plasma Sheaths Using the Flux-Corrected Transport (FCT) Algorithm

Plasma sheaths are non-neutral boundary layers that form adjacent to material surfaces due to the higher mobility of electrons relative to ions, establishing a strong electrostatic field normal to the boundary. Under steady-state (DC) conditions, sheath formation is governed by the Bohm criterion, which requires ions to enter the sheath with a velocity exceeding a critical value [1–3]. This time-independent limit provides a fundamental benchmark for more general time-dependent sheath models.
In many practical plasma applications, electrodes are often driven by radio-frequency (RF) sources, introducing explicit time dependence into the sheath dynamics through oscillatory boundary conditions. In RF-driven sheaths, the sheath potential ∅s(t), sheath width ds(t), and electric field E(x,t), vary periodically in time, leading to modulation of ion acceleration and energy deposition at the boundary. The characteristic ion response depends on the ratio of the RF frequency ω to the ion plasma frequency ωpi. For ω ≪ωpi ions respond quasi-statically to the instantaneous sheath electric field, whereas for ω~ωpi, ion motion becomes significant and a fully time-dependent treatment is required. Many analytical RF sheath models, therefore, rely on simplifying assumptions such as cold ions, negligible ion inertia, or time-averaged electric fields, which restrict their validity in regimes where finite ion temperature and pressure effects play an important role.
Motivated by these limitations, the present work develops a fully time-dependent fluid model for collision-less RF plasma sheaths [4], incorporating ion pressure effects and driven by a sinusoidal current source. The complete set of ion fluid equations is solved numerically using a flux-corrected transport (FCT) algorithm to ensure stability and accuracy. An equivalent circuit model is coupled self-consistently with the fluid equations to relate the instantaneous sheath potential to the sheath thickness. The present model provides an enhanced and self-consistent description of RF sheath dynamics, particularly in regimes where pressure effects cannot be overlooked

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Contribution ID: **23** Type: **not specified**

Physics Informed Neural Network Approach for Numerical Solution of Heat Equation

Background: Heat conduction is a fundamental physical process governing thermal energy transport across diverse media. While traditional numerical methods (e.g., Finite Difference) are physically powerful, they often require complex meshing and can be computationally expensive for high-dimensional. The heat equation serves as the primary mathematical framework for modeling these diffusion-driven transport phenomena.
Purpose: The objective of this work is to obtain the solution of the heat equation using Physics-Informed Neural Networks (PINNs).
Methodology: A physics-informed neural network is formulated by embedding the governing heat equation, along with the prescribed initial and boundary conditions, into the loss function through residual based terms of a neural network. Automatic differentiation is employed to compute the required spatial and temporal derivatives. The network is trained using collocation points sampled across the space–time domain, without the need for labeled training data.
Results: The PINN-based solution exhibits excellent agreement with the actual solution of the one-dimensional heat equation, correctly reproducing the spatial temperature profiles and their temporal evolution. The study highlights the effectiveness of PINNs as a reliable alternative to traditional numerical methods and establishes a foundation for extending the approach to higher-dimensional heat conduction problems.

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Contribution ID: **24** Type: **not specified**

LANTANA CAMARA DILUTE ACID HYDROLYSIS

Optimization of Acid Hydrolysis of Lantana camara Biomass for Reducing Sugar Production toward Biofuels and Bioproducts

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Abstract
One of the most destructive invasive plant species is Lantana camara, which displaces native plants and changes ecosystem functions, leading to extensive ecological and economic damage. However, its fast replication and significant lignocellulosic biomass production create an opportunity for sustainable valorization via bioprocessing. The current work focuses on the process optimization of total reducing sugars as a prospective bio-based application derived from dilute acid hydrolysis of L. camara biomass. Hydrolysis was performed at a constant temperature of 120 ℃ and a solid loading of 1:10 (w/v). A systematic evaluation of the effects of acid concentration (0.5–3.0%) and residence time (15–60 min) was implemented. It was found that both parameters had a significant effect on sugar yield. The highest levels of combined reducing sugars were achieved at an acid concentration of 3% and residence time of 30 min. The pentose rich acid hydrolysate generated under optimized conditions can serve as suitable substrates for bioethanol production via modified ethanologenic strains, as well as bioproducts such as xylitol. The findings demonstrate an effective strategy for converting invasive biomass into renewable resources, offering a dual benefit of ecological management and sustainable bio-based production.

Keywords: Invasive weed management, Biomass valorization, Hemicellulose, Bioprocessing

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Contribution ID: **26** Type: **not specified**

Application of Thermal Plasma in hydrogen production

Hydrogen is one of the best alternatives to traditional fuels for developing carbon-less energy resources. However, the hydrogen containing resources are utilized to generate hydrogen. Traditionally, methane (CH4) is used in industries to generate hydrogen while acetylene (C2H2) is used to form carbon black. A popular method to generate hydrogen from methane is steam methane reforming (SMR) [1]. However, SMR generates CO2 which is released in atmosphere. Hence, a challenge remains to develop a method which will not emit carbon products. One such method is pyrolysis of methane by thermal plasma [2]. Now, thermal plasma has high temperature which is essential to dissociate molecules into their constituents.
In this study, different hydrocarbons like CH4, C2H2 was used as source of hydrogen. The DC-arc thermal plasma reactor was used to pyrolyze these hydrocarbons. The product gas was collected and analyzed by GC-MS while the carbon products were analyzed using XRD, Raman spectroscopy and electron microscopy.
The systematic efforts have been undertaken to understand the effect of different plasma plume gases on the hydrogen production efficiency and carbon morphology. Further, the hydrocarbon gases have been flowed through different temperature regions. This variation has also been checked for hydrogen efficiency and carbon products formed.
The hydrogen efficiency is found in range of 60-90% while the carbon products differ from amorphous to crystalline as well as their morphology changes depending on the various factors. Further, carbon products are tested for energy applications like supercapacitor.

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Contribution ID: **27** Type: **not specified**

Fabrication and Characterization of Spinel $SrFe_2O_4$ Nanoparticles by Sol-Gel Method

Strontium ferrite ($SrFe_2O_4$) nanoparticles with a spinel structure were prepared using the sol-gel method. The structural, dielectric, and optical properties of the nanoparticles were investigated using X-ray diffraction (XRD), LCR measurements, UV-visible spectroscopy, and photoluminescence (PL) spectroscopy. XRD results confirmed the formation of a single-phase cubic spinel structure at 700 ℃. Scanning electron microscopy showed that the particles are fairly uniform, though their magnetic nature causes some aggregation. The dielectric behavior was studied at room temperature over frequencies from 20 Hz to 10 MHz. It was observed that the dielectric constant and loss increase as frequency decreases, while AC conductivity rises, which can be explained by the Maxwell-Wagner model. UV-visible measurements indicated that the energy gap of the nanoparticles decreases with increasing temperature. PL analysis revealed an emission peak in the ultraviolet region, resulting from the recombination of free excitons, also known as near-band-edge (NBE) emission.

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Contribution ID: **28** Type: **not specified**

Synthesis and Characterization of Barium Spinel Ferrite nano material using sol gel method

$BaFe_2O_4$ is an emerging functional ferrite material known for its versatile magnetic, optical, and electrochemical properties. Owing to its orthorhombic spinel-like crystal structure slightly different from typical spinal structure and narrow band gap, $BaFe_2O_4$ has gained attention for applications in energy storage, photocatalysis, sensing, and environmentally sustainable technologies.

$BaFe_2O_4$ nanomaterials have attracted increasing research interest due to their multifunctional structural, optical, magnetic, and electrochemical properties, making them promising candidates for energy, sensing, photocatalytic, and environmental applications. We want a comprehensive investigation of $BaFe_2O_4$ nanomaterials synthesized via an eco-friendly green sol–gel route, emphasizing sustainable material development without the use of toxic chemical chelating agents. Plant-derived extracts rich in phytochemicals such as flavonoids, polysaccharides, and phenolic compounds are employed as reducing, chelating, and stabilizing agents to facilitate controlled phase formation and nanoscale morphology.

Although several studies have successfully synthesized $BaFe_2O_4$ through soft-chemical routes such as the Pechini method, there is still a lack of research specifically focused on plant-based green sol–gel synthesis.
We have synthesized Barium Spinel Ferrite nano material and structural properties like average particle size is reported in this communication.

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Contribution ID: **29** Type: **not specified**

Neutrino Oscillations with Earth Matter Effects: A PREM-Based Analysis

A precise understanding of matter effects is essential for neutrino oscillation experiments that aim to explore leptonic CP violation. As neutrinos propagate through the Earth, coherent forward scattering with electrons modifies their oscillation behavior, and these effects depend sensitively on
the underlying matter density profile. In this work, we study three-flavor neutrino oscillations in vacuum and matter by incorporating a realistic Earth density distribution based on the Preliminary Reference Earth Model (PREM). The neutrino evolution equations are solved numerically with a position-dependent matter potential, and the resulting oscillation probabilities are compared with those obtained using commonly employed constant-density approximations. Particular emphasis is placed on CP-sensitive νμ → νe appearance probabilities relevant for long-baseline neutrino experiments. Our study highlights the role of realistic Earth matter modeling in achieving reliable predictions for precision oscillation studies.

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Contribution ID: **30** Type: **not specified**

Space-Charge compensation in low energy beam transport

Co-traveling ion beams interact with one another along the beam transport path primarily through space-charge (SC) forces (coulomb), which can significantly influence beam propagation and power transport efficiency of multi-beam group-based ion sources. Previous studies in the ROBIN source have shown the role of SC interactions during transport, and their correlation with the accelerator parameters [1]. However, during transport, the charge state of the beam species evolves due to collisions with the background neutral gas, accompanied by the generation of secondary charged particles through beam-induced ionization processes [2]. These mechanisms lead to a partial neutralization of the beam space charge, thereby mitigating inter-beam Coulomb interactions. For extended transport lengths (˜ 1 - 10 m), the background gas pressure is spatially non-uniform due to the location of pumps and different beamline components, and follows a characteristic pressure profile. In the present work, the neutral gas density profile along the transport line is computed using Molflow+, a dedicated Monte Carlo–based code designed for pressure calculations inside a vacuum chamber in the molecular flow regime [3]. The resulting pressure profile is subsequently employed to evaluate beam-induced ionization rates and to model the evolution of beam species and secondary charged particles along the transport path [4]. These studies are aimed at understanding and optimizing space-charge effects in high-power ion beam transport and contribute to improving the power transport performance of large-area neutral beam sources developed for fusion reactor applications.

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Contribution ID: **32** Type: **not specified**

Green synthesis of nano materials against bacteria and viruses for treatment of pathogen

Green synthesis of nano materials against bacteria and viruses for treatment of pathogen

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Abstract
Green synthesis of nanomaterials has emerged as an eco-friendly, cost-effective and sustainable alternative to conventional chemical and physical methods. In the present study nanomaterials were synthesized using plant-based biological extracts as reducing and stabilizing agents, eliminating the use of toxic chemicals. The antimicrobial efficacy of the green-synthesized nanomaterials was evaluated against selected pathogenic bacteria and viruses. Antibacterial activity was assessed using the well diffusion method, and zones of inhibition were measured to determine the effectiveness of the nanomaterials at different concentrations. The results demonstrated significant inhibitory activity against both Gram-positive and Gram-negative bacteria, indicating strong antimicrobial potential. Additionally antiviral activity showed promising pathogen suppression, highlighting the therapeutic relevance of this nanomaterial. The study concludes that green-synthesized nanomaterials possess potent antibacterial and antiviral properties and can serve as a promising alternative for the treatment and management of pathogenic infections in biomedical applications.

Keywords: Green synthesis, nanomaterial, antibacterial activity, well diffusion method , Biomedical applications

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Contribution ID: **33** Type: **not specified**

Iron -basec nano biocatalytic systems for lignocellulosic biomass hydrolysis for bioethnol production.

The growing demand for renewable energy has accelerated research on efficient enzymatic conversion of lignocellulosic biomass into biofuels. However, the large-scale application of free cellulase enzymes is limited by high cost, low stability, and poor reusability. Iron-based nanobiocatalytic systems, particularly cellulase immobilized on iron oxide nanoparticles, have emerged as effective solutions to these challenges. This paper highlights the application of iron oxide nanoparticle-immobilized cellulase in biofuel production and biorefinery processes. The magnetic nature of iron oxide nanoparticles enables easy separation and repeated reuse of enzymes, while their high surface area and tunable surface chemistry improve enzyme stability and catalytic efficiency. Recent studies demonstrating enhanced saccharification performance and reduced enzyme loading are discussed. Key challenges, including enzyme leaching, nanoparticle aggregation, mass transfer limitations, and scale-up feasibility, are also addressed. Overall, iron-based nanobiocatalysts offer a sustainable and promising platform for advancing lignocellulosic biofuel technologies.
Keywords: Lignocellulosic biomass Biocatalysts, cellulase immobilization, iron oxide nanoparticles, biofuel production,Feasibility is also addressed. Overall, iron-based nanobiocatalysts offer a sustainable and promising platform for advancing lignocellulosic biofuel technologies. Keywords: Iron-based nanobiocatalysts, cellulase immobilization, iron oxide nanoparticles, biofuel production, lignocellulosic biomass.

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Contribution ID: **34** Type: **not specified**

Analysis of microplastic in river water.

Analysis of Microplastic Pollution in Water

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Abstract
Microplastic pollution has emerged as a critical environmental concern due to its widespread presence and persistence in aquatic ecosystems. This study presents a comprehensive analysis of microplastic pollution in water, aiming to assess its occurrence, distribution, and potential environmental implications. Water samples were collected from selected aquatic environments and analysed using standardized sampling, filtration, and stereomicroscopic examination techniques for the identification and characterization of microplastics. The extracted microplastic particles were categorized based on size, shape, color, and polymer type to better understand their sources and behaviour in aquatic systems. The results revealed a significant presence of microplastics across all sampled locations, with fibers and fragments identified as the dominant forms under stereomicroscopic observation. Size distribution analysis indicated a higher abundance of particles smaller than 1 mm, highlighting their increased potential for ingestion by aquatic organisms. Variations in microplastic concentration were observed among sampling sites, suggesting the influence of anthropogenic activities such as urban discharge, wastewater effluents, and improper plastic waste management. The detection of diverse polymer types further indicates multiple sources of plastic input into water bodies. This study underscores the growing threat posed by microplastic pollution to aquatic environments, including potential risks to aquatic life and human health through bioaccumulation and trophic transfer. The findings emphasize the urgent need for improved waste management strategies, enhanced public awareness, and strengthened regulatory measures to mitigate microplastic pollution. Overall, this research provides valuable baseline data for future monitoring efforts and supports the development of effective strategies to address microplastic contamination in water resources.

Keywords: Microplastic, Plastic pollution, fibers, fragments, water contamination.

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Contribution ID: **35** Type: **not specified**

Analysis of Microplastic Pollution in Water

Analysis of Microplastic Pollution in Water

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Abstract
Microplastic pollution has emerged as a critical environmental concern due to its widespread presence and persistence in aquatic ecosystems. This study presents a comprehensive analysis of microplastic pollution in water, aiming to assess its occurrence, distribution, and potential environmental implications. Water samples were collected from selected aquatic environments and analysed using standardized sampling, filtration, and stereomicroscopic examination techniques for the identification and characterization of microplastics. The extracted microplastic particles were categorized based on size, shape, color, and polymer type to better understand their sources and behaviour in aquatic systems. The results revealed a significant presence of microplastics across all sampled locations, with fibers and fragments identified as the dominant forms under stereomicroscopic observation. Size distribution analysis indicated a higher abundance of particles smaller than 1 mm, highlighting their increased potential for ingestion by aquatic organisms. Variations in microplastic concentration were observed among sampling sites, suggesting the influence of anthropogenic activities such as urban discharge, wastewater effluents, and improper plastic waste management. The detection of diverse polymer types further indicates multiple sources of plastic input into water bodies. This study underscores the growing threat posed by microplastic pollution to aquatic environments, including potential risks to aquatic life and human health through bioaccumulation and trophic transfer. The findings emphasize the urgent need for improved waste management strategies, enhanced public awareness, and strengthened regulatory measures to mitigate microplastic pollution. Overall, this research provides valuable baseline data for future monitoring efforts and supports the development of effective strategies to address microplastic contamination in water resources.

Keywords: Microplastic, Plastic pollution, fibers, fragments, water contamination.

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Contribution ID: **36** Type: **not specified**

EXPERIMENTAL AND SIMULATION STUDIES OF ION MASS DEPENDENCE ON ION BEAM DIVERGENCE

Low-energy broad beam ion sources are essential components in a wide range of advanced technologies, including neutral beam injectors (NBIs) for fusion research, plasma diagnostic systems, electric propulsion for spacecraft, and ion-based material surface modification processes. These ion sources produce ion beams by extracting and accelerating ions through multi-aperture, multi-grid structures under the influence of applied electric fields. The positive space charge of the extracted ion beam is compensated by electrons supplied either through charge-exchange processes or by thermionic emission from heated cathodes. Beam divergence, which measures the spread of ions in the radial direction and impacts the beam quality and transport efficiency, is influenced by factors such as beam perveance and space charge effects. In this study, the radial profiles of argon and xenon ion current densities from a ring cusp ion source were experimentally measured using a two dimensional Multi-channel Faraday cup array. The measured beam divergences are benchmarked against self-consistent beam extraction and transport simulations using the AXCEL-INP code and CST PARTICLE STUDIO. Based on these results, the role of ion mass and space-charge effects in ion beam divergence will be discussed.

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Contribution ID: **37** Type: **not specified**

A Computational Framework for One-Loop Radiative Neutrino Mass Generation

Neutrino oscillation experiments establish that neutrinos have nonzero but very small masses, which is beyond the scope of Standard Model of particle physics. Radiative neutrino mass models address this by generating neutrino masses at the loop level, naturally suppressing their scale. By considering the scotogenic model, this study established a framework for the minimal mass of neutrinos at the one-loop level. The framework includes generic Yukawa couplings, heavy fermion masses, and scalar mass splittings to construct the Majorana neutrino mass matrix, which is then diagonalized to obtain neutrino mass eigenvalues and a Pontecorvo–Maki–Nakagawa–Sakata like mixing matrix. This setup provides a clear and flexible method to study neutrino mass generation and related phenomenology. By imposing a discrete Z_2 symmetry, the framework can be extended to ensure the stability of the lightest Z_2 -odd particle, making it a viable dark matter candidate. The dependence of neutrino masses and mixing parameters on model inputs such as Yukawa couplings and heavy fermion masses can be systematically studied.

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Contribution ID: **38** Type: **not specified**

Electrical characterization of sub-atmospheric pressure alternating current carbon dioxide plasma

Carbon Capture and Utilization (CCU) is essential for mitigating climate change by re-purposing CO_2 emissions into sustainable fuels and chemicals. A pivotal step in this process is the conversion of CO_2 into carbon monoxide (CO), a precursor for syngas, methanol, and Fischer-Tropsch hydrocarbons. While traditional thermal and electrochemical methods often suffer from high costs, limited scalability, and the need for harsh operating conditions [1], plasma-based technologies offer a promising alternative. These systems can be driven by renewable energy and utilize electron-driven mechanisms to dissociate CO_2 at milder temperatures [2, 3]. In this study, we utilize a sub-atmospheric alternating current (AC) plasma system to investigate the electrical characteristics of pure CO_2 plasma. By analyzing current-voltage profiles and plasma power via Lissajous figures across varying pressures[4], we aim to determine the optimal power requirements for efficient CO_2 dissociation.

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Design and Development of a Multi-Functional DC Glow Discharge Plasma Reactor for Targeted Surface Engineering and Thin-Film Synthesis

Abstract:
The transition from fundamental plasma physics to translational material science requires robust, scalable hardware capable of precise plasma-matter interactions. While plasma processing is a staple in semiconductor manufacturing, there is a lack of accessible, versatile systems capable of handling the diverse requirements of 2D/3D nanomaterials, polymers, and complex oxides in a single environment. This work presents the indigenous design and development of a Customized DC Glow Discharge Plasma Reactor optimized for the dual purpose of surface modification and plasma-assisted thin-film deposition.
This work details the design and indigenous development of a multi-functional DC Glow Discharge Plasma Reactor engineered for dual-mode operation: Surface Modification and Thin-Film Deposition. Drawing from our previous research—which demonstrated that the reactor effectively modulates the electrical conduction mechanisms and dielectric characteristics of rare-earth orthoferrites by controlling oxygen vacancy density through plasma dose management. It also aims to enhance β-phase nucleation in Graphene/P(VDF-TrFE) reinforced polymer composites films —a result traditionally difficult to achieve without high-temperature annealing. The reactor features a variable-gap and dc power supply, parallel-plate electrode geometry and a multi-gas inlet manifold for Air, Ar, N2, or O2 that maintains precise working pressures between 10-2 and 10-3 mbar. To ensure material versatility, an integrated water-cooled substrate holder allows for the simultaneous processing of heat-sensitive composite polymers and high-temperature ceramics without structural degradation.

Keywords: DC Glow Discharge; Thin-Film Deposition; Surface Modification; Graphene-Polymer Composites

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Magnetic Field–Assisted Thermal Arc Plasma Synthesis of Core/Shell Fe-based Nanoparticles and Their Magnetic Properties

Core/shell Fe-based nanoparticles were synthesized using a thermal arc plasma technique. To investigate the influence of an external magnetic field, synthesis was carried out in a helium atmosphere at an arc current of 50 A and atmospheric pressure, both in the presence and absence of a transverse magnetic field of approximately 100 G applied perpendicular to the plasma plume.

Transmission electron microscopy revealed well-defined core–shell architectures with predominantly spherical nanoparticles, whose size distribution was noticeably influenced by the applied magnetic field. Structural phase formation and elemental composition were verified using X-ray diffraction and elemental mapping. Magnetic measurements performed at 300 K showed a clear reduction in saturation magnetization (from ˜69 to ˜44 emu/g) and remanent magnetization (from 18 to 12 emu/g) for samples synthesized under magnetic field conditions. Additionally, variations in zero-field-cooled and field-cooled magnetization behavior further highlight the role of the magnetic field during nanoparticle formation.

These findings demonstrate that magnetic field–assisted thermal plasma synthesis provides an effective route for tuning the structural characteristics and magnetic properties of Fe-based core–shell nanoparticles, offering potential for applications in data storage, biomedical technologies, and energy-related systems [1-2].

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Wastewater treatment using constructed wetland of ornamental plants

Wastewater treatment using constructed wetland of ornamental plants
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Abstract
The continuous discharge of untreated domestic, industrial, and agricultural wastewater into natural water bodies poses serious threats to aquatic ecosystems and public health. Constructed wetlands (CWs) are recognised as cost-effective and environmentally sustainable wastewater treatment technologies, particularly suitable for developing countries. In this study, the performance of a constructed wetland planted with ornamental plant species was evaluated for wastewater treatment. The system was constructed using graded filter media layers and operated at different hydraulic retention times (HRTs) to assess pollutant removal efficiency. Performance analysis revealed significant reductions in biochemical oxygen demand (BOD), chemical oxygen demand (COD), total nitrogen (TN), and total phosphorus (TP). The results demonstrate that ornamental plants exhibit high adaptability, rapid growth, and strong pollutant uptake capacity, indicating their suitability for application in constructed wetland systems. Overall, the findings confirm that constructed wetlands planted with ornamental vegetation offer a sustainable, low-maintenance, and effective solution for wastewater treatment, particularly in peri-urban and rural areas of tropical developing regions.
Keywords: Constructed wetlands; Ornamental plants; Wastewater treatment; Nutrient removal; BOD; COD; Hydraulic retention time

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Contribution ID: **42** Type: **not specified**

Dynamics of Quasilocal Horizons: Black Hole and Cosmological

Black holes are described as regions from which light cannot escape to an asymptotically faraway observer, and the boundary of this black hole region is called an Event Horizon (EH). During the 70s-80s, the EH formulation had been used to study classical and quantum properties of black holes, including their thermodynamics. However, it has been understood that EH are teleological; their present dynamics depend on boundary conditions set at the future and hence, are not particularly suitable to understand dynamics. Therefore, it has become increasingly important that an alternate definition which is local in both space and time be used instead. The quasilocal formalism of Dynamical Horizons, based on Penrose's idea of trapped surface provides an ideal framework to study the gravitational dynamics of horizons. We shall take a large number of examples to establish that indeed both the black hole and the cosmological horizon may be viewed as the time development of trapped surfaces.

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Contribution ID: **43** Type: **not specified**

1D calculation of beam focusing by aperture displacement in ion extractor grids and effects of thermal expansion on focal lengths

Ion extractor grids are the beam-forming component of the ion source[1]–[3]. It plays a vital role in separation of ions from plasma source and accelerated to the desired energy for Neutral Beam (NB) production required for Tokamak plasma heating and current drive. Steady-State Superconducting Tokamak (SST) -1 NB Injection (NBI) system has rectangular ion extraction area of size 23 cm (W) × 48 cm (H). Beams originating from the extraction plane are horizontally focused (fh) at 5.4 m and vertically focused (fv) at 7 m respectively. This paper describes the MATLAB program developed based on 1D calculation of focusing of multi ion-beamlets by mechanical offset given to the apertures of ion extractor grids. A model of ion extractor grids assembly is presented and showed that effect of thermal expansion of the grids during beam extraction has minimum effect on horizontal and vertical focal length. This calculation is compared with experimental results and found good agreement. Also, the effects of thermal expansion of the grids on beam transmission is studied. It shows, as the grid temperature increases, transmission begins to decline, with values reducing to nearly 85% at $\Delta T \approx 25$ ℃, 84.4% at $\Delta T \approx 50$ ℃, and continuing to fall until it reaches about 83.8% at $\Delta T \approx 125$ ℃. The analysis validates that the thermal expansion model provides a reasonable prediction of experimental behaviour, emphasizing the importance of incorporating effective cooling strategies and mechanical design adjustments to minimize misalignment and ensure stable beam transmission under operational heating conditions.

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Taming Instability: Scaffold like Polyaniline for enhancing the sedimentation stability and their Influence on Stability-Magnetization Trade-Off in Viscoelastic Magnetorheological Fluids

Magnetorheological fluids (MRFs) rely on the dynamic interplay of magnetic interaction, particles dispersion, and viscoelastic response, yet achieving long-term sedimentation stability without significantly compromising magnetic properties remains a significant challenge. This study introduces a pioneering strategy by employing polyaniline (PAni) as a scaffold-like additive to enhance the sedimentation stability of Fe-based MRFs. The high surface area and porous architecture of PAni foster a supportive network that evidently enhances particle dispersion, achieving a sedimentation ratio of 43.97% at an optimal 2 wt. % PAni concentration—more than doubling the stability of bare Fe-based MRFs (20.88%). Brunauer–Emmett–Teller (BET) surface area analysis confirms that PAni's porous morphology (˜24× higher pore volume than Fe) facilitates enhanced particle dispersion and steric stabilization, mitigating gravitational settling. This investigation elucidates the nuanced trade-off between sedimentation stability and magnetic properties, offering a physics-driven framework to optimize MRFs for practical applications. The incorporation of non-magnetic PAni introduces a deliberate trade-off, wherein enhanced colloidal stabilization and steric hindrance come at the expense of reduced magnetic coupling efficiency and field-induced dipolar interactions. While the saturation magnetization (Ms) reduces from 218.16 emu/g (Fe) to 71.41 emu/g (Fe with 4 wt.% PAni) due to particle dilution and increased interfacial porosity, the magneto-yield stress remains sufficiently high—decreasing from 940.96 Pa to 437.83 Pa at H = 123 kA/m—preserving functional field-responsiveness. Oscillatory shear analysis reveals that storage modulus (G′) attains 2.22×10^5 Pa at 123 kA/m for FeP 2%, with $\tan\delta < 0.2$ in the linear viscoelastic regime, indicating a strongly elastic character necessary for dissipative control applications. The flow behavior transitions into a pronounced shear-thinning regime (n ˜ 0.7–0.9), which aligns with the breakdown of anisotropic field-induced structures under strain. This rheo-magnetic trade-off between PAni-induced stabilization and reduction in magneto-mechanical coupling is carefully optimized, yielding MRFs with sufficient magnetic actuation and improved structural fidelity. The insights provided herein offer a robust structure-property framework for designing application specific MRFs, where sedimentation stability, magnetic tunability, and rheological integrity must be simultaneously addressed.

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Contribution ID: **45** Type: **not specified**

Numerical Simulation of Hydrogen Atom using Physics -Informed Neural Networks

Numerical Simulation of Hydrogen Atom using Physics-Informed Neural Networks
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Abstract
Background: The hydrogen atom is the simplest bound quantum system and serves as a standard benchmark for testing numerical methods in quantum mechanics. Traditional numerical techniques, such as matrix-based approaches with predefined basis sets, often require domain truncation and careful treatment of singular potentials and boundary conditions.
Purpose: This study aims to apply Physics-Informed Neural Networks (PINNs) to solve the time-independent Schrödinger equation for the hydrogen atom, accurately determining energy eigenvalues and radial wavefunctions, and to assess the effectiveness of PINNs as an alternative computational approach for quantum systems.
Methods: The radial Schrödinger equation is solved using PINNs by approximating the radial wavefunction with a neural network. A physics-informed loss function is formulated by incorporating the residual of the Schrödinger equation along with the imposed boundary conditions. The energy eigenvalue is treated as a trainable parameter and optimized simultaneously with the network weights using gradient-based learning.
Results: The PINNs model accurately reproduces the ground and low-lying excited states of the hydrogen atom in atomic units. The predicted ground-state energy is -0.499 Hartree, showing an absolute error of 2.3 × 10−5relative to the exact value -0.500 Hartree. For the first excited states (⊠= 2, ⊠= 0) and (⊠= 2, ⊠= 1), the PINN yields energies of -0.136 Hartree and -0.140 Hartree, respectively, demonstrating close agreement with the analytical value -0.125 Hartree. The learned radial wavefunctions exhibit correct nodal structure and asymptotic behavior.
Conclusion: Physics-Informed Neural Networks provide an accurate and basis-free approach for solving the hydrogen atom Schrödinger equation. The quantitative agreement between PINN-predicted and exact energies, along with physically consistent wavefunctions, highlights the potential of PINNs as a robust computational framework for quantum mechanical systems.

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Contribution ID: **46** Type: **not specified**

Physics-Informed Neural Networks for determination of Vibrational Energy Levels of the HCl Molecule

Abstract
Background:
Understanding vibrational energy levels in diatomic molecules is fundamental to molecular spectroscopy and quantum chemistry, as these levels govern molecular structure and dynamics. However, conventional numerical approaches often rely on predefined analytical wavefunctions or supervised datasets, which can limit their applicability in the presence of anharmonic molecular interactions.
Purpose:
The purpose of this work is to develop a physics-informed neural network (PINN) framework to accurately compute the vibrational energy levels of the hydrogen chloride (HCl) molecule in a fully unsupervised manner.
Methods:
The vibrational dynamics of the HCl molecule are modeled using the one-dimensional time-independent Schrödinger equation, with the interatomic interaction described by the Morse potential to account for anharmonic effects. A PINN is constructed to simultaneously learn the vibrational wavefunctions, energy eigenvalues, and optimized potential parameters. The training process minimizes a composite loss function incorporating the Schrödinger equation residual, boundary conditions, normalization, and orthogonality constraints.
Results:
The optimized Morse potential parameters and the computed vibrational energy levels obtained from the PINNs show strong agreement with theoretical values. The network successfully captures the anharmonic vibrational behavior of the HCl molecule and accurately predicts multiple vibrational states without the use of labeled data.
Conclusions:
Overall this work shows that Physics informed neural network (PINNs) serves as powerful method to simultaneously determine the vibrational frequencies and molecular potential parameters, establishing PINNs as a powerful and data efficient framework for molecular spectroscopy and computational quantum chemistry.

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Contribution ID: **47** Type: **not specified**

Solving the Time-Dependent Schrödinger Equation for a Harmonic Oscillator and Extracting the Bohm Quantum Potential Using PINNs.

Background: Physics-informed neural networks (PINNs) are numerical methods for solving partial differential equations by embedding physical laws into the learning process. In quantum mechanics, they provide smooth approximations of wavefunctions, enabling the computation of standard observables as well as Bohmian quantities. The quantum harmonic oscillator is a fundamental model with applications in quantum mechanics and plasma physics, particularly for describing confinement and collective oscillations.

Purpose: This work aims to develop a PINNs - based framework for solving the one-dimensional time-dependent Schrödinger equation (TDSE) for the quantum harmonic oscillator and to extract physically relevant quantities, including the ground-state energy and the Bohm quantum potential, from the learned wavefunction.

Methods: A physics-informed neural network is used to represent the real and imaginary parts of the wavefunction through a fully connected architecture. The TDSE is enforced via the loss function together with appropriate initial and boundary conditions corresponding to the harmonic oscillator ground state. Training is carried out using randomly sampled space–time collocation points. Automatic differentiation is employed to evaluate the required derivatives, enabling computation of the ground-state energy from the Hamiltonian expectation value and the Bohm quantum potential from the wavefunction amplitude.

Results: The trained PINNs reproduces the ground-state wavefunction of the quantum harmonic oscillator and yields a ground-state energy consistent with the analytical value $\square = 0.5\hbar\square$. The Bohm quantum potential obtained from the network shows good agreement with the corresponding analytical expression, indicating that the model captures the essential spatial structure of the quantum amplitude.

Conclusions: These results indicate that physics-informed neural networks provide a viable approach for solving the time-dependent Schrödinger equation and for extracting Bohmian quantities. In the context of plasma physics, this framework may be useful for studying quantum confinement effects, effective potentials, and wave-particle interactions in dense plasmas where quantum effects play a role.

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Contribution ID: **48** Type: **not specified**

Solving Time-Independent Schrodinger Equation for a Double-Well Potential in Quantum Plasma Systems using Physics-Informed Neural Networks (PINNs)

Background: The time-independent Schrödinger equation is central to the description of bound states and quantum tunneling in double-well potential systems. Such potentials are important in molecular inversion phenomena and can also arise as effective quantum potentials in plasma environments due to external fields, confinement effects, and plasma-surface interactions. Conventional numerical approaches, such as finite-difference matrix methods, rely on spatial discretization and can become computationally demanding for accurate solutions.
Purpose: The purpose of this study is to investigate the applicability of Physics-Informed Neural Networks (PINNs) for solving the one-dimensional time-independent Schrödinger equation with a symmetric double-well potential and to obtain accurate ground and low-lying excited state solutions relevant to quantum plasma systems.
Methods: A Physics-Informed Neural Network framework is employed in which the wavefunction is represented using fully connected feedforward neural networks, while the energy eigenvalues are treated as trainable parameters. The Schrödinger equation is enforced through a residual-based loss function, supplemented by boundary condition, normalization, and orthogonality constraints. Even- and odd-parity neural network architectures are used to directly capture symmetric and antisymmetric eigenstates. The PINN solutions are validated by comparison with reference results obtained from a finite-difference-based matrix diagonalization method.
Results: The PINN approach successfully reproduces the ground and low-lying excited states of the double-well potential. In atomic units ($\hbar = 1$, ⊠ = 1), the ground-state energy is obtained as ⊠0 ≈ 1.973, compared to the finite-difference value ⊠0 ≈ 1.971. The first excited-state energy is predicted as ⊠1 ≈ 2.220, while the corresponding finite-difference result is ⊠1 ≈ 2.012. The second excited-state energy is also well captured, with PINN and finite-difference values of ⊠2 ≈ 4.911and ⊠2 ≈ 4.908, respectively. The small energy separation between the lowest two states reflects the near-degeneracy characteristic of symmetric double-well potentials, arising from quantum tunneling between the wells.
Conclusions: This study demonstrates that Physics-Informed Neural Networks provide an accurate and flexible alternative to traditional numerical techniques for solving the Schrödinger equation with double-well potentials. The approach is suitable for modeling tunneling phenomena and effective quantum potentials in plasma-related systems.

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Contribution ID: **49** Type: **not specified**

Black hole thermodynamics beyond Einstein gravity

We extend the isolated horizon formalism
to include rotating black holes arising in five dimensional Einstein- Gauss- Bonnet (EGB) theory of gravity, and derive the laws of black hole mechanics. This result allows us to show that the first law of black hole mechanics is modified, due to the Gauss- Bonnet term, so as to include corrections to (i) the area of horizon cross- sections and, to (ii) the expression of horizon angular momentum. Once these modifications are included, the Hamiltonian generates an evolution on the space of solutions of the EGB theory admitting isolated horizon as an internal boundary, the consequence of which is the first law of black hole mechanics. These boundary conditions may help in the search for exact solutions describing rotating black holes in this theory.

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Contribution ID: **50** Type: **not specified**

Effect of Axial Magnetic Field on Negative Ion Production in Asymmetric Cylindrical Capacitively Coupled Plasma

Electropositive argon plasma mixed with small fraction of electronegative oxygen gas is widely used in plasma processing applications such as etching, thin-film deposition, oxide formation and negative ion sources, where precise control over plasma density and negative ion concentration is essential for process optimization [1-4]. Since the plasma characteristics strongly depend on gas composition and external magnetic field, understanding the behavior of mixed electropositive-electronegative gas is an important topic of research.

In this study, we have experimentally investigated the production of negative ions in geometrically asymmetric cylindrical capacitively coupled radiofrequency (RF) plasma. The plasma is generated using a mixture of oxygen and argon gases. An axisymmetric magnetic field, varying from 0 to 10 mT is applied along the axial direction of the discharge chamber, which produces an azimuthal E×B drift. The effect of RF power and axial magnetic field on key plasma parameters such as electron, positive ion, and negative ion densities, negative ion fraction and electron temperature has been examined at a fixed gas pressure of 1×10^{-3} mbar. The experimental results explore a magnetic field domain for enhanced ionization and optimized negative ion production in cylindrical CCP discharges required for several applications.

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Broad Area:
Broad Area Plasma Sources and Diagnostics
Oral / Poster Oral

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Contribution ID: **51** Type: **not specified**

Realtime Measurements for Closed-Loop Control and Plasma Endpoint Detection for Wound Healing

The transient application of cold atmospheric pressure plasma (CAP) exposes cells to reactive oxygen and nitrogen species (RONS) which changes the redox status of cells immediately. However, several biological changes occur hours or days later. Therefore, it is difficult to establish relationships between applied doses and CAP effectors with biological outcomes and CAP dosing remains empirical. We used a cell model and a mouse model of wound repair to identify correlations between CAP effectors, early, intermediate and late molecular changes and their role in promoting healing. We used sub-optimal (no therapeutic benefit), optimal (improved wound repair as compared to untreated controls), and excessive (damage and poor wound repair) doses of CAP for each model. We used electrochemical wire sensors to monitor in situ two effectors in CAP, hydrogen peroxide (H2O2), and nitric oxide (NO). The immediate biological response to the different doses of CAP was determined by measuring calcium (Ca2+) release in the tissue culture fluid and wound bed. Oxidation-reduction potential (ORP) served as a combined indicator of CAP processes and biological responses. These sensor measurements were used to identify the threshold value of each, and a control scheme was developed to automatically terminate treatment once the desired concentration is reached. These studies lay the foundation for development of standardized treatment protocols.

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Contribution ID: **52** Type: **not specified**

Applications of Power Beams: Translation of Research Outcome into Industrial Solutions

New inventions and technologies are conceived every day, yet many remain dormant within the laboratory. Whether by oversight or missed connections, we often fail to breathe life into these innovations and bridge the gap to industrial application. Ultimately, process efficiency, environmental sustainability, and economic viability are the pillars that determine a product's marketability and demand. Guided by these principles, our team at Bharathiar University has targeted specific research areas designed for direct translation into industrial solutions. In this presentation, I will demonstrate how we have leveraged our research to develop market-need technologies through few case studies in the area of "waste to wealth"and advanced manufacturing:
1. Waste to wealth
i. Plasma-based reclaiming of gold and silver from jewellery wastes
ii. Plasma-assisted conversion of grinding sludge into value-added products
iii. Plasma processing of aluminum dross to produce micro- and nano- alumina
2. Advanced Manufacturing
i. Development of a laser and plasma-based wire-feed 3D printer
ii. Plasma assisted production of specialized metal powders for 3D printing

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Contribution ID: **53** Type: **not specified**

PLASMA BASED NANOTECHNOLOGY AND BIOLOGICAL APPLICATIONS

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Non-thermal gas plasma technologies provide environmentally sustainable solutions for pathogen control, environmental remediation, and advanced biomedical applications. This talk highlights plasma-based strategies for decontamination, microbial inactivation, and viral sterilization in soil, water, and air, with particular emphasis on preparedness against future pathogenic threats.
Our laboratory advances green plasma nanotechnology for eco-friendly synthesis of functional nanomaterials and plasma-enabled biomedical applications. We present plasma–liquid interaction–driven approaches for the green synthesis of metallic nanoparticles, offering precise control over composition and functionality without toxic chemicals or high-energy inputs. These nanoparticles exhibit strong antimicrobial and anticancer activities with excellent biocompatibility. In addition, plasma-based pathogen control platforms are explored for emerging and unknown biological threats.
Beyond therapeutics, non-thermal plasma shows significant promise in plasma cosmetics and anti-aging applications through enhanced skin regeneration, collagen stimulation, and tissue rejuvenation. Plasma technologies are further extended to agriculture for pathogen suppression and sustainable crop enhancement, as well as to space technology, where plasma-based sterilization, material modification, and life-support sustainability are critical.

Keywords: Plasma, Nanotechnology, Material Science, Pathogen, Environment

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Contribution ID: **54** Type: **not specified**

Investigation of Plasma Parameters in a Capacitively Coupled Plasma Discharge using Homogeneous Discharge Model

Capacitively coupled discharges are extensively employed in industrial applications such as deep reactive ion etching and plasma-enhanced chemical vapor deposition (PECVD) owing to their excellent plasma uniformity, precise controllability, and strong ion directionality toward the electrodes. Optimization of plasma parameters is essential for improving process efficiency and productivity; however, real-time invasive diagnostic techniques often degrade plasma stability, process performance, and product quality. As a result, there is an increasing shift toward non-invasive diagnostic approaches.

In the present work, a non-invasive diagnostic technique based on the homogeneous discharge model is employed to externally estimate key plasma parameters. The obtained results are validated through comparison with electron density and temperature measurements acquired using a Langmuir probe. Within this framework, the plasma is modeled as an equivalent series RLC circuit consisting of sheath capacitance (C_p), bulk plasma resistance (R_p), and plasma inductance (L_p). The model is analytically solved in conjunction with a power balance equation expressed in terms of electron temperature and density. By using experimentally accessible parameters such as RF power, discharge voltage, discharge current, and phase difference as inputs, the model enables the determination of fundamental plasma parameters, including electron density and temperature [1]. Furthermore, the analytical approach is applicable over a broad range of operating pressures, extending up to atmospheric pressure.

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Crystallographic and Morphological Properties of Mn-Zn Spinel Ferrite Nanoparticles

Manganese ferrite and zinc ferrite nanoparticles were successfully synthesized using the autocombustion method, which offers advantages such as low synthesis temperature, rapid reaction and uniform composition. The structural characteristics of the prepared samples were analyzed by X-ray diffraction (XRD). The XRD results confirmed the formation of a single-phase cubic spinel ferrite structure with good crystallinity. The surface morphology were studied by field emission scanning electron microscopy (FESEM). The FESEM images revealed fine particles with relatively uniform distribution along with slight agglomeration, which can be attributed to magnetic interactions between particles. The results demonstrate that the autocombustion method is an effective route for the synthesis of manganese and zinc ferrites nanoparticles with well define structural and morphological properties, making them suitable for potential applications in magnetic and electronic devices.

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Contribution ID: **56** Type: **not specified**

NEUTRAL BEAM INJECTOR –A POPULAR HEATING AND CURRENT DRIVE SYSTEM FOR FUSION

The neutral beam injector (NBI) is one of the most successful and popular auxiliary heating and current drive systems for fusion devices. The popularity increases after the discovery of H-mode or high-confinement mode of plasma in ASDEX tokamak due to intense heating of the tokamak plasma by its NBIs [F. Wagner et.al., PRL49, pp. 1409 - 1412 (1982)]. This H-mode breakthrough gave a big boost to the usefulness of NBI to heat the fusion plasma in a fusion reactor to achieve the desired Lawson criteria, and gave great hope to the possibility of energy extraction in a laboratory through fusion reaction. The NBI delivers high-energy neutral particles (like hydrogen atoms) into the fusion reactor (e.g. tokamak) that can penetrate the strong (˜ a few T) magnetic field, become ionized inside the plasma, and then transfer their vast kinetic energy through collisions with plasma ions and electrons. As a result, raises the core temperature to fusion-relevant levels (Lawson Criteria). Tangentially injected NBI also provides current drive and helps plasma rotation in the torus of a tokamak for steady-state operation through momentum transfer. The majority of NBIs are based on positive ion source technology with the gas-based neutralizer (PNBI). Their beam energies are restricted to ˜ 100keV per nucleon. For larger fusion machines (like ITER, LHD, JT60U), NBIs with beam energy > 100 keV per nucleon are required to provide sufficient penetration depth in the fusion plasma to heat the core. Because the neutralization efficiency of positive hydrogen ions in the conventional gas-based neutralizer is significantly low at energies above 100 keV per nucleon, these NBIs are based on negative ion source technology (NNBI). However, NNBI has some critical technical issues, and those need to be addressed for efficient long-pulse operation. The challenges are mainly from power efficiency, negative ion yield, Caesium (Cs) catalyst dynamics, neutralization efficiency, thermal and neutron-induced damage perspectives. The talk will give an overview of the NBI system and some of its technical issues, highlighting contributions of IPR in this field.

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Plasma Gasification for Municipal Solid Waste Treatment

Addressing the growing challenges in municipal solid waste (MSW) management and the limitations of conventional treatment technologies, plasma-based thermal treatment has emerged as a promising solution. This study conducts a comprehensive investigation, combining both lab-scale and pilot-scale plasma gasification systems to evaluate and optimize the performance of plasma-based waste processing. Initially, a lab-scale plasma gasification setup was developed to conduct detailed optimization studies focused on the preheating chamber's temperature and electrode consumption, which are crucial for improving long-term operational efficiency. The experiments aimed to achieve a consistent preheating temperature of more than 850 ℃ using various carrier gases, including argon, nitrogen, air, and mixtures. At 250 A and 300 A currents with a 25-35 V range, temperature profiles were monitored over one hour to evaluate thermal performance and power consumption. Among the tested configurations, argon plasma (15 LPM, 300 A) reached the target temperature in 16 minutes with the lowest power consumption of 1.95 kW, followed by air plasma (15 LPM, 300 A) in 20 minutes at 2.33 kW, and argon-air plasma (10 LPM & 5 LPM, 300 A) in 20 minutes at 2.23 kW. Electrode consumption was also studied to assess operational sustainability. Argon-nitrogen plasma exhibited the lowest electrode wear (9 g/h for anode, 3 g/h for cathode), whereas argon-air plasma showed the highest rates (66 g/h anode, 48 g/h cathode) [1]. Recently, it has been shown that CO2 plasma also produces high temperatures and increases CO concentration [2]. Building on these lab-scale findings, a pilot-scale plasma chamber with a 50 kg/h installed capacity was assessed for its energy efficiency, gas composition, byproduct characterization, and environmental compliance. The system processed the combustible fraction of MSW at approximately 1000 ℃, achieving a total energy consumption of 0.586 kWh/kg of waste after implementing a temperature shoot control strategy, resulting in a ~15% reduction in energy use. Mass and energy balances were performed to quantify heat losses and material flows. Gas analysis revealed that CO and H2 were the dominant gaseous products, accounting for nearly 30% of the total output, with a lower heating value (LHV) of 4.7 MJ/Nm3 and cold gas efficiency between 44-53%. The solid residue (ash) was analyzed using EDX and ICP-MS techniques and found carbonless and non-toxic. Furthermore, wastewater from the gas cleaning system was found to have a neutral pH with total dissolved solids (TDS) between 1200-1500 mg/L, supporting the system's environmental safety and viability for sustainable waste management [3]. This study underscores plasma-based system's technical feasibility and optimization potential for environmentally sound and energy-efficient MSW treatment, with crucial insights into gas quality, energy dynamics, and material durability.

KEYWORDS: Plasma Gasification; Graphite electrode; Preheating; MSW;

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Contribution ID: **58** Type: **not specified**

Learning Solutions of Coupled Differential Equations with Physics-Informed Neural Networks

This study demonstrates the application of Physics-informed neural networks (PINNs) to solve the initial-value problem of a two-mass coupled nonlinear oscillator system. The system is governed by the coupled second-order ordinary differential equations.
A fully-connected feed-forward neural network is trained to directly approximate the displacement fields $x_1(t)$ and $x_2(t)$. The network is optimized by minimizing a composite loss function consisting of the physics residual and a weighted initial-condition loss. No labeled trajectory data are used to train the model. The PINNs solution is validated against a high-accuracy numerical method. The predicted displacements show excellent quantitative agreement with the numerical solution, achieving sub-millimeter root-mean-square errors for both masses throughout the simulated interval. These results illustrate that PINNs can accurately predict the solutions of nonlinear differential equations.

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Contribution ID: **59** Type: **not specified**

ZnO/g-C_3N_4 Heterojunctions with Optimized Band Structure for Enhanced Photocatalytic Environmental Remediation

ZnO/g-C_3N_4 heterojunctions were synthesized by systematically varying the concentration of zinc nitrate hexahydrate, and the effect of this variation on the structural, optical, and photocatalytic properties was investigated using experimental techniques. The optical band gap energies were evaluated from UV–visible spectroscopy, revealing that the band gap of ZnO/g-C_3N_4 heterojunctions lies in the range of 2.55–2.70 eV, which is slightly narrower than that of pristine g-C_3N_4 (2.76 eV). This band gap narrowing indicates improved visible-light absorption upon heterojunction formation.

XPS analysis confirmed the presence of Zn, O, C, and N along with their respective oxidation states, validating the successful formation of the heterostructures. The ZnO/g-C_3N_4 heterojunctions exhibited significantly enhanced photocatalytic degradation of methylene blue (MB) dye compared to the individual components. Among all samples, the optimized heterojunction ZnO/g-C_3N_4 (ZCN4) demonstrated the highest degradation efficiency of 97%.

The superior photocatalytic performance of ZCN4 is attributed to the optimized ZnO content, improved charge separation efficiency, suppressed recombination of photo-generated charge carriers, and the reduced band gap.

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Electron Driven Plasma Instabilities in EBIS and ECR Ion Sources

Plasma instabilities, particularly electron driven instabilities, play a critical role in limiting the performance of advanced ion sources used for particle accelerators. In systems such as Electron Beam Ion Sources [1] and Electron Cyclotron Resonance ion sources [2], energetic electrons interacting with magnetized plasmas can excite collective modes due to strong anisotropies in the electron energy distribution, with perpendicular to parallel temperature ratios typically in the range of two to ten, steep density and potential gradients, and intense electromagnetic fields with magnetic field strengths commonly between about half a tesla and six tesla. These electron beam driven instabilities strongly influence energy transport, particle confinement, and charge state evolution. In EBIS devices, high current density electron beams, with beam currents of order one tenth to ten amperes, electron energies of a few to several tens of kiloelectronvolts, and current densities reaching hundreds to thousands of amperes per square centimetre, can drive instabilities that lead to anomalous ion heating to energies of a few electronvolts and reduced confinement times, thereby limiting the achievable charge states, especially for heavy ions. In ECR ion sources, radio frequency generated energetic electrons, with hot electron populations extending from roughly ten to one hundred kiloelectronvolts at microwave frequencies in gigahertz, can excite low frequency drift type instabilities, typically observed in the kilohertz to megahertz range, resulting in enhanced cross field transport and fluctuations in the extracted beam intensity at the level of a few percent. A detailed understanding of electron driven instability mechanisms, including their characteristic frequency ranges and dependence on operating parameters, is therefore essential for optimizing ion source stability and performance.

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Contribution ID: **61** Type: **not specified**

Experimental Studies on the Design and Characterisation of a Dielectric Barrier Discharge Plasma Thruster for Microsatellite Propulsion

The rapid expansion of satellite missions has created a growing demand for compact, low-power propulsion systems capable of delivering precise micro-Newton thrust for orbit correction, station keeping, and attitude control. Conventional propulsion technologies often rely on mechanical complexity or propellant-intensive processes that limit scalability for small platforms. Plasma-based electric propulsion offers an attractive alternative, particularly for devices that operate with minimal moving parts and low energy requirements. There are different kinds of advanced plasma propulsion systems, such as Hall-effect, pulsed plasma, Dielectric Barrier Discharge (DBD) thrusters, and helicon plasma thrusters, that have been investigated worldwide. In the past, several studies have been conducted on the DBD plasma actuators for aerospace applications. The studies are limited to DBD plasma for aerodynamic flow control and DBD plasma thruster for the atmospheric or near-space environment. DBD plasma thrusters provide a simple and robust architecture for generating directed plasma jets and electrohydrodynamic forces under near-atmospheric conditions. Still, there is a need to investigate a novel micro-propulsion technology based on DBD plasma within a single-thruster architecture.
In this study, an atmospheric-pressure DBD plasma thruster has been designed and fabricated to evaluate its feasibility as a micro-propulsion source. The device operates with flowing noble gases such as helium and argon, and is driven by a bipolar pulsed high-voltage supply to produce stable, non-equilibrium plasma jets. A systematic parametric investigation is performed to examine the influence of applied voltage, excitation frequency, mass flow rate, and dielectric barrier thickness on discharge characteristics, power deposition, thrust output, and thrust-to-power efficiency. Experimental measurements demonstrate clear scaling of thrust with electrical input parameters and reveal optimal operating regimes that maximise propulsion efficiency while maintaining discharge stability. Overall, this study provides fundamental insights into the operating physics and performance trends of DBD-based plasma microthrusters, establishing a baseline for future optimisation and scalable designs for next-generation propulsion technologies.

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Contribution ID: **62** Type: **not specified**

Plasma Agriculture: A New Frontier for Sustainable Food Systems

The world population continuously icnreasing and there are growing concerns about future global food production and consumption. Feeding a growing global population under increasing environmental constraints is one of the major challenges of our time. Conventional agricultural fertilization has delivered remarkable gains, but often at the cost of soil health, biodiversity, and long-term sustainability issues. Addressing this challenge demands not only fundamentally new but sustainable approaches.
Plasma agriculture represents one such emerging frontier [1]. By applying low-temperature, non-thermal plasma to seeds, water, and agricultural environments, it is possible to stimulate plant growth, enhance stress tolerance, reduce reliance on chemical fertilizers, and degrade pesticides [2-6] that too without genetic modification or harmful residues. At its core, plasma agriculture leverages physical energy to trigger biological responses, creating a powerful interface between plasma physics, food chemistry, and living systems [1].
This plenary talk will highlight recent advances in plasma-based agricultural technologies, from plasma-treated seeds and plasma-activated water to their impacts on plant physiology, soil remediations, and nutrient dynamics. Drawing on laboratory studies and early field-tests, both the opportunities and the challenges of translating non-equilibrium cold plasma technology into real-world food systems will be discussed. Beyond individual applications, plasma agriculture can offer a new way to think about how physical sciences can support sustainable agriculture. Controlled plasma processes can help in developing future farming systems that are more resilient, efficient with resources, and environmentally benign, highlighting the value of plasma science for the future need of food.
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Contribution ID: **63** Type: **not specified**

Laser Induced Process: Plasma to Graphene

This talk explores the synergistic relationship between laser and plasma sciences, bridging fundamental physics with material engineering. The work on laser-produced isotopically pure plasmas, focusing on the complex ion collection dynamics essential for isotopic purification process, will be presented. In biomedical applications, laser-induced surface structuring that can be used to tune the bio-functionality of materials. Specifically, experimental evidence of improved cell adhesion, enhanced antibacterial properties, and superior corrosion resistance achieved through precise topographical modification will be discussed. Finally, we discuss recent results in Laser-Induced Graphene (LIG) synthesis, introducing a novel defect-healing technique developed in our laboratory to enhance the structural integrity and electrical performance of the graphene lattice.

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Contribution ID: **64** Type: **not specified**

TRAPPING AND DISSOCATION OF MOLECUALR IONS

Molecular reactions and the interaction of molecules with charged particles and photons are central to the chemical sciences. In this talk, I will talk about: (i) a hybrid electrostatic ion beam trap (HEIBT) and (ii) the dissociation dynamics of molecular ions produced through interactions with charged particles and photons. The HEIBT enables coincidence imaging of
both cationic and neutral fragments resulting from interactions of electrostatically trapped molecular ion beams with laser fields, as well as from low-energy collision processes involving merged beams of counter ions or neutral species. Building on the electrostatic ion beam trap
(EIBT) [1] and a multi-fragment spectrometer [2], the HEIBT mirror design allows ions to be trapped on stable trajectories while minimizing disturbances to the trajectories of ions with either the same or opposite charge [3]. The ionization and subsequent fragmentation of molecules induced by charged particles and photons are studied using recoil-ion momentum spectroscopy to understand the underlying
dissociation dynamics. From these measurements, the kinetic energy release (KER) and the angular distributions of the fragments are also obtained [4-5].

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Pulsed Power and Beam Technology for Visit Bharat: Science, Strategy, and Societal Impact

India's march toward becoming a developed and self-reliant nation will be powered by indigenous, cutting-edge technologies capable of transforming society at scale. Among these, pulsed power, plasma, and beam technologies stand out as true game-changers. Pulsed power systems, capable of delivering multi-gigawatt bursts within micro- to nanosecond timescales, hold immense strategic importance across industrial domains—from advanced welding to rock fracturing—and have been nurtured in national R&D laboratories for decades. Plasma devices, both pulsed and DC, are being engineered for societal applications, particularly in healthcare and sterilization industries. Globally, plasma systems that mimic the Sun's fusion processes are under development to unlock clean and limitless energy. Similarly, electron beam accelerators have matured into versatile tools for industrial applications spanning food preservation, environmental remediation, border security, and non-destructive testing. These technologies are not futuristic aspirations; they are practical enablers that can strengthen security infrastructure, propel spacecraft deeper into the cosmos, and support India's quest for sustainable energy solutions. In defense, pulsed power enables electromagnetic launchers and directed energy systems, redefining readiness. In space, plasma propulsion enhances satellite agility and makes interplanetary missions more feasible. Current plasma research is advancing toward fusion energy, novel materials, and radiation-hardened technologies that secure our energy future while minimizing climate impact. Industrial accelerators are poised to replace radioisotope-based irradiators, offering safer and more sustainable solutions for neutron radiography, food processing, and medical sterilization.

The true opportunity lies in translational research and innovation through collaboration. Universities can push the boundaries of fundamental science and technology demonstration, while industries can engineer prototypes and scale them for national missions. Together, academia and industry can establish innovation hubs, shared test facilities, and joint research programs that serve strategic sectors while delivering societal benefits—ranging from plasma-based healthcare solutions to clean energy and industrial modernization. By integrating science with strategy, pulsed power and beam technologies can become a cornerstone of India's technological sovereignty. They will ensure that Viksit Bharat is not merely a vision, but a reality built on indigenous innovation, global leadership, and societal impact.

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Dielectric barrier discharged cold atmospheric plasma for the inactivation of multi drug resistance microbes

Cold atmospheric plasma (CAP) is generally a nonthermal plasma having plasma gas temperature around room temperature. Presence of reactive oxygen and nitrogen species (RONS) in CAP along with the charge particles makes the CAP a therapeutically important agent. Application of cold plasma in the field of biomedicine is recently becomes a cutting-edge research field since last two decades. CAP have been successfully applied for inactivation of various multidrug resistance microbes. CAP has been successfully applied for chronic wound healing. Research is going on to apply CAP in the field of oncology by various groups. Various discharge configurations have been used for the production of CAP suitable for biomedical application. Dielectric barrier discharge is one of them. At Institute of Advanced Study in Science and Technology (IASST), Guwahati a dielctric barrier discharged cold atmospheric plasma set up has been developed in house in aim to its application in medical field. It consists of a cylindrical shape brass electrode of diameter 10 mm with hemispherical tip. The electrode is covered with 1-mm thick quartz glass. A stainless steel mesh is used as a grounded electrode. A quasi sinusoidal high voltage pulse $(V_{PP} \sim 20 - 30kV)$ of pulse repetitive frequency $\sim 20 - 30$ kHz from a in-house made power supply has been applied between the electrodes to obtain the CAP. Electrical characterization of the device has already been performed [1]. The CAP produced from the setup has been successfully utilized to inactivate microorganisms, namely multi-drug resistant Escherichia coli (ATCC BAA-2469), Staphylococcus aureus (MTCC 96), and Candida albicans (MTCC 227) and compare the efficacy with tested antibiotics [2]. Notably, just 20s CAP treatment has surpassed the zone of inhibition (ZOI) of 10-50mcg tested antibiotics. The study shows its novelty in uniquely delaying the growth of microorganisms after CAP treatment. Detailed results will be presented.

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Contribution ID: **67** Type: **not specified**

IUAC: Accelerator-based national facility for interdisciplinary research

The Inter-University Accelerator Centre (IUAC) is the first Inter-University Centre (IUC) in India, providing energised ion beams that span nearly the entire periodic table, with energy ranges from a few tens of electron volts (eV) to several hundred million electron volts (MeV). It serves a diverse research community across the country. The facility offers advanced experimental capabilities that support research in basic experimental nuclear physics, accelerator mass spectrometry, ion-beam modification and analysis of materials, as well as various multidisciplinary areas.
The main accelerator facilities at IUAC include a 15UD/16MV Pelletron tandem accelerator and a superconducting booster linear accelerator (SC-LINAC). Additionally, an Accelerator Mass Spectrometry (AMS) facility has been established for radiocarbon dating of geological and prehistoric samples.
Upcoming developments at IUAC include the commissioning of a High Current Injector (HCI), which comprises a superconducting Electron Cyclotron Resonance (ECR) ion source, a Radio-Frequency Quadrupole (RFQ), and six Drift Tube LINAC (DTL) modules. The centre collaborates with various national and international organizations on research and development initiatives, contributing to projects of national importance, such as low fluence irradiation of devices intended for space applications. IUAC is also engaged in the indigenous development of an MRI machine equipped with a superconducting magnet.
Furthermore, IUAC is involved in In-Silico Methods in Physics and the Use of High-Performance Computing (HPC), where the integration of simulation and advanced experimentation is advancing research in materials, chemistry, and physics by enhancing the discovery, validation, and optimization processes.

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Contribution ID: **68** Type: **not specified**

Study of plasma blobs under the influence of magnetic field and background plasmas

Blobs are observed in the scrape-off-layer (SOL) of various TOKAMAKs and fusion devices and opposes the core plasma confinement. SOL (the region characterized by open magnetic field lines) absorbs most of the plasma exhaust (particles and heat) and transports it along the field lines to the divertor plates. Hence, this region is of prime importance for future reactors. The operation of fusion reactors is significantly affected by blob transport in the SOL region. Blob transport and mitigation in the plasma SOL is of vital importance to the performance of existing and future magnetic confinement fusion devices. This important issue needs to be addressed for future fusion machines to get pure and cheap energy for mankind. In our experiment it is observed that some plasma particles and energy ejected out in the form of blobs from the plasma produced by a pulsed washer plasma gun which is injected radially to the curved vacuum chamber. The plasma parameters such as ion density n_i, electron density n_e and electron temperature T_e of plasma in presence of magnetic field and background plasma are estimated using various diagnostic techniques. The effects of magnetic field and background plasma on the plasma blob formation and mitigation processes are discussed.

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Contribution ID: **69** Type: **not specified**

Evolution of Nuclear techniques into Earth System Science research and Ion irradiation-based Radiation Biology Research at IUAC

The upcoming talk will offer a thorough exploration of critical topics surrounding nuclear energy and its implications for the future. A central focus will be the SHANTI Bill, which aims to improve safety and accountability in the nuclear sector by addressing public concerns and refining regulatory frameworks. Additionally, the discussion will cover the Civil Liability for Nuclear Damage Act, tracing its origins and key components while highlighting the legal responsibilities imposed on operators to compensate for any nuclear incidents. This examination will reveal the balance between liability and encouraging investment in the industry.
The talk will also reflect on the lessons learned from the Bhopal gas tragedy, particularly regarding supplier and operator liability, and how these insights might shape future policies to prevent similar occurrences in the nuclear sector. Another key point will be the rationale for privatization in the energy sector, weighing the benefits of increased efficiency and innovation against potential challenges and criticisms.
Furthermore, the session will assess current energy consumption patterns in developed countries and explore projections for 2047, focusing on how nuclear energy could help bridge gaps in energy supply while fostering economic growth through employment and entrepreneurship. The role of the Nuclear Power Corporation of India Limited (NPCIL) as a monopoly in the nuclear energy market will be critically examined, looking at its implications for innovation and competition.
Concerns related to the privatization of nuclear energy, such as safety and regulatory challenges, will also be discussed, along with strategies to mitigate these risks to ensure sustainable and responsible development. The necessity of strengthening the Atomic Energy Regulatory Board (AERB) will be emphasized to enhance oversight and maintain public trust through transparent operations.
The conversation will extend to the pivotal role of nuclear energy in achieving national and global Net Zero targets, particularly in relation to climate change discussions highlighted in recent conferences. Myths surrounding nuclear energy will also be addressed, providing factual information to clarify misconceptions and facilitate informed discussions about its safety and viability as a clean energy source.
Overall, this talk promises to foster meaningful dialogue on the future of nuclear energy and its essential role in sustainable development.

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Contribution ID: **70** Type: **not specified**

Non thermal plasma sources and emerging applications

Non thermal / Low pressure plasmas have a unique place in processing of functional materials. These plasmas are widely used for various industrial processes including thin film deposition by Chemical Vapour Deposition (CVD) and Physical Vapour Deposition (PVD). These plasmas have the ability to generate chemically reactive species at low temperature which is due to the non-equilibrium nature of the plasma state. Due to high internal energy of low-pressure plasma, processes that are thermodynamically allowed but kinetically hindered in a conventional process, proceed with a high rate under plasma conditions.

Among the plasma sources that have been developed for processing of various functional materials, microwave and radio frequency based non-thermal plasma sources are attracting a lot of attention because of their inherent superiority over other kinds of plasmas. These plasma sources can be operated in a varied range of pressures starting from 10-5 mbar to 1 atmosphere. The promising applications of these high frequency plasmas have been appearing in the fields of chemical processes and semiconductor manufacturing. Applications include surface deposition of all types including Diamond / Diamond like Carbon (DLC) coatings, etching of semiconductors, promotion of organic reactions, etching of polymers to improve bonding of the other materials etc.

Starting with the introduction regarding types of plasmas that are being used for processing of materials, this talk will discuss fundamentals of RF and microwave based non-thermal plasma generation and plasma sources such as capacitively coupled RF Plasma (CCP), large area inductively coupled plasma (ICP), fused hollow cathode based atmospheric pressure glow discharge (APGD) plasma and Microwave Electron Cyclotron Resonance (ECR) plasma that are developed using RF and microwave radiations. The emerging applications of these sources will also be discussed.

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Contribution ID: **71** Type: **not specified**

Thermal Plasma Catalytic System for Fast Synthesis of Nitrogen Fertilizer from Air and Water

Nitrogen forms the most vital organic compounds of life like amino acids, proteins, nucleoside triphosphates, the molecular precursors to nucleic acids DNA and RNA. In spite of nitrogen being highly abundant in atmosphere, it cannot be directly used by most of the living organisms. The strong triple covalent bond makes it to behave mostly like an inert gas. Nitrogen needs to combine with some other elements to form functional compounds like ammonia, nitrate or nitrite usable by living beings.

Industrial nitrogen fixation methods mostly use Haber-Bosch process as the most dominating industrial practice where nitrogen is fixed in the form of Urea. The process uses fossil fuel and hence not sustainable. It is not decentralizable due to requirement of heavy installations related to high temperature and high pressure. It also has adverse environmental effects due to emission of thousands of tons of greenhouse gases like CO2. A primary issue, often oversighted, is the fact that ammonia being gaseous, more than 50% of applied fertilizer nutrients in urea simply gets lost to the atmosphere. Practically, it is only 17% of the applied nitrogen in the fertilizer that finally gets used by the agricultural products. Loss of fertilizer to aquatic world may lead to algal boom and may severely hamper biodiversity.

The study presents a newly developed novel thermal plasma based compact portable catalytic system for fast synthesis of nitrate and nitrite. The system offers single-step ultra-fast high throughput synthesis at atmospheric pressure under nascent plasma condition with minimal waste production as compared to traditional wet chemistry processes. It requires significantly lower capital investment for small scale, decentralized fertilizer production and has the compatibility to work with intermittent renewable energy. Its ability to operate with renewable energy sources, independent of fossil fuel has the potential to secure enhanced stability in fertilizer price and food price. On-site production of nitrate and nitrite fertilizer using atmospheric N2 and readily available abundant H2O on earth as feed stocks eliminates the emission of CO2, as well as costs associated with transportation of feed stocks and fertilizer distribution. Fast synthesis, operability with renewable energy, zero CO2 emission, feasible small-scale distributed production and less capital investment are the key features of the developed system discussed.

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Contribution ID: **72** Type: **not specified**

Collisionless scattering of fast runaway-like electron beams in warm magnetized plasmas

The tokamak scheme for magnetic confinement of hot plasma requires careful optimization before operations with active fusion grade plasmas. The Con-trolled operations aim to maintain a thermalized state of hot plasma species where generation of fast beam-like population of electron species must be prevented, especially during the disruption events when sudden loss of plasma current induces large toroidal electric field, capable of producing so called run-away electrons. Number of runaway electrons produced during disruption in large tokamaks depends sensitively on the magnetic field strength[1]. The collisionless Whistler mode instability is identified to be preventing
run-away generation in a sub-threshold regime. The whistler growth rate is inversely proportional to magnetic field allowing them to scatter runaways and prevent runaway beams from forming. The phase-space distributions of runaway electrons however remain very complex requiring large scale kinetic-simulations to analyze the scattering process. The 1X-3V fully electromagnetic Vlasov simulations done of the collisionless whistler instability allow the run-away-like beam distributions to be used [2-3]. The simulations address both linear and nonlinear operational regimes of the instability. The limiting regime of marginal propagation of nonlinear whistler instability is also characterized.

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Contribution ID: **73** Type: **not specified**

Energy Environment Symbiosis: Way forward towards a Vikshit Bharat

Sustainable and Inclusive development of a nation like India is about developing a method of resource use that aims to meet human needs across the entire socio-economic spectrum while preserving the environment so that these needs can be met not only in the present, but in the indefinite future. Energy is the primary resource closely linked to the economic growth while preservation of ecology preserves our life. After nearly a century of unbridled techno- industrial growth, the world is facing twin energy related threats, On the one hand, to maintain the growth momentum, humanity needs to provide adequate energy availability to all at affordable costs and on the other hand, the fast spiraling deterioration of environment due to ever increasing energy consumption has resulted in severe climate crises. In fact, unless human wisdom quickly combines with our cumulative scientific and technical knowledge to find a solution, sustainability will become an issue. Global recognition of these issues means the drive for new and clean energy generation, supply, distribution and consumption technologies is real and it is here to stay. The challenge is how to achieve energy self sufficiency or strategic energy independence with non carbon sources and consistent with the tenets of social equity and strict compliance of environmental ethics. ; elements of sustainable energy culture. The next three or four decades are going to stress on renewable non carbon energy sources for more than 80% of human activities with major research and innovation focus on new energy, new materials, net zero practice and radical steps towards carbon sequestration utilization and storage. The talk will be a semi popular one stressing on this central theme.

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Contribution ID: **75**   Type: **not specified**

Initial investigations in the development of the Electron Cyclotron Resonance (ECR)-based Large Negative Ion Beam Source (ELNIBS)

Plasma based large area negative hydrogen ion source is an essential part of Neutral Beam Injector (NBI) modules of thermonuclear fusion reactors like ITER, since H-/D- ion beams can be efficiently converted into high energy neutral H0/D0 beams (˜ 1 MeV/u) for heating of fusion plasma [1]. The target H- current that has to be delivered to the NBI of ITER is around 40 A which requires production of ˜ 33 mA/cm2 H- current density over a grid area of approximately 2 m2 [2]. This in turn demands production of high-density uniform hydrogen plasma of the order of 1012 cm-3 at operating pressures of 2-3 mTorr (0.27 –0.4 Pa) [3] and electron temperature (Te) ˜ 1-2 eV, to avoid electron stripping of H-. Further, plasma uniformity of 10% over the plasma grid is desired, which ensures a good quality beam extraction. Present negative ion sources use around 0.8-1 MW RF (1 MHz) inductive power to achieve the target plasma density [4]. Such high-power investments face several technical and economic challenges that have triggered the search for alternate technologies offering more efficient power coupling / absorption [5]. Microwave based Electron Cyclotron Resonance (ECR) absorption can be one such scheme [6], since this scheme, due to the microwave power being coupled to a set of resonating electrons, enables a very efficient production of high plasma densities at low pressures and relatively lower powers, encouraging utilization of ECR schemes for negative hydrogen ion sources.
Tarey et. al. [7] have shown that multiple Compact ECR Plasma Sources (CEPS, patentee: Plasma Lab, IIT Delhi) [8] can be configured in appropriate arrays to produce uniform, large area, high density plasma in argon at very modest power. On this basis, the Plasma Physics Laboratory at IIT Delhi (PPL-IITD), in collaboration with Neutral Beam Division at Institute for Plasma Research, has been associated with the development of an ECR-based large area negative hydrogen plasma source (ELNIBS) for the past few years in a 1 m diameter and 0.5-1.5 m long (scalable) stainless steel chamber. The uniqueness of this source is that it is based on plasma generation through electron cyclotron resonance (ECR) mechanism in contrast to the rf-based sources being used in fusion devices currently.
However, one must note that the ECR based sources have an inherent magnetic field, which also provides one the challenge in identifying the right set of source and magnetic field configurations along with the optimal operating conditions that would deliver the required plasma parameters suitable for large area production of H− ions suitable for extraction for fusion applications. Further, unlike argon, hydrogen is a molecular gas, wherein plasma particles can exist in various neutral / ionic state: H2, H, H+, H2+, H3+, H-, etc. and as suggested by some recent experiments using both gases [9], the behaviour of hydrogen plasma differs significantly from that of argon, emphasizing the need for a detailed scientific investigation of hydrogen plasma production using different CEPS-based [10] source array configurations optimizing it for the conditions suitable for fusion plasmas. These above challenges also make the efforts in the development of ELNIBS unique.
This paper presents the journey of the development of ELNIBS viz., optimization of source configuration through plasma characterization with the ultimate detection of negative hydrogen ions in ELNIBS. The characterization process used electrostatic probes [11,12], viz., Langmuir probes (LP) and retarding field analyzers / retarding particle analyzers (RFEA / RPA), along with a quadrupole molecular beam mass spectrometer (MBMS). Experiments were performed with the geometrical configuration of 1 m diameter, 1m high cylindrical expansion chamber. Hydrogen plasma was produced using the optimal configuration of a CEPS mounted onto the top dome of the chamber. The magnetic field configuration of the source section (cylindrical, diameter Φ = 91mm and length, ⊠ = 110 mm) has the field strength decaying exponentially into the 1m diameter plasma expansion chamber. The plasma was characterized under different operating conditions of microwave power (400–600 W) and gas pressure (1–3 mTorr) using a Langmuir probe that was fabricated in-house.

The low-pressure plasma was observed to have a moderately uniform high density (~ 1011 cm-3) plasma across a cross-section of 70 cm with low electron temperature (~ 1 - 3 eV) in the downstream section (≈ 30-40 cm downstream of plasma generation). The RFEA measurements showed energetic ion beams emanating from within the source mouth, with upstream ion beam energies being as high a few 10s of eV. A molecular beam mass spectrometer (MBMS, Model: Hiden HPR-60) was used to investigate the relative intensity of the plasma produced positive ions (H+, H2+, H3+) as well as negative ions (H-) along with its respective energy spectra and that of gas neutrals. Detailed results with varying microwave power and gas pressure will be presented.

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Contribution ID: **76** Type: **not specified**

Low energy ion beam for nanostructuring of Cu/PTFE surface for water harvesting

Interaction of low energy ions often leads to self-organized regular nanostructure on the surfaces. However, their arrangements, surface roughness depends largely on material properties, ion energy, and ion angle of interaction with the surface and ion dose. In the recent time these artificially produced nanostructures have potentially been utilised for tailoring surface wettability, magnetism and optical properties of the bulk material. In the current work, we shall show how low energy ion can remarkably change surface wettability of PTFE polymer surface. Just in 10s of second exposure time, it becomes superhydrophobic due to the formation of freely standing Nanostructures [1, 2]. Using the fast CCD camera we have investigated the bouncing dynamics of water droplets and effect of surface properties on the bouncing dynamics. Later the PTFE surface is tested for the self-cleaning applications [2]. PTFE films were compared with bulk PTFE surface after ion irradiation. It was found that PTFE films make nanoripple like structures and shows the anisotropic wettability behaviour [1-2]. Later these patterns are utilized for water harvesting application.

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Contribution ID: **77** Type: **not specified**

Vigna Radiata Extract Assisted Sol-Gel Synthesis of Strontium Ferrite for Supercapacitor Applications

This study reports the preparation of strontium ferrite using sol-gel method with vigna radiata (moong dal) extract as a natural, plant based and eco-friendly chelating agent for supercapacitor applications. The use of plant based extract offers a cost effective and sustainable approach to material synthesis. The structural and morphological properties of the synthesized strontium ferrite were examined using x-ray diffraction (XRD) and field emission scanning electron microscope (FESEM) characterization techniques. Electrochemical performance was evaluated through cyclic voltammetry and Galvanostatic charge-discharge studies. The electrochemical properties of the prepared sample were studied using an electrochemical workstation with a three electrode setup in a 1M Na2SO4 electrolyte. Electrochemical analysis revealed a specific capacitance of about 765 Fg-1 at a scan rate of 5 mVs-1, while different capacitance values were observed at other scan rates. This work highlights the potential of green sol-gel synthesis routes in the development of energy storage materials.

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Contribution ID: **78** Type: **not specified**

Isolating Nuclear Optical Variability in Active Galaxies: Limits of Host-Contaminated Light Curves

Accretion discs around supermassive black holes constitute extreme astrophysical environments in which ionized, radiatively efficient flows regulate mass transport and energy dissipation. Optical variability in active galactic nuclei (AGNs) therefore provides an important, though indirect, observational window into the dynamical behaviour of accretion flows on spatial and temporal scales inaccessible to direct imaging. In our recently published work, we conducted a comparative statistical analysis of long-term optical brightness and colour variability in two bolometric luminosity (LBol) –redshift (z) matched samples consisting of 2095 Narrow-line Seyfert 1 (NLSy1) galaxies and 2380 Broad-line Seyfert 1 (BLSy1) galaxies, using more than six years of quasi-simultaneous g- and r-band photometry from the Zwicky Transient Facility. Variability was quantified using flux variability, fractional variability, peak-to-peak amplitude variability, and ensemble structure function analysis, revealing systematically stronger variability in BLSy1 galaxies, with structure function amplitudes exceeding those of NLSy1s by a factor of 1.44 ± 0.06, while both subclasses exhibit statistically consistent structure function slopes. Our colour variability analysis indicated that a large fraction of sources show an apparent bluer-when-brighter (BWB) trend, observed in approximately 74 % of NLSy1 galaxies and 79 % of BLSy1 galaxies. However, we emphasize that these results are based on observed total flux light curves, which include an unavoidable contribution from the host galaxy. The presence of a relatively stable, predominantly red host component superposed on a variable, hotter nuclear component introduces significant ambiguity in interpreting the intrinsic variability behaviour of the accretion-powered nucleus. Consequently, the observed BWB trend cannot be robustly attributed to genuine spectral changes of the nuclear emission alone. Motivated by this limitation, we have developed an improved probabilistic flux variation gradient (PFVG) method to statistically disentangle host-galaxy and nuclear flux contributions in optical light curves. To assess the impact of host contamination on inferred variability properties, we apply this method to a sample of host-dominated BL Lac objects spanning the redshift range $0 \le z \le 1$. We present preliminary results demonstrating how host subtraction alters the inferred brightness and colour variability behaviour, providing a clearer view of the intrinsic nuclear variability. This approach offers a promising pathway toward isolating accretion-flow–driven variability and placing more reliable observational constraints on the radiative and dynamical properties of accretion-disc plasma and hot AGN jet affects the variability, without over-interpreting host-contaminated observables.

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Contribution ID: **79** Type: **not specified**

Physics Informed Neural Network approach for estimating the coefficients of the Semi Empirical Mass Formula

Background: The Semi-Empirical Mass Formula (SEMF), also known as the Weizsäcker formula, provides an approximate description of nuclear binding energy by incorporating volume, surface, Coulomb, asymmetry, and pairing effects within the liquid-drop model framework. Conventionally, the coefficients of the SEMF are determined using least-squares regression on experimental nuclear mass data.
Purpose: The purpose of this study is to develop and demonstrate a Physics-Informed Neural Network
(PINN) framework for estimating the coefficients of the SEMF by embedding the nuclear-physics structure of the model directly into the learning process.
Methods: A Physics-Informed Neural Network was constructed in which the SEMF was incorporated explicitly into the loss function. Experimental nuclear mass data were used as training inputs, while the SEMF coefficients were treated as trainable network parameters. The optimization was performed using ⊠2 minimization, where the loss function quantified the weighted squared deviation between experimentally
measured and model-predicted binding energies. Physically motivated bounds were imposed on the coefficients to ensure stability and interpretability.
Results: The PINN framework successfully recovered physically meaningful values of the SEMF coefficients with improved numerical stability compared to conventional regression-based methods. The predicted binding energies exhibited strong agreement with experimental data across a wide range of nuclei. Incorporation of physical constraints significantly reduced overfitting and enhanced the generalization
capability of the model.
Conclusion: This study demonstrates that Physics-Informed Neural Networks provide an effective and reliable framework for estimating the coefficients of the Semi-Empirical Mass Formula.

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Contribution ID: **80** Type: **not specified**

Nuclear Fusion, Tokamaks, and Indian Program

Fusing light atomic nuclei to yield a heavier nucleus while releasing vast amounts of energy, a process known as 'Nuclear Fusion', has long been dreamt of as a permanent solution to the energy requirement of all of mankind. The world is eagerly looking forward to this virtually
limitless and environmentally friendly energy source, which at present stands at a threshold of transition: from theoretical promise to engineering demonstration and, eventually, to practical
energy generation. Hence, fusion research is aggressively pursued worldwide to turn this dream into a reality. Achieving controlled fusion on Earth is not an easy task, as extreme conditions required for fusion i.e., temperatures exceeding tens or even hundreds of millions of degrees and keeping the high-temperature plasma in magnetic traps or inertial systems, pose immense demands on materials surrounding the traps, energy input, and engineering. Based on research spanning over several decades, the magnetically confined plasma-based fusion reactor strategies –led by the tokamak device- are emerging as the front-runners. Both the leading experimental devices for demonstrating fusion, the Government-funded 'International Thermonuclear Experimental Reactor (ITER)'and the private-funded 'Smallest Possible Affordable, Robust, Compact (SPARC) Tokamak'are based on Tokamak configuration. Although realization of fusion power generation in a tokamak-based reactor is
considered far more feasible compared to other configurations, several challenges related to high magnetic fields, high-power beams, radio-frequency waves and their supplies, complex operation, materials, radiations etc., are still required to be surmounted.
India invested significantly in magnetically confined fusion research for decades through the indigenous construction of tokamaks and the development of several fusion technologies.
These efforts culminated in several pioneering discoveries in the field of tokamak research and facilitated India's becoming a full partner in the ITER mega-project. In this presentation, the overall progress of tokamak-based fusion research worldwide, along with Indian contribution
will be presented, outlining the challenges that still need attention.

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