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IEMPHYS-26

International Conference on Advanced Physics: Innovations for a Sustainable Future

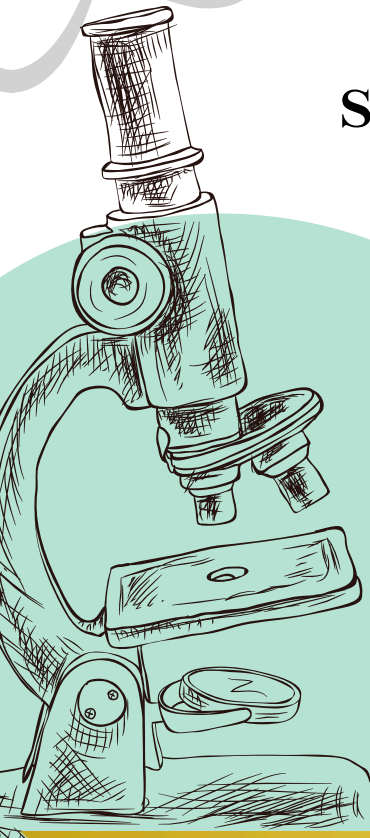
09.01.2026 - 11.01.2026

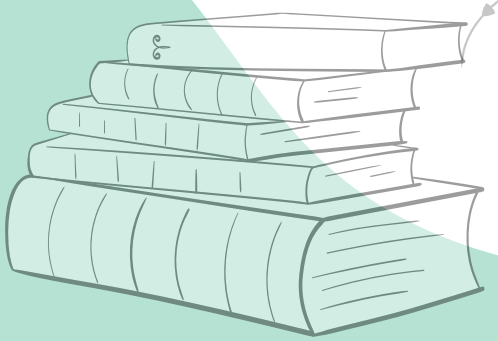
Organised by

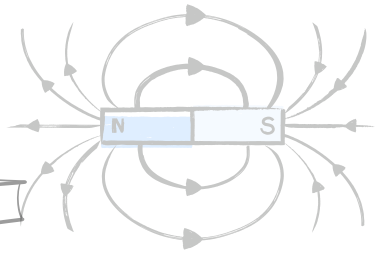
Department of Basic Science and Humanities,
Institute of Engineering & Management,Kolkata
School of
University of Engineering and Management,Kolkata

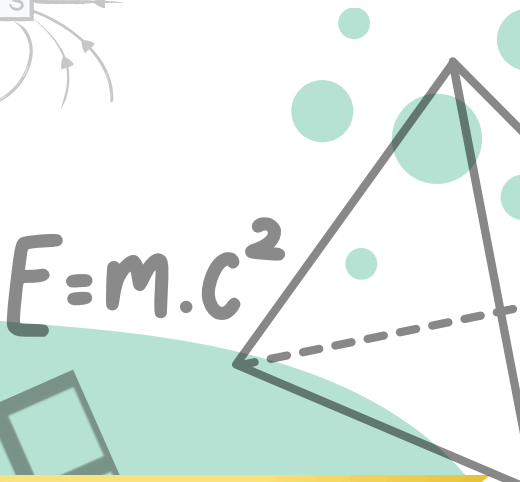
In collaboration with

Society of Physics Students (SPS) IEM Chapter
Smart Society, USA









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Welcome Message

With immense pleasure Department of Basic Science and Humanities, Institute of Engineering & Management (IEM), school of University of Engineering and Management, Kolkata presents the International Conference on Advanced Physics : Innovations for a Sustainable Future - IEMPHYS-26 in collaboration with IEM Society of Physics Student Chapter an association of American Institute of Physics and SMART Society, USA from 09th to 11th January 2026.

Physics lays the foundation for an engineer. All engineering streams are basically specializations of different branches of Physics. A good expertise in Physics will lead to a good engineer. Since IEM is an engineering college, to inculcate the beauty of Physics in the minds of budding engineers, Department of Basic Science& Humanities, IEM organizes a conference exclusively in the Physics domain.

After the successful execution of IEMPHYS-19, IEMPHYS-20, IEMPHYS-21, IEMPHYS-22, IEMPHYS-23 and IEMPHYS-24 this is the Sixth venture of Department of Basic Science & Humanities, IEM in organizing a conference in Physics.

IEMPHYS-26 intends to bring together renowned scientists and academicians round the globe to share their innovative thoughts and research ideas in different fields of Advanced Physics.

IEMPHYS-26 is an interdisciplinary forum on broad areas of Advanced Materials for Sustainability, Nano Science and Nano Technology, Climate Physics and Modelling, Urban Physics and Sustainable Cities, Polymers and Nano Composites, Surface Science, Photonics and Optoelectronics, Bio molecular Physics, Quantum Computing and Quantum Information, AI based Computational Physics, Nuclear Science, Plasma Physics and Fusion Energy, High Energy and Particle Physics, Dark Matter and Dark Energy, Gravitational Waves etc.

The conference aspires to exhibit the research and technical excellence of scientists and technocrats, representatives from academia and industry. It will include talks and keynote lectures delivered by eminent speakers from reputed institutions, contributed oral paper presentations and poster presentations and

workshops on advanced topics in Physics. The selected contributed papers will be peer reviewed and will be published by European Physical Journal Web of Conference under SCOPUS indexed category.

We sincerely hope that this serves as an international platform for meeting researchers from around the world, widen professional contact and create new opportunities, including establishing new collaborations.

We are looking forward to seeing you at “IEMPHYS-26”.

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Scale-bridging approach to simulating magnetic materials from first principles

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Abstract: Discovery of new magnetic materials for applications in energy production, transport and information technologies benefits nowadays a lot from theory support which helps to accelerate the search and design of materials with required functionality. More specifically, first-principles theory simulations can predict materials properties and how they change due to structural and chemical engineering. However, most accurate simulations of this kind are based on the numerical solution of the quantum-mechanical problem of correlated electrons in solids, which is computationally expensive and feasible only for relatively simple material models. Applicability of first-principles theory methods can be greatly extended by means of so-called effective models, which simplify the material modelling but keep important features of electronic structure. In this talk, different levels of effective models - atomistic spin models and micromagnetic models - will be discussed and how they can be used to model magnetic materials on the length scales between a few nanometres and micrometres. Importantly, it will be also discussed how theory descriptions at different length scales are connected, such that all the effective models are based on first-principles material-specific parameters. A few examples from the concurrent research will be presented, which illustrate the power of this scale-bridging approach, which is well established in the literature since many years due to efforts of many research groups worldwide.

From Medical Isotopes to New Elements: Relevance of Nuclear Data

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Abstract: Nuclear data, including half-lives, decay modes, branching ratios, radiation energies and intensities of radionuclides, cross section, excitation function, range of ionization radiations in matter, etc., form the foundation of nuclear science. Reliable and comprehensive nuclear data ensure safety, efficiency, and optimised use across multiple domains such as healthcare, power, reactor design, and radiation protection, among others. In healthcare, nuclear data directly governs the production, selection, and clinical deployment of radioisotopes in the form of radiopharmaceuticals. Starting from the most commonly used clinical radioisotopes, such as ^{99m}Tc, ^{131}I, ^{18}F, tonewlyexploredther agnostic pairs, all depend on reliable decay information for their dosimetry, imaging, and efficacy. Schematic decay diagrams, visual representations of parent-daughter transformations, provide scientific basis for effective nuclear medicine. As targeted radionuclide therapy expands, especially through alpha-emitting isotopes, the need for precise nuclear decay data is more relevant than ever.

On the other hand, high-quality nuclear datasets play pivotal role in supporting the continuous international efforts of exploring the “island of stability” and confirming new elements. The production and characterisation of superheavy nuclei, including flerovium (Z=114), livermorium (Z=116), moscovium (Z=115), tennessine (Z=117) or the latest oganesson (Z=118) rely on identifying specific decay chains, alpha energies, and spontaneous-fission signatures. Without accurate decay fingerprints and predictive nuclear structure data, these landmark discoveries would have been impossible.

Thus, exploring and generating precise nuclear data strengthen the fields of nuclear medicine, nuclear power, and fundamental sciences.

Multimodal theragnostic material for precise therapy and monitoring of MDA-MB-231

Chandan Kumar Ghosh

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Kolkata, India

Abstract: Novel Yb^{3+}, Er^{3+} co-doped GdOF-based nanoprobe with integrated multimodal functionalities has been, designed, optimized for simultaneous pH responsive drug release, photothermal-photodynamic therapy (PTT-PDT), and dual mode upconversion luminescence and magnetic resonance imaging. The nanoprobe comprises polydopamine (PDA) coated Yb^{3+}, Er^{3+} co-doped GdOF nanoparticles, functionalized with NH_2 – PEG – NH_2 and hyaluronic acid (HA) to endow physical stability and impart CD44-targeting specificity, while doxorubicin (DOX) is loaded for chemotherapy. We show in this proof-of-concept demonstration that upon 980 nm (0.1 W) near-infrared (NIR) laser irradiation, the system exhibits intense red UCL emission at 668 nm for cell imaging application. Additionally, it functions effectively as a dual mode MRI contrast agent with excellent relaxivities values ($r_1 \sim 9.7916 \pm 2.06$ and $r_2 \sim 14.7393 \pm 0.89$ $mM^{-1}s^{-1}$ at 3T) endowing sufficient information about anatomic and cellular progress of the lesions. This developed nanoprobe also exhibits a pH-responsive DOX release mechanism and facilitates chemo-photothermal-photodynamic therapy under NIR exposure affording its potentiality as next-generation non-invasive curative strategy against triple negative breast cancer (TNBC). Our combined therapy shows apoptotic death cells through CD44-TP53-BAX-BCL2-CASP3 signalling in cascade. Overall, this work will shed new light on developing GdOF based next-generation nanotheranostic agent with multiple real-time imaging modalities and precise spatio-temporal therapeutic properties suitable at cellular level, thereby rendering them sensitive and specific TNBC treatment.

Keywords: Yb^{3+}, Er^{3+} co-doped GdOF, UCL, MRI, *in silico*, photo-chemotherapy, Apoptosis, MDA-MB-231

Interaction, Topology and Non-equilibrium Dynamics in Twisted Multilayers

Arijit Kundu

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Kanpur, India

Abstract: Twisted heterostructures have transformed condensed matter research, offering unprecedented tunability to access novel and symmetry-broken phases. These systems have rapidly become a powerful platform for probing strong correlations, topological effects, and far-from-equilibrium dynamics. This talk will present our work on realizing exotic phases—such as skyrmion lattices, network of Josephson arrays, and super solids—within such heterostructures. I will further discuss manifestations of non-trivial topology, including Chern bands with higher Chern numbers, and discuss signatures of 'dynamical' topology nearing quantization.

Facility for Antiproton and Ion Research (FAIR)in Germany and Indian contribution

Saikat Biswas,
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Kolkata, India

Abstract: India is a founder-member country towards the construction of international accelerator facility, FAIR (Facility for Antiproton and Ion Research) at Darmstadt, Germany. Bose Institute, Kolkata, has been designated as the Indian shareholder of the FAIR GmbH and the nodal Indian Institution for managing the FAIR programmed from India.

Indian participation in FAIR is twofold. Firstly, the advancement of knowledge in the areas of astrophysics, high-energy physics, nuclear physics, plasma physics and biophysics through the participation of Indian researchers, engineers and students of different Institutes and Universities across the country in various experiments planned at FAIR. In addition to this, India is also contributing high-tech equipment as in-kind supplies to FAIR.

Our active involvement for the in-kind contributions e.g. power converters, vacuum chamber, beam stoppers, IT cable etc. for accelerator and coordinate participation of Indian scientists in the experiments including detector development, physics simulation, experimental data analysis at FAIR under the project entitled “India’s participation in the construction of Facility for Antiproton and Ion Research (FAIR) at Darmstadt, Germany”, turning this mission into reality.

India is participating in the NUSTAR and CBM experiments at FAIR and in particular Bose Institute is involved in the Compressed Baryonic Matter (CBM) experiment, to study and characterize the matter created in the relativistic nucleus-nucleus collisions at low energy and moderate to high baryon density.

In this talk the details of FAIR facility and the experiments at FAIR will be presented. The detector developments for CBM will also be discussed.

Holography, black holes, and quantum information

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Abstract: Black holes have emerged as a profound theoretical laboratory for unifying gravity with quantum mechanics, from an information theoretic perspective. The discovery that black holes possess thermodynamic properties, most notably, entropy proportional to area of the event horizon, led to the holographic principle, which states that the physics of a gravitational system in some spacetime dimensions can be fully encoded on the lower-dimensional boundary. This remarkable and deep insight is concretely realized in a duality known as the gauge/gravity (AdS/CFT) correspondence in the literature, where spacetime geometry is mapped to quantum degrees of freedom without gravity. In this framework, the dynamics of black hole, evaporation of black holes, and the resolution of the information loss paradox are naturally recast in the language of quantum information theory. Furthermore, information theoretic quantities such as entanglement entropy, mutual information, complexity, can be understood from the gauge/gravity duality. The duality also helps to understand quantum gravity from theories which do not have gravitational degrees of freedom. Together, holography, black holes, and quantum information form a coherent paradigm in which spacetime itself can be viewed as an information-theoretic construct, offering new pathways toward a theory of quantum gravity. In this talk, we shall discuss some of the latest developments in this direction.

Mathematical Modelling of Blood Flow in a Human Artery with Stenosis

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Abstract: Mathematical modelling plays a crucial role in understanding the hemodynamic behaviour of blood flow in diseased arteries, particularly in the presence of stenosis. This talk presents a mathematical analysis of blood flow through a constricted human artery, where stenosis significantly alters flow characteristics and contributes to cardiovascular complications. Blood is modelled as a Newtonian and non-Newtonian fluid to capture its complex rheological behaviour under physiological conditions. The governing equations, derived from the principles of mass and momentum conservation, are solved using analytical and numerical techniques to obtain expressions for velocity profiles, flow rate, pressure gradient, and wall shear stress. The influence of key parameters such as stenosis geometry, fluid rheology, and physiological conditions on hemodynamic variables is examined and illustrated graphically. The results provide valuable insights into the biomechanical effects of arterial constriction and highlight the relevance of mathematical models as effective tools for predicting flow behaviour and supporting clinical understanding of stenosis-related cardiovascular disorders.

CONTRIBUTED ABSTRACTS

Extraction of Phospholipid as an Antibacterial Effect by Nano sheet of Graphene and its Derivatives along with Related Thermodynamics

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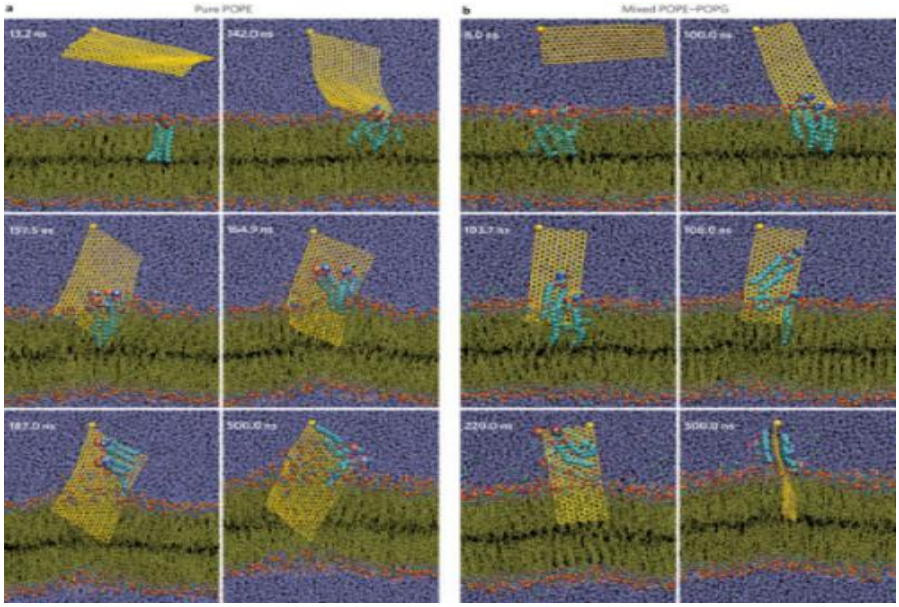
DEBIPRASAD JANA (RKMRC, NARENDRAPUR)
MALAY PURKAIT (RKMRC, NARENDRAPUR)

Abstract: With the advancement of various research works in medical science different non-invasive techniques have been introduced to rupture the viability of bacterial effects. The nano-sheets of Graphene and its derivatives play a key role over the entire practical field. The thickness, size, shape, nature of ligand present, concentration, aggregation, orientation, density of water [2,3] are the parameters that effect the function of the nano-sheet. There are typically two types of antibacterial activities possible: the first one is the direct insertion or penetration of the nano-sheet through the membrane whereas the other mechanism is the extraction of the phospholipid in between the bilayer by creating pores on the membrane. The latter one occurs due to assembly of hydrophobic tails against surrounding water by some sort of Van der Waal type attractive interaction. It accords with adhesion and the hydrophobic lipid tails feel attraction with the hydrophobic surface of Graphene [1]. Another important aspect is lipid flip flop [5] which is nothing but the transfer of lipids from one leaflet to another in a particular bilayer in which Potential of Mean Force (PMF) is important. Actually, here the lipids face a potential well from the strong dispersion interaction or the Van der Waal force. This is actually a slow process but challenge is to increase the speed for the sake of cell signalling and apoptosis [5]. The Graphene Nanosheet [GN) is advantageous from the ground of large surface area to volume ratio and arrangement of its basis in accordance with SP^2 hybridization. At the same time the amphipathic lipid such as phospholipid comprises with both hydrophobic tails and hydrophilic heads. The heads get attracted on use of derivative of graphene; Graphene Oxide (GO) nano-sheet and extracted lipids are spread well over the nanosheet. Two types of lipids are of interest; one is Dipalmitoyl phosphatidylcholine (DPPC) and 1,2--dioleoyl-sn-glycero-3-phosphocholine (DOPC). Actually, DPPC is in a gel phase at room temperature due to which the insertion of this is not prone to ruptures. It is very rigid so that compression does not occur easily. On the other hand, DOPC is in fluid state at room temperature, thus is more prone to keeping GO nanosheet well sandwiched between leaflets of lipid [3]. The ratio of Dimyristoylphosphatidylcholine (DMPC) and Dimyristoylphosphatidylglycerol (DMPG) play an important role which is pertinent to the absorption to nanosheets. The former one is zwitterionic and the latter is anionic. The cationic surface of the nano-sheet attracts more the lipid from DMPG than that from DMPC. Another important discussion is the thermodynamics regarding the extraction. As there is an extraction from the system, so there is a story of change of both the mass and energy of the system i.e. there will be a consideration of grand canonical ensemble. The lipids may be in different states. Change in temperature and pressure have effects on phase transition, the flip flop model discussed earlier the seed of which influences thermodynamic conditions. The continuation of density fluctuation

of different matters involved also impact the thermodynamics of the system. [4] concludes that the interactions are more entropic than enthalpic. Entropic process pertains to the change of molecular
arrangement and disorder whereas enthalpic process pertains to the change of thermal energy and chemical bonds of molecules. These two thermodynamic parameters effect Gibb's free energy.



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Theoretical and experimental assessment of radioisotopes produced from $^{14}N+^{nat}Cu$ reaction from 85 - 126 MeV projectile energy

Chiranjib Barman[1], S. Mukherjee[1], S. Dasgupta[2,3], J. Datta[2,3], S. Chatterjee[4], S. Bhattacharyya[2,3], G. Mukherjee[2,3,] S. Lahiri [1,5,6]*

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Abstract: Heavy ion (HI) induced nuclear reactions are of interest because of their wide range of applications in production of neutron deficient isotopes, study of nuclear reaction mechanisms, understanding nuclear fission dynamics, etc. Earlier, Cho et al. reported 37 isotopes produced in the ^{12}C + ^{nat}Cu reaction of at 15-45 MeV/A [1]. Kim et al. measured production cross sections of 44 radioisotopes produced from the same reaction at 135 MeV/A [2]. In the present study, five natural copper foils of thicknesses 5-6.5 mgcm^{-2} were bombarded with $^{14}N^{5+}$ of energy 85-126 MeV using the K-130 cyclotron at VECC, Kolkata. To the best of our knowledge, this is the maiden instance of excitation function measurement of $^{14}N+^{nat}Cu$ reaction in this energy range. The offline gamma spectrometry of the irradiated targets was carried out using a 40% HPGe detector from 0.7 h after the end of bombardment (EOB) to 60 days after EOB. Total 16 radioisotopes of A 60-80 (e.g^{60,61}Cu, ^{65,66,67,68}Ga, ^{66,67,69}Ge, ^{70,72}As, ^{74,75}Br, ^{73}Se and ^{76,77}Kr) were identified following the analysis of the photo-peaks and half-life. The cross sections have been theoretically calculated using two different simulation techniques using PACE4 and FLUKA4-3.3 Monte-Carlo codes. PACE4 incorporates the contribution of only the compound nucleus fusion whereas FLUKA comprehensively includes all probable reaction mechanisms. Interestingly, both the simulations predict the production of the radioisotopes those were identified experimentally. The current analysis compares the theoretical and the measured excitation functions which would help to ascertain the involved reaction mechanisms.

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Preparation of Pristine ZnO Thin Film for UV Photodetector Device Application

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Abstract: Transparent, pure ZnO thin films were deposited on corning glass substrates using the pulsed laser deposition (PLD) technique at room temperature. The as-deposited films were annealed in air at 600 °C for 1 h to enhance their optoelectronic properties, making them suitable for UV photodetector applications. Structural, morphological and optical properties of the as-deposited and annealed ZnO thin films were studied comparatively. The ZnO films exhibited hexagonal wurtzite structure with a preferential orientation along the (002) plane, and their crystallinity improved notably after annealing. The surface roughness slightly increased from 0.77 nm to 1.25 nm after annealing, while the optical bandgap decreased from 3.30 eV to 3.18 eV, attributed to grain growth. The photodetector device was fabricated by depositing Ti/Au electrodes on the annealed ZnO film in a parallel-electrode configuration with an inter-electrode spacing of 30 µm. The device performance was evaluated at room temperature under UV illumination (~365 nm) with an intensity of 70 µW/cm². The as-deposited device showed negligible photo-response under UV illumination. In contrast, the annealed device demonstrated pronounced photoconductive behaviour with superior performance metrics, including a sensitivity of 18.54, a normalized sensitivity of 6.18×10^4/cm², and a high responsivity of 86.04 A/W.

Keywords: ZnO thin film, Pulsed laser deposition, Photodetector, Photoconductive device

Quantitative Forecasting of Sunspot Numbers: Statistical Methods and Deep Learning Models

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Abstract: Forecasting sunspot numbers is vital for understanding solar activities and their impact on space weather, which have profound effects on satellite operations, communication systems and power grids on earth. This study investigates statistical and deep learning approaches to predict Sunspot numbers using daily, total and hemispheric sunspot data from SILSO.

Traditional time-series techniques like TBATS and SARIMA are used to capture the seasonality and long-term patterns that characterize the solar cycles. Parallelly, advanced machine learning models like ANN-MLPRegressor and CNN-LSTM are used. ANN-MLPRegressor, a feedforward ANN, can handle modelling complex relationships within the data, whereas CNN-LSTM is effective in addressing nonlinear and sequential dependencies. As seen in the figure given below, the CNN-LSTM network closely follows the observed asymmetry values during both training (red vs blue) and testing (yellow vs green) phases. This overlap indicates a strong learning of nonlinear fluctuations and abrupt variations in hemispheric sunspot activity. Thus, integrating diverse methodologies helps assess both predictive abilities of the statistical models and explore the hemispheric asymmetry.

In an earlier study by *Dubey et. al (2021*) [1], they found that CNN LSTM performed best, offering high accuracy, temporal awareness, and nonlinear pattern recognition on monthly total data. Similarly, in another work by *Pala, Z., & Atici, R. (2019)* [2], they showed that LSTM outperformed ARIMA in long-term nonlinear forecasting. In comparison, our current study uses daily totals and hemispheric asymmetry and effectively evaluates model performance through various metrics and produces a more comparative study. It reveals the strengths and weaknesses of these approaches and provides a perspective on the usage of these techniques in future works.

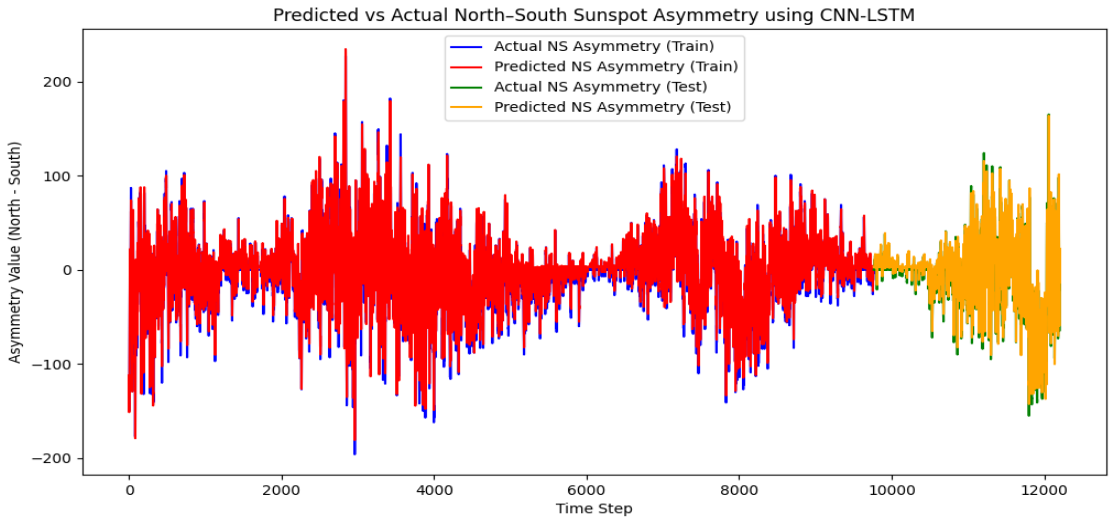

Figure 1: *The CNN-LSTM network closely follows the observed asymmetry values during both training (red vs blue) and testing (yellow vs green) phases.*

To conclude, Neural networks, particularly **CNN–LSTM**, outperformed traditional methods by capturing **nonlinear dependencies** and long-term patterns, achieving high correlation (>0.98) with observed data. Including **north–south sunspot data** improved prediction accuracy, revealing important magnetic asymmetries in solar activity. Thus, this study gives an insight into the comparison between traditional statistical models and cutting-edge machine learning techniques, and their performance in dealing with solar activity. This study contributes to the ongoing research work happening to develop and improve predictive models of solar activity and cycle.

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Geometry of Multi-Temporal Space-Time: A Unified Model of Subluminal, Null, and Superluminal Regimes

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Abstract: Previous proposals on higher temporal dimensions, like String theory, Kaluza-Klein, multi-time cosmologies etc. treat additional axes of time differently (rather specially) from the one that we perceive. They are either tied to perception, entropy, metaphysics, or curved at a quantum level. They are not considered as isotropic or interchangeable. In this proposition, we assume that each temporal axis is physically equivalent i.e. the geometry of time obeys the same tensor symmetries that govern space. We define three kinematic classes of an entity: subluminal, luminal, and super-luminal. We propose a unified framework where the dimensional structure of space-time depends on the three classes. A smooth scalar field $\emptyset$ selects the effective dimensional pair $(D_s,_t)$ that explains the number of spatial and temporal axes. A canonical projection-penalization term enforces the corresponding local signature in the tetrad fields. In the subluminal regime, observers experience the usual (3+1) dimensional geometry. In the luminal case, entities travelling at c, they occupy an intrinsic (2+2) dimensional regime with two spatial and two temporal coordinates. In this case, a photon is represented by a null world-sheet $\Sigma(\sigma,\tau)\subset\mathbb{R}^{2+2}$ satisfying intrinsic null constraints $\gamma_{AB}\partial_\alpha X^A\partial_\alpha X^B=0$. We show that the wave-like behaviour of a photon arises from the projection of intrinsic $2D-time$ oscillations into a $1D-time$ observational frame. Furthermore, entities in the super-luminal regime are governed by (1+3) dimensional system where space-like and time-like dimensions reverse or swap functions. This framework provides a mathematically consistent reformulation of photon kinematics and shows a future path toward a unified geometric theory of subluminal, luminal and super-luminal states and higher dimensions of time.

Keywords: Multiple timelike dimensions, signature field dynamics, 2D and 3D time

Non-Markovian Signatures in the Classicality Assessment via Kolmogorov Consistency

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Abstract: The Kolmogorov consistency condition (KCC) defines the statistical boundary between classical and quantum dynamics. Its violation signifies the breakdown of a classical Markov description of temporal correlations. In this work, we establish a direct analytical connection between KCC violation and non-Markovianity in open quantum dynamics, revealing how memory effects manifest as departures from classical probabilistic consistency. Within a generic two-level open quantum system framework, we establish quantitative connections between the magnitude of KCC violation and key thermodynamic quantities, such as entropy production rate, heat exchange, mutual information, and the Fano factor, enabling an energetic interpretation of temporal quantum correlations. Furthermore, we uncover formal correspondences between KCC violation, the Leggett--Garg inequality, and the negativity of the Kirkwood--Dirac quasi-distribution, identifying them as complementary witnesses of temporal quantum non-classicality. Our results thus provide a unified framework linking information-theoretic, thermodynamic, and temporal indicators of quantum Ness in open quantum systems.

Urban expansion and wetland shrinkage estimation using QGIS- tool A Kolkata Case-Study

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Abstract: Urban wetlands play a critical role in regulating hydrological balance, microclimate, and ecological sustainability within rapidly expanding metropolitan regions. However, accelerated urbanization has resulted in substantial degradation of these ecosystems. This study investigates the spatio-temporal dynamics of wetland transformation across **Kolkata** using a **GIS-based NDWI framework** integrated with predictive analysis. Multi-temporal satellite data for various years were processed in QGIS to quantify changes in wetland extent across distinct urban typologies of **Burrabazar (urban core), Salt Lake (planned city), New Town (expansion zone), and the metropolitan scale of Kolkata**. Results indicate a consistent and accelerated decline in wetland area across all spatial scales. At the metropolitan level, wetland coverage reduced from **1,244.41 km² (3.41%) in 2014** to **357.05 km² (0.98%) in 2023**, despite negligible variation in total geographical area. Micro-scale analysis reveals near-terminal wetland conditions in the urban core, moderate resilience followed by decline in planned urban areas, and rapid depletion in expansion zones. Predictive assessment suggests that, under existing urban growth trajectories, remaining wetlands are likely to transition into fragmented, non-functional hydrological features. The findings highlight a critical imbalance between urban expansion and ecological sustainability, emphasizing the urgency for wetland-sensitive urban planning, continuous geospatial monitoring, and policy-driven conservation strategies to mitigate irreversible environmental loss. The study is confirmed using Linear Regression and Polynomial Regression (degree = 2) which predicted that in the year 2030, 0.131 km^2 wetland will be present in Kolkata and by 2040 it will reach a saturation point.

Keywords: Urban wetlands, NDWI, GIS, QGIS, Spatio-temporal analysis, Urban expansion, Wetland degradation, Kolkata

Integrator Sensitivity of Chaos in the Ultradian Glucose-Insulin Model

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Abstract: Diabetes Mellitus is a chronic metabolic disorder that arises from dysfunction of the body's glucose-insulin feedback control system. Mathematically, it behaves like a nonlinear feedback oscillator with delay. The ultradian model [1] bridges the gap between biological physiology and nonlinear physical dynamics that mimic the body's inherent rhythmic regulation.

In this work, the dynamical behaviour of the regulatory system for glucose-insulin is studied, incorporating periodic pulsatile forcing based on the model proposed by Karamched et al. (2022) [2]. We investigate the system using a range of numerical integrators, and employ multiple chaotic indicators, including the Maximal Lyapunov Exponent (MLE) and Fast Lyapunov Indicator (FLI) for a large number of kick-relaxation cycles, to characterize its dynamical nature.

We note that the Maximal Lyapunov Exponent (MLE) as a function of the inter-kick time varies over different numerical integrators, even with different tolerances, as shown in Figure [1]. Our results reveal that the choice of integrator and its computational efficiency play a crucial role in the observed behavior and the values of these chaotic indicators altered the previous studies that reported the emergence of chaos in specific regimes.

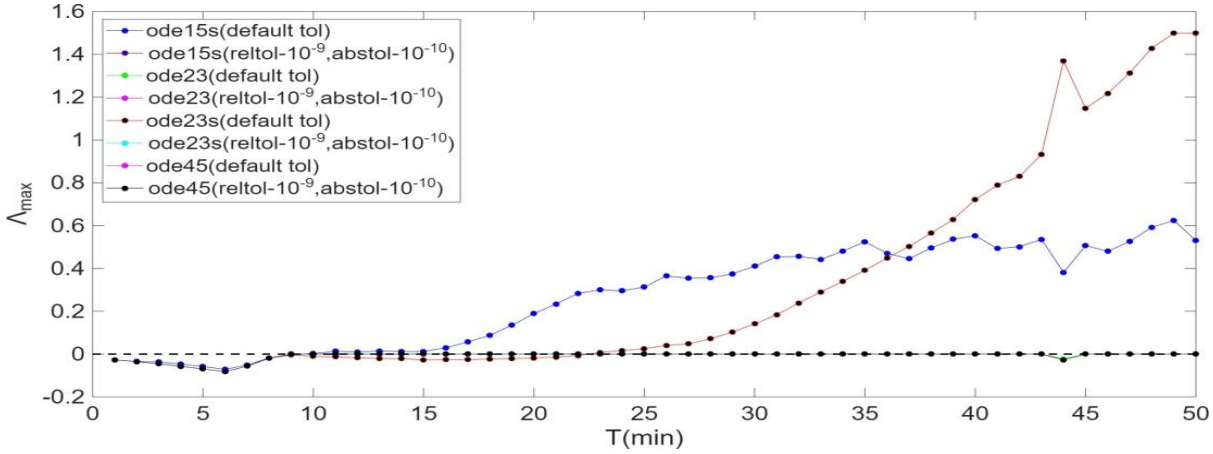

Figure 1: Maximal Lyapunov Exponent (MLE) as a function of inter-kick time (T) for different integrators

Based on these non-trivial findings, we present a detailed initial analysis of this newly identified integrator-sensitive behaviour. We believe that this analysis will help us to discern the interplay between the choice of integrators and the method used for quantifying chaos, over a large range of parameter variation and provide some conclusive insights into this issue for nonlinear differential equations including linear delay filter.

To conclude, we would like to point out that glucose dynamics does exhibit periodic or quasi-periodic behaviour at higher inter-kick times. Our current findings highlight the importance of rigorous numerical validation to model the glucose-insulin system and have implications for the reliable identification of chaotic regimes linked to diabetic states. Extending this work further, we will also integrate machine learning to predict numerical artifacts from integrator settings and kick intervals and try to develop physics-guided neural surrogates for robust, integrator-independent detection of chaos across physiological regimes.

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Dual-Sensor Fingerprint Authentication System

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Abstract: This article presents a prototype of Image and Thermal Fingerprint Dual-Sensor that includes collecting optical fingerprint ridges with simultaneous analysis of the session thermal heat distribution. The prototype uses Raspberry Pi 3B+ with a Pi Camera (OV5647) to capture optical images and a MLX90640 thermal infrared array (24×32 pixels resolution) for thermal images and to establish "physiological" confirmation. The optical and thermal exposure systems capture images in two different formats (.jpg for optical and. npy for thermal matrix). Once the images are enrolled, similarity between the input images and data are compared using SSIM and MSE algorithms. Experimental verification showed the SSIM of the genuine trials were >0.55 and the thermal MSE of <4.0. The prototype was able to fully complete a full verification cycle in ~8-10 seconds in a verifiable nature.

Free Drug vs. Nanomedicine in Transdermal Patches: A Comparative Exploration of Etoricoxib Drug Release and Its Analgesic Activity

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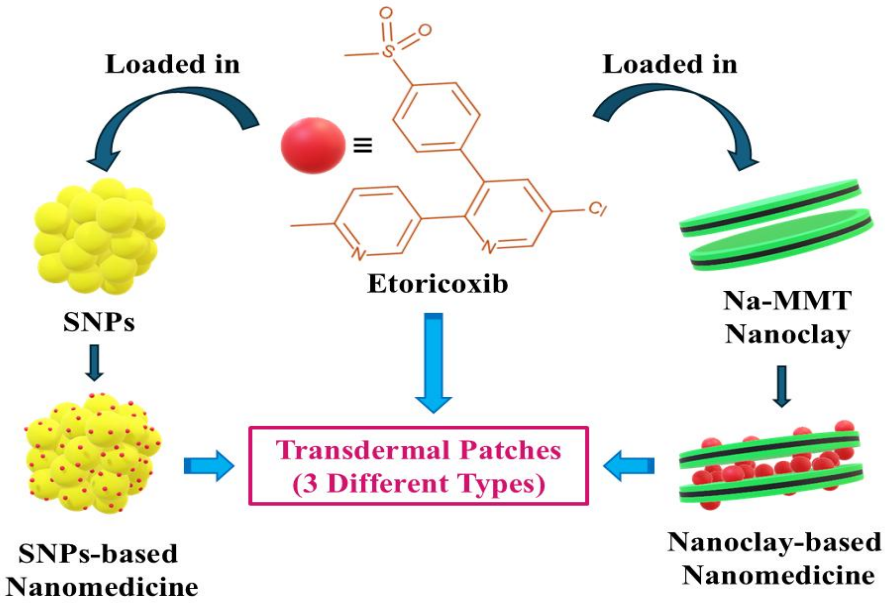
Abstract: Transdermal patches of several Non-Steroidal Anti-Inflammatory Drugs (NSAIDs), such as diclofenac, are already available on the market [1]. Both diclofenac and etoricoxib belong to the NSAID class and are commonly used to treat pain and inflammation. However, no transdermal formulation of etoricoxib has been commercialized to date, primarily because of its extremely poor aqueous solubility (log P ≈ 2.79; solubility 0.01–0.5 mg/mL at 25°C) [2]. While diclofenac, a non-selective COX inhibitor, is associated with renal, cardiovascular, and gastrointestinal risks, etoricoxib selectively inhibits COX-2 and may offer a safer profile for long-term pain management. This makes the development of an etoricoxib transdermal system highly desirable. In this study, we developed nanomedicine-impregnated transdermal patches of etoricoxib (EB) to address its solubility limitations and enhance therapeutic outcomes. Etoricoxib was encapsulated into silica nanoparticles (SNPs) and sodium montmorillonite (Na-MMT) nano clay, chosen for their high surface area, biocompatibility, and potential to improve drug solubility and skin permeation. Transdermal patches containing either pure EB or EB-loaded nanomedicines were fabricated to enable a systematic comparison. A series of pharmaceutical evaluations were performed, including *in vitro* drug release at pH 5.5 and 7.4, *ex vivo* skin permeation using Franz diffusion cells, drug release kinetics, skin irritation assessment in mice and rats, and *in vivo* analgesic study via Hot-Plate and Tail-Flick methods. The prepared materials and patches were thoroughly characterized using DLS, FTIR, N_2 adsorption-desorption, SEM, TEM, and XRD.

Keywords: Transdermal Patch, Nanomedicine, Sustained Release, Skin Permeation, Analgesic Activity.

Graphical Abstract



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Spinning compact object and chaos in galactic centers

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Abstract: Galactic centres are highly dynamic regions dominated by a supermassive black hole (BH) surrounded by nuclear star clusters (NSC), molecular gas, and asymmetric matter distributions such as disks or halos. The combined gravitational effects of these components, along with relativistic corrections from the BH's spin, generate strongly nonlinear dynamics and frequent chaotic orbital behaviour. To model this environment, we employ a multipolar expansion potential (1) in which the central compact object is represented by the Artemova–Björnsson–Novikov pseudo-Newtonian potential, effectively capturing spin-dependent features of a Kerr-like BH. The surrounding halo is treated as an axisymmetric, shell-like mass distribution expanded up to third order in multipolar terms to account for realistic asymmetry. Previous studies have mainly explored the influence of multipolar moments and BH spin using Poincare sections, SALI (2), and related chaos indicators. In this work, we extend these analyses by incorporating stability analysis and basins of convergence to achieve a more complete understanding of the system's dynamics. Poincare sections reveal global phase-space structure, including regular tori, resonant islands, and chaotic layers. Stability analysis around equilibrium points provides insight into local behaviour, while basins of convergence highlight sensitivity to initial conditions and expose fractal basin boundaries. Our results show that the BH spin significantly reshapes phase space: depending on its magnitude and orientation, it can either amplify chaotic scattering caused by halo asymmetry or stabilize specific orbital families. These findings enhance our understanding of how relativistic spin effects and multipolar mass distributions jointly govern the dynamical architecture of galactic centres.

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Comparative Analysis of Noise-Reduction Filters for Low-cost Radio Telescope Data

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Abstract: Accurate extraction of solar radio signals is essential in observational astronomy; however, strong narrowband interference often reduces the quality of data obtained from low-cost radio telescopes [1]. These telescopes, typically assembled from readily accessible components such as parabolic dish antenna, connecting cables, low-cost satellite meters and spectrum analysers tend to be highly susceptible to external noise because of their limited shielding and hardware constraints. To address these challenges, this study conducts a detailed comparative analysis of widely used filtering techniques through software simulations—specifically lowpass, Chebyshev, Gaussian, median, band stop, and notch filters [2]—to identify the most suitable method for improving solar radio observations. The performance of each filter was evaluated using three standard metrics: mean squared error (MSE), signal-to-noise ratio (SNR), and correlation coefficient. Among all methods examined, the notch filter demonstrated the highest effectiveness, achieving an SNR of **46.10 dB**, the lowest MSE of **0.100035** and a correlation coefficient of **0.9992**. These outcomes confirm its superior ability to suppress interference while preserving the integrity of the original signal. In comparison, other filters produced lower SNR values or introduced greater distortion, thereby limiting their practicality in this context. The choice of notch filter is primarily justified by the nature of the interference, being localized and narrowband. The notch filter targets interference precisely, minimizing data loss, unlike broader filters that weaken wider frequency ranges. Even in urban environments with substantial light pollution and signal interference, this unique approach would enable minimum-cost radio telescopes to effectively process and recover high-quality solar radio signals.

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Development of a simple refractive index sensor by using splice loss in optical Fibers

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Abstract: We investigate, extensively, the effect of aspect ratio on the splice loss due to certain longitudinal misalignment at the joint between two single mode trapezoidal index fibers of identical aspect ratio. We report that there is considerable increase of splice loss with the decrease in the value of aspect ratio from 1.0 to 0.0 and, hence, maximum loss is exhibited by triangular index fibre. Further, the effect of refractive index of the index matching fluid filling the gap between two identical single mode triangular index Fibers in reducing the splice loss has been investigated. Using the knowledge of splice loss, a simple empirical relation for refractive index in terms of splice loss is prescribed to predict the refractive index of a medium leading to a prospective proposal of a refractive index sensor. It is developed involving the loss-sensitive triangular index profile in an optical fibre. Also, our relation is reliable for the system users even for little digression from triangular index profile during fabrication. The physical significance of our results is justified from basic diffraction ideas.

Keywords: Splice loss, aspect ratio, refractive index profile, refractive index sensor.

Highly transparent Zn coated Al doped ZnO films for Transparent Conducting Electrode Application

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Abstract: A worldwide strong interest in realizing inexpensive transparent conducting layers exists for production of optoelectronic devices. Doped ZnO is among the few metal oxides which potentially used as a transparent conducting oxide (TCO). The advantages of ZnO are the wide band gap of 3.3 eV, low resistivity, high transparency in the visible range, and low preparation costs. The n-type dopants used in ZnO are mainly In^{3+}, Al^{3+}, B^{3+}, Ga^{3+} [1]. Among all these dopants, Al is relatively a cheaper, abundant, and non-toxic material hence Al-doped ZnO (AZO) films can be a prominent, low-cost substitute for high-cost ITO films in TCO applications. The native defects in ZnO can cause enhancement/generation of new properties [2]. If the donor defects can be increased in AZO films, higher carrier concentration may be achieved maintaining a higher mobility. A novel idea to improve the electrical properties of AZO films by coating them with a Zn layer and face-to-face annealing at higher temperature has been proposed. Face-to-face annealing is a mechano-chemical pathway where the exposure of the top layer to the ambient is restricted by mechanically holding two films in a face-to-face condition so that diffusion to the next immediate layer is forced to occur during annealing. Magnetron sputtering has been adopted to produce AZO films and subjected these to a post-growth Zn coating treatment which causes a carrier concentration as high as 2.29×10^{21} cm^{-3}, resistivity as low as 1.13×10^{-4} Ω-cm and a mobility value of 24 cm^2/Vs without scarifying the transparency in the visible region.

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Modelling of Non-Specific Liver Biomarkers for the Early Screening of Ovarian Cancer

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Abstract: Ovarian Cancer (OC) cases are exponentially growing across the world and the mortality rate are also very alarming. The present screening and detection methods of OC cases includes a series of physical tests, imaging test followed by biopsy. Such tests are time consuming, costly and painful. This contributory study attempts to identify and modelling of various non-specific Liver bio-markers and its subsequent impacts on the early detection of the OC risk factors. Blood composed of various biomolecules such as plasma, proteins, osmotic pressure, hormones, enzymes, and antibodies. A secondary blood dataset was pre-processed and analysed in this study followed by extraction of the key significant predictors for the modelling of various non-specific blood markers for the early screening of OC cases. Albumin, Alkaline Phosphate, Direct Bilirubin and Globulin were found as significant predictors biomolecules from the dataset for OC cases detection using rankers and best first attribute selection method. The study subsequently framed three machine learning models named Instance-Based k-nearest neighbours (IBK), Random Forest (RF) and Logistic Regression (LR) classifiers with each 10-fold cross validation and compares the model performances for the selection of the best framework for the early detection of OC cases. The study evident that the accuracy of the IBK, Random Forest and Logistic Regression frameworks are 59.8%, 69.6% and 73.3% respectively with ROC value 0.60, 0.75 and 0.77 respectively. That evident the performance of LR is best among other models for the accurately detection of the cases of OC with high true positive rate (76.4%) and low false positive rate. The study shows a pathway on combining features from various non-specific biomarkers for screening the risk factor of OC cases at early stage. The authors are hopeful such low cost, less invasive approaches with promising pattern finding methods of machine learning, will appreciate by medical professionals through clinical studies and tests that will help to detect OC cases at very beginning for better treatment outcome.

Keywords: Biomarkers, Machine Learning, Bio-molecules, Cross Validation

Nano bioremediation Technologies for Potential Application in Environmental Cleanup

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Abstract: Bioremediation is a strategy for decontamination of pollutants from the environment and industrial waste based on the simple natural phenomenon of decomposition of waste products using suitable microorganisms. The modern development of nanotechnology is now bridging the gaps with technological advancements to produce more effective and efficient nanoparticles using living systems in bioremediation. Nano-biosorption can be defined as the removal of metal or metalloid species, compounds and particulates from solution or any other source by biological material using nano-technology. Bacteria and fungi could be used as biosorbents because of their small size, ubiquity and ability to grow under controlled conditions. Many eco-friendly applications of nano-biosorbent detect and clean up environmental contaminants, waste and toxic materials. This method combines nanotechnology and bioremediation to achieve a more efficient remediation that is both environment friendly and less time-consuming than the individual processes. In this chapter, we focus on the removal of toxic pollutants using the cumulative effects of nanotechnology with microbial technology and their applications in different domains.

Keywords: Nanotechnology, Bioremediation, hybrid technology, sustainable, Nanotechnology

Improved mechanical and tribological behaviour of peepal-okra-Madar fibre hybrid composites reinforced with Tio_2 nanoparticles

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Abstract: The hybridization of natural fibre composites is increasing to enhance material performance through the synergistic effects of several fibres. The addition of filler materials has significantly improved the wear resistance of hybrid composites. This study examines the mechanical and wear properties of a unique hybrid composite reinforced with 6 wt% of Peepal fibers, and varying weight percentages of Okra, and Madar fibres. The fabricated specimens were assessed using mechanical characterizations including hardness, impact resistance, flexural strength, interlaminar shear strength, and tensile strength. Different weight percentages (2, 4, 6 and 8wt%) of Titanium Dioxide (TiO_2) nano powder were included as a filler material to enhance the tribological performance. The mechanical properties of the filler-free composite samples comprising 15wt% Okra and 15wt% Madar fibres were superior to those of the other samples. Moreover, among all the configurations analysed, the sample augmented with 6 wt% TiO_2 filler exhibited the lower wear rate, indicating a significant enhancement in wear resistance. This study emphasizes the potential of TiO2 reinforced hybrid natural fiber composites for advanced structural and abrasion-resistant applications.

A Simulation-Based Assessment of Proton Beam Therapy for Oesophageal Cancer

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Abstract: Proton beam therapy, a form of external beam radiation therapy, utilizes protons to treat cancer. This advanced radiological approach uses a beam of protons that interacts with various layers of the human body through nuclear and electronic interaction. The energy deposition profile of these interactions reveals that the proton deposits its maximum energy at Bragg peak [1], effectively destroying the DNA of cancer cells at the target. Therefore, understanding the precise interaction characteristics is crucial before treatment. Proper simulations demand precise qualitative and quantitative data, such as the thickness and composition of the body parts through which the proton beam travels. With this information, the interaction of the proton beam can be accurately modelled, allowing for the selection of the appropriate proton beam energy for treatment. The oesophagus is a muscular conduit that safely transports food to the stomach while preventing airway intrusion and reflux. Oesophageal cancer, a high-burden gastrointestinal malignancy linked to smoking, alcohol, nutritional factors, and chronic reflux, is managed through multimodal treatment. However, its proximity to the heart, lungs, spinal cord, and liver means conventional photon therapy often irradiates surrounding tissues, raising the risk of cardiopulmonary toxicity. In this work, to evaluate the suitability of proton beam therapy for oesophageal cancer, we use a two-stage simulation workflow with SRIM and FLUKA. SRIM (with TRIM) provides proton energy-loss profiles, stopping powers, ranges, and Bragg peak localization in multilayer tissue-equivalent targets. FLUKA then model's proton interactions in realistic anatomical geometries for improved accuracy.

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Uncovering Nuclear Structure Patterns through AIML: A Case Study of β^- Decay Rates Related to Nuclear Astrophysics

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Abstract: Artificial intelligence and machine learning (AIML) techniques are now widely used for recognizing pa erns in data and building models to describe complex relationships. Unlike the traditional analytical models, machine learning (ML) models do not require an explicit theoretical formula in advance; instead, they learn the underlying trend from the data itself. This makes ML particularly effective for dealing with problems that involve nonlinear behaviour and multiple parameters. Such capabilities of ML make it an important tool to use in nuclear physics, where experimental information is o en sparse and theoretical models involve complex, many-body interactions.

In this work, we present a preliminary exploration of applying ML-based regression methods to β^- decay systematic. In the case of stellar environments or in storage ring experiments in a terrestrial laboratory, atoms may get fully ionized. In this scenario, β^- decay to the unoccupied atomic orbitals, i.e., bound state β^- decay, becomes another probable channel along with the existing decay to the continuum [1]. The relative importance of these two channels depends sensitively on nuclear properties such as the Q value, mass number, and proton number of the daughter nucleus, making it challenging to predict the circumstances under which bound-state decay dominates.

Here, we employ ML regression models on theoretically calculated decay rates for a set of nuclei to train the system and investigate these dependencies. Also, we explore how the decay behaviour varies with key nuclear parameters and try to assess the potential of ML in uncovering systematic trends in weak-interaction processes.

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Shell-Model Interpretation of Seniority Isomers in Yttrium Isotopes Around the *N*= 50 Shell Gap

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Abstract: The study of nuclear structure aims to understand the strong interaction between protons and neutrons inside the nucleus. It also examines how the internal arrangement of nucleons gives rise to the observed energy levels, transitions, and isomeric states. In medium mass nuclei, the behaviour of nucleons in high–j orbitals have a significant influence on the emergence of isomerism. Seniority, defined as the number of nucleons not paired to total angular momentum J=0, offers a simple but powerful framework for interpreting these isomeric states. Changes in seniority reflect the breaking of pairs and the alignment of individual nucleon spins, which naturally lead to slow electromagnetic transition rates and long-lived configurations. Shell model calculations are particularly useful in this context, as these provide specific proton and neutron configurations that generate the observed isomers and connect experimental level schemes with underlying microscopic structures [1].

In this work, we have explored the structure of Yttrium (Z =39) isotopes near the N=50 shell closure by performing shell-model calculations in a valence space of 1f5/2, 2p3/2, 2p1/2, and 1g9/2 orbitals and employing the available interaction Hamiltonians, we interpret the isomeric states in terms of their seniority assignments. The theoretical results will be compared with the existing experimental data to evaluate the performance of these Hamiltonians in this mass region and to identify the possible seniority-driven configurations underlying the isomeric states.

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Free vibration behaviour of rotating porous micro-disk made of functionally graded material

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Abstract: Due to the advancements in micro-fabrication technology, micro- and nano-size components are being widely used in various engineering applications, such as, use of micro-disk in micro engines for power genera on, micro-propulsion in aerospace, and micro-motors for robotic and biomedical applications. Most important analysis of a rotating micro-disks is free vibration analysis. However, classical continuum mechanics cannot include size effects of micro- and nano-scaled structures whereas non-classical modified couple stress theory (MCST) [1] can resolve this problem. For the current study, functionally graded materials (FGM), which are far superior to conventional composites, has been considered. Porosity in these materials offer multi-functionality and weight reduction compared to nonporous materials. However, free vibration analysis of the porous FGM micro disk is challenging work. For the present work, an annular rota ng micro-disk of uniform thickness is considered where the inner radius is clamped and the outer radius is free. The effect of porosity has been included through different material parameter. The model is validated against literature, and results for the first four modes are presented in non-dimensional speed–frequency plots for varying size and gradation parameters.

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Ultrasonic-assisted Additive Manufacturing: A review on Recent Advancements

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Abstract: Ultrasonic-assisted additive manufacturing (U-AAM) is an emerging technology integrating ultrasonic energy into traditional additive manufacturing (AM) processes to address critical challenges such as defects, microstructural inhomogeneity, and residual stress. This review comprehensively synthesizes recent advancements in ultrasonic field-assisted metal AM, highlighting the mechanisms by which ultrasonic vibration modifies melt pool dynamics, solidification behaviour, and material bonding to enhance densification and mechanical properties. Key developments include refined grain structures, defect reduction, and expanded material processability enabled by ultrasonic energy. The paper also discusses integration approaches of ultrasonic fields with various AM techniques, summarizes experimental and simulation studies, and explores future prospects such as parameter optimization, process scalability, and hybrid manufacturing systems. Challenges including process parameter optimization and scalability are discussed, as well as future research prospects such as AI guided control and multi-material hybrid manufacturing. This systematic review aims to provide insightful guidance for researchers and industry practitioners to harness ultrasonic fields for advancing metal and multi-material additive manufacturing.

Phase-Field Investigation on of the Influence of Initial Grain Size Distribution on Grain Growth Kinetics in Additive Manufacturing

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Abstract: Grain growth during heat treatment of additively manufactured parts strongly influences the microstructure and properties of polycrystalline materials, and is o en described by a power law relation of the form ⟨R⟩^n-⟨R_0 ⟩^n=Kt under normal conditions. However, experimental observations and simulations frequently report significant deviations from parabolic (n=2) kinetics, especially in systems with strong hetero geneity, nanoscale grains, solute drag, or abnormal grain growth, where the grain size distribution becomes markedly non-self-similar and can evolve toward bimodal forms. In this work, a mesoscale phase-field model is employed to systematically investigate whether and how the initial grain size distribution (unimodal versus bimodal) can influence subsequent grain growth kinetics under nominally curvature-driven conditions. Two-dimensional multi-order-parameter phase-field simulations are performed for idealized polycrystals with controlled initial distributions, while keeping grain boundary energy and mobility uniform so that curvature is the primary driving force. The temporal evolution of the mean grain size, grain size distribution, and higher-order statistical descriptors is analyzed to assess the emergence (or suppression) of steady-state, me-invariant normalized distributions and their associated growth exponents. The simulations reveal that the initial grain size distribution can significantly delay or modify the approach to a steady-state regime and can induce transient deviations from classical parabolic kinetics, even in the absence of extrinsic pinning or anisotropy.

A theoretical study to understand the photophysical properties of a fluorescent compound (HINA)

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Abstract: The photophysical properties of fluorescent molecules are investigated theoretically by different methods using Hartree-Fock and density functional theory-based (HF/DFT) models. The observed UV-Visible spectra and related photophysical properties are explained with the help of the energy value from the ground state geometry. and trying to calculate the excited state geometry. The structure-property relationship of the fluorescent molecule is discussed, and finally, the theoretical data will be validated against the experimental data. In our current study, the photophysical properties of 3-hydroxy-4-pyridine carboxaldehyde (HINA) is studied theoretically in the gas phase. Using DFT calculation along with the exchange correlation function [6-311++G (d, p)], we are trying to find out the ground state geometry and potential energy surface. With the help of the TD-DFT method, we are trying to calculate the excited state geometry of the molecule and finally, try to correlate the obtained results with the experimental data.

Keywords: photophysical properties, computational study, fluorescent molecule.

Abbreviation: Density functional theory (DFT), 3-hydroxy-4-pyridine carboxyldehyde (HINA), Time-dependent density functional theory (TD-DFT).

Influence of Zirconia Nanofillers on Physical and Mechanical Characteristics of Palmyra Palm Fruit and Jackfruit Peel Fiber–Reinforced Polymer Composites

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Abstract: This study seeks to examine the mechanical properties of epoxy composites reinforced with natural fibers derived from hybrid palmyra palm fruit waste and jackfruit (Artocarpus heterophyllus) peel waste fibers, as well as to evaluate the impact of varying zirconia (ZrO_2) nano filler loadings on their physical and mechanical attributes. A 5% NaOH solution was utilized to mercerize the fibers of the palmyra palm fruit, and X-ray diffraction (XRD) analysis verified the crystallinity of the treated fibers and ZrO_2 nanofillers. Three distinct loadings of ZrO_2 nano fillers (2.5 wt. %, 5 wt. %, and 7.5 wt. %) and three fiber fractions (20 wt. %, 25 wt. %, and 30 wt. %) were employed. Composites were manufactured via hand lay-up techniques, and evaluations were conducted in accordance with ASTM standards. The findings indicated that the incorporation of $nZrO_2$ markedly improved tensile strength (up to ~32 MPa), tensile modulus (up to ~1555 MPa), flexural strength (up to ~78 MPa), impact resistance (up to ~1.8 J), hardness (up to ~64 HV), and interlaminar shear strength (up to ~82 MPa) relative to unfilled composites, with optimal performance achieved at 25 wt. % fiber loading and moderate filler content (2.5–5 wt %). Excessive fiber or filler loadings (30 wt % fiber or ≥7.5 wt % filler) led to diminished characteristics due to agglomeration and an increase in voids (up to about 7 wt. %). Composites containing 5 wt. % ZrO_2 nanoparticles and 20 wt. % fiber (1:1 ratio of palmyra palm to jackfruit peel fiber) shown enhanced hardness, impact resistance, compressive strength, and flexural strength. Morphological investigation validated the effective interfacial bonding among ZrO_2 nanofillers, epoxy matrix and the natural fibers. The findings indicate that the produced composites possess promise for structural and non-structural applications under low to medium stress situations.

Mechanical Behavior Optimization of Titanium-Alloy-Reinforced PLA Using Taguchi- -Driven FDM Parameter Selection

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Abstract: The primary aim of research is to find optimal fused deposition 3D printing settings by Taguchi approach such that polylactic acid (PLA) reinforced with 25% titanium alloy powder. The optimization of process parameters and the L16 OA matrix based on Taguchi were both designed and executed using the Minitab program. Nozzle temperature (200º C to 245ºC), layer thickness (120 µm to 420 µm), infill density (40–100%), concentric (C)), triangular (T), grid (G), infill patterns, (line (L) and Filament type (25% TAP-PLA) were all part of the experimental design. The test components were made using FDM and their tensile, flexural, and impact properties were evaluated according to ASTM standards (D-638, D-790, and D-256). According to the findings, the mechanical strength was primarily affected by the infill density. The optimal configuration for optimal results included a nozzle temperature of 230ºC, a layer thickness of 320 µm, an infill density of 100%, and a grid infill pattern. Together, these parameters provide tensile strength (TS) of 51.79 MPa, an impact strength (IS) of 16.98 kJ/m2, and flexural strength (FS) of 91.69 MPa. In addition, scanning electron microscopy (SEM) was used to analyze morphological changes on the fractured surfaces. The results show that it is possible to 3D print using the ecofriendly 25%TAP-PLA, which is a major step toward the sustainability goals for 3D printing material utilization.

Sustainable Hybrid Epoxy Composites Reinforced with Hemp Fiber Coir and Nano Egg Shell Particle for Biodegradability Evaluation

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Abstract: Sustainable applications like, biodegradable packaging, aerospace and automotive industries are objective of this study's efforts to enhance and evaluate novel hybrid composite substances utilizing Hemp, Coir, and Nano Egg Shell Particle (NESP) as reinforcements at epoxy polymer matrix. The unique aspect of this work is the lack of prior research on composite systems that combine natural fiber (Hemp), bio-ceramic reinforcement (NESP), and an agro-waste filler (coir). In order to test the mechanical, thermal, biodegradability, and water absorption characteristics of five distinct compositions, we kept the epoxy content constant and varied the hemp fiber (25-5%), coir powder (5-25%) and nano egg shell particle (5%). For the composites, the production process began with hand lay-up and ended with hot pressing. In terms of tensile strength (44 MPa), flexural strength (87 MPa), and maximum hardness (90.5 Shore D), the sample that contained 25% hemp, 5% coir, and 5% nano egg shell particle had the best results. On the other hand, samples that had a higher Coir content were more suitable for environmentally friendly uses since they were more biodegradable (losing up to 18.2% of their weight) and absorbed more water (7.1% after 72 hours). Reinforcing all samples with nano egg shell particles greatly improved their thermal stability. Composites with the best combination of biodegradability, mechanical durability and environmental sustainability can be achieved by precisely controlling the reinforcing content, as shown in the study. A fresh approach to creating environmentally friendly composites with various uses has emerged with this integrated reinforcement system, which draws on both natural and waste-derived materials.

Catalytic Transesterification of Rubber Seed Oil to Biodiesel Using SrO/Al_2O_3: A Statistical Approach

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Abstract: This work is a study of biodiesel synthesis from Rubber Seed Oil (RSO) with SrO/Al_2O_3 heterogeneous catalyst in order to optimise the key parameters of the process for improved production levels. The transesterification reaction was carried out under different process variable conditions such as feed temperature, catalyst loading and molar ratio of methanol to oil. An L16 orthogonal array, based on the Taguchi approach was applied to establish nine experimental runs in order to efficiently study the influence of these factors and also to reduce the experimentation work. The SrO/Al_2O_3 catalyst was prepared and characterised in structural points of view, which enabled effective activation for oil-to-biodiesel conversion. The yield of biodiesel was calculated for each experiment and the results were analysed by statistical methods as S/N ratio and ANOVA to find out the most influential factor. According to the results, catalyst concentration and methanol-to-oil ratio are most crucial to improve biodiesel yield where ideal temperature plays an important role for effective reaction kinetics. This study suggests potential usage of non-edible rubber seed oil with solid base catalyst for the sustainable and low-cost production of biodiesel which in turn helps to the development of renewable energy technologies.

Keywords: Rubber Seed Oil, SrO/Al_2O_3 catalyst, catalyst concentration, Taguchi method and biodiesel yield

Multi-Response Optimization of ECM Parameters Using Silicon and Al_2O_3 Powders In NaOH Electrolyte For High Entropy Alloy

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Abstract: In this work, the ECM of the high-entropy alloys were studied for the improvement of machining performance in terms of MRR and overcut. Two significant input variables of electrolyte concentration and Si-Al2O3 addition have been chosen. ANOVA was performed to determine the influence of machining responses. The effect of the electrolyte concentration is the most influential parameter on MRR where its contribution was 49 % and the percentage of Si-Al2O3 as a moderate factor that affect in overcut with 58 %. The composite desirability function evaluated as a multi response optimisation offering the best conditions at an electrolyte concentration of 31.85 g/l and Si-Al2O3 of 2 wt%. and the overall desirability of 0. 8835. The maximum MRR was 1.7974 mm^3/min with desirability of 0.88285 and the minimum overcut was 0.0020 mm with a desirability value of 0.88418. The obtained results revealed that the concentration of electrolytes and percentage of abrasive particles in ECM process were the critical parameters for optimisation of machining to obtain better MRR for optimal machining efficiency and minimal overcut.

Keywords: ECM process, High entropy alloy, optimisation, composite desirability function

Feedforward ANN Model for Predicting Ultimate tensile strength and Hardness in Al 6061 Reinforced AMCs with Multiple Reinforcements

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Abstract: This study attempts to predict the mechanical properties of Al 6061 reinforced with various materials such as Al_2O_3, SiC, B_4C, glass, MoS_2, bamboo charcoal, and iron ore. UTS and hardness are considered output responses, while the stir casting parameters of temperature, stir speed, and stir time are considered as input variables. Predictive modelling with Artificial Neural Network (ANN) methods in MATLAB is done using 46 data sets from previous studies. The architecture of the ANN model is 3-10-2 which consist of three input neurons, ten hidden nodes and two output nodes. The model parameters are training to minimize the prediction error. The best validation set was attained with ANN and the value is 82.065 at epoch number 25 by ANN detailed in the result. Regression analysis based evaluation is carried to report the performance of the model which shows good fitting for training, testing and validation datasets and regression values are 0.97932 for training, 0.99227 for testing and 0.97189 for validation respectively with the overall regression value of 0.97899. The predictions made by the ANN are very close to the actual values for both UTS and BHN, demonstrating the ANN's capability to accurately predict the mechanical properties of AMCs based on stir casting parameters and reinforcement types. This model offers a promising tool for optimizing the production of high-performance Al 6061 hybrid composites.

Excitation function of ^{27}Al+ ^{20}Ne reaction upto 166 MeV

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Aluminum is commonly used in nuclear physics experiments as an energy degrader, catcher foil or backing material due to its easy availability, malleability and high stopping power. The reaction products on the interaction of projectile with Al might interfere with the experiment under study. Therefore, it is of utmost importance to know the reaction products arising from the interference of Al and various projectiles in wide energy range. We studied the interaction of Al foils with the heavy ion beam ^{20}Ne from 53.5-170 MeV using stacked foil technique. Excitations functions of ^{27}Al+ ^{20}Ne reaction were measured upto 166 MeV and the produced cross sections were compared with theoretical code EMPIRE3.2.2. Evaporation residues such as ^{43,44}Sc, ^{41}Ar, ^{34m,38}Cl, etc., were identified in the matrix. The experiment also marked the possibility of alternative production routes for above mentioned radioisotopes, some being of clinical significance such as ^{43,44}Sc. The following Table lists the nuclear characteristics of the produced radioisotopes.

Table: Nuclear characteristics of the radioisotopes produced (https://www.nndc.bnl.gov/chart/chartNuc.jsp)

Radioisotope	Half-life	Decay mode (%)	Principal Gamma energies (keV) (I,%)	Possible Production route	$E_{Threshold}$ (MeV)
^{43}Sc	3.89 h	$\varepsilon+\beta^+$ (100)	372.7 (23)	^{27}Al(^{20}Ne,2p2n)	32.6
^{44}Sc	3.92 h	$\varepsilon+\beta^+$ (100)	1157.03 (99.9)		
^{44m}Sc	58.6 h	IT (98.8)	271.1 (86.7)	^{27}Al(^{20}Ne,2pn)	15.7
		$\varepsilon+\beta^+$ (1.2)	1157.03 (1.2)		
^{42}K	12.3 h	β^- (100)	1524.7 (18)	^{27}Al(^{20}Ne,4pn)	46.0
^{41}Ar	109.3 m	β^+ (100)	1293.5 (99.1)	^{27}Al(^{20}Ne,5pn)	62.1
^{34m}Cl	32.0 m	IT (44.6)	146.3 (40.5)		
		$\varepsilon+\beta^+$ (55.4)	1176.6 (14.1)	May be	-
^{38}Cl	37.24 m	β^- (100)	1642.7 (32)	spallation/fission	
^{24}Na	14.95 h	β^- (100)	1368.6 (100)		

The produced no-carrier-added (NCA) ^{43,44}Sc radioisotopes were further separated from bulk Al by liquid-liquid extraction using the cation exchanger HDEHP with a separation factor >12000.

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