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INTERNATIONAL CONFERENCE ON EMERGING TRENDS IN PHYSICS ICP-2026

Abstract Book

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Theme:

Smart Energy Solutions: Physics for a Sustainable Future

DATE	VENUE	ORGANIZER
June 04–06, 2026 *Thursday – Saturday*	**Hakeem M. Saeed Seminar Hall** UMT, Johar Town, Lahore	**Department of Physics** School of Science, UMT

PREFACE

It is with immense pride, profound gratitude, and an unwavering commitment to the advancement of scientific knowledge that we present the **Abstract Book of the 3rd International Conference on Emerging Trends in Physics (ICP-2026)**, organized by the Department of Physics, School of Science, University of Management and Technology (UMT), Lahore, Pakistan. Held from **June 4–6, 2026**, at the prestigious **Hakeem M. Saeed Seminar Hall, UMT, Johar Town, Lahore**, this conference serves as a vibrant platform for intellectual exchange, scientific collaboration, and the dissemination of cutting-edge research in contemporary physics and allied disciplines.

The theme of ICP-2026, **"Smart Energy Solutions: Physics for a Sustainable Future,"** reflects one of the most pressing challenges facing humanity today—the urgent need to develop innovative, sustainable, and environmentally responsible energy technologies. As the world grapples with climate change, resource depletion, environmental degradation, and increasing energy demands, the role of physics in providing solutions has become more critical than ever. From the discovery of advanced functional materials and renewable energy technologies to breakthroughs in nanotechnology, quantum science, computational modeling, and energy-efficient systems, physics continues to shape the foundation of a sustainable future.

Recognizing this global imperative, ICP-2026 brings together an exceptional assembly of physicists, engineers, material scientists, chemists, computational researchers, medical physicists, environmental scientists, industry experts, policymakers, and young scholars from around the world. The conference provides a multidisciplinary forum where participants can share their latest findings, discuss emerging challenges, and explore innovative approaches that bridge fundamental science and technological applications.

This abstract book represents the collective scientific contributions of researchers from universities, research institutions, laboratories, and industries across numerous countries. Each abstract included in this volume has undergone a rigorous peer-review process conducted by members of the Scientific Program Committee and subject experts to ensure the quality, originality, and relevance of the research presented. The collection reflects the diversity and dynamism of modern physics research, encompassing a broad spectrum of topics including:

- Condensed Matter and Materials Physics
- Nanoscience and Nanotechnology
- Thin Films and Surface Engineering

- Renewable Energy Materials and Devices
- Semiconductor Physics and Electronics
- Photonics, Optoelectronics, and Laser Physics
- Plasma Physics and Applications
- Computational and Theoretical Physics
- Quantum Science and Emerging Quantum Technologies
- Medical Physics and Radiation Sciences
- Environmental and Atmospheric Physics
- Applied Physics and Interdisciplinary Research

Together, these contributions provide valuable insights into the latest scientific developments and emerging research directions that are expected to influence future technological innovations and societal progress.

A distinctive feature of ICP-2026 is its emphasis on fostering collaboration across generations of researchers and across disciplinary boundaries. The conference program has been carefully designed to provide participants with opportunities not only to present their work but also to engage in meaningful discussions with internationally recognized experts. Through **Keynote Lectures**, **Plenary Sessions**, **Distinguished Speaker Presentations**, **Technical Oral Sessions**, **Poster Presentations**, and the **Young Investigators' Forum**, participants gain exposure to pioneering research while receiving constructive feedback and mentorship.

Particularly noteworthy is the **"Meet the Professor"** networking initiative, which offers students and early-career researchers the opportunity to interact directly with leading scientists and academics. Such engagements are invaluable in nurturing scientific curiosity, encouraging innovation, and building professional networks that can lead to future collaborations and career development. By creating an environment that promotes dialogue and knowledge sharing, ICP-2026 seeks to strengthen the global scientific community and inspire the next generation of researchers.

The successful organization of an international conference of this magnitude is only possible through the dedication and collective efforts of numerous individuals and institutions. We extend our deepest appreciation to our **Patron-in-Chief, Prof. Dr. Asif Raza, Rector, UMT**, whose visionary leadership and unwavering support continue to foster a culture of academic excellence, innovation, and impactful research. His commitment to advancing higher education and scientific inquiry has been instrumental in establishing UMT as a hub for scholarly engagement and international collaboration.

We are equally grateful to **Prof. Dr. Muhammad Imran Jamil, Dean, School of Science**, for his continuous encouragement, guidance, and support throughout the planning and execution of ICP-2026. His dedication to promoting research excellence has played a vital role in strengthening scientific activities within the School of Science and beyond.

Our sincere thanks are extended to all members of the **Organizing Committee**, **Scientific Program Committee**, **Reviewers**, **Session Chairs**, **Volunteers**, **Sponsors**, and **Collaborating Institutions**. Their hard work, professionalism, and commitment have ensured the success of this conference and the publication of this abstract volume. We also acknowledge the invaluable contributions of our keynote speakers, plenary speakers, distinguished guests, and invited experts whose participation has enriched the scientific content of the conference.

Most importantly, we express our heartfelt appreciation to all researchers, scholars, students, and professionals who submitted their work and chose ICP-2026 as a venue to share their scientific achievements. Your contributions are the essence of this conference and a testament to the vibrant spirit of scientific exploration that drives progress and innovation.

As you explore the abstracts presented in this volume, we hope you discover new ideas, emerging trends, and opportunities for collaboration that inspire further research and innovation. We trust that the discussions initiated during ICP-2026 will extend beyond the conference halls, leading to meaningful partnerships, groundbreaking discoveries, and impactful solutions to the challenges facing our world.

Physics has always been a catalyst for human advancement, enabling us to understand nature, harness energy, and improve the quality of life. In an era characterized by rapid technological transformation and global environmental challenges, the need for scientific cooperation and knowledge exchange has never been greater. It is our sincere hope that ICP-2026 contributes to this endeavor by fostering a spirit of inquiry, innovation, and collaboration among researchers from diverse backgrounds and disciplines.

We welcome you to the proceedings of ICP-2026 and thank you for being part of this important scientific gathering. May this conference serve as a source of inspiration, learning, and professional growth, and may it further strengthen our collective commitment to using physics as a driving force for a sustainable and prosperous future.

ABOUT THE HOST INSTITUTION

University of Management and Technology (UMT), Lahore

The **University of Management and Technology (UMT), Lahore**, is one of Pakistan's leading private research universities, renowned for its commitment to academic excellence, innovation, and impactful research. Established in 1990 under the visionary leadership of the late **Prof. Dr. Hasan Sohaib Murad (Shaheed)**, UMT has evolved from a pioneering management institute into a comprehensive multidisciplinary university offering programs in the sciences, engineering, business, social sciences, law, health sciences, humanities, and emerging technologies.

Situated in the heart of Lahore at **C-II, Johar Town**, UMT is recognized nationally and internationally for its dynamic learning environment, strong research culture, and industry-academia linkages. The university serves thousands of students through a diverse portfolio of undergraduate, graduate, and doctoral programs, supported by state-of-the-art laboratories, research centers, and modern academic facilities.

Today, UMT continues to advance the vision of its founder under the leadership of **Mr. Ibrahim Hasan Murad**, President of UMT and ILM Trust, whose strategic focus on innovation, entrepreneurship, sustainability, and global engagement has further strengthened the university's position among Pakistan's premier higher education institutions. Academic leadership is provided by **Air Vice Marshal (Retd.) Prof. Dr. Asif Raza, HI(M), TI(M)**, Rector UMT, whose extensive experience in higher education, research management, and technological innovation continues to guide the university toward excellence in teaching, research, and international collaboration.

A Research-Intensive University

UMT's mission is to foster intellectual growth through high-quality education, applied research, and community engagement. The university is recognized by the Higher Education Commission (HEC) of Pakistan and holds international institutional affiliations. UMT's research output spans peer-reviewed international journals, collaborative projects with global institutions, and a growing portfolio of patent applications and technology-transfer initiatives.

School of Science

The School of Science at UMT is a dynamic hub of scientific inquiry, housing departments in Physics, Mathematics, Chemistry, and Biosciences. The school is committed to nurturing both fundamental and applied research, with a particular emphasis on nanotechnology, renewable

energy materials, computational sciences, and biomedical applications. Its faculty includes internationally trained scientists with active research collaborations spanning Europe, North America, and the Middle East.

Department of Physics

The Department of Physics is the organizing body of ICP-2026. With dedicated laboratories in thin film deposition, spectroscopy, laser physics, and computational modeling, the department carries out cutting-edge research in condensed matter physics, semiconductor devices, plasma physics, and energy materials. The department trains students at BS, MS, and PhD levels, contributing significantly to Pakistan's scientific human capital. ICP-2026 represents the department's third international conference — a testament to its growing global scientific footprint.

Commitment to Sustainability

UMT aligns its institutional vision with the United Nations Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education), SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation and Infrastructure), and SDG 13 (Climate Action). ICP-2026 is an expression of that alignment, bringing the global scientific community together to address the physics underlying sustainable energy futures.

CONFERENCE CITY

Lahore — The Cultural Capital of Pakistan

Lahore, the capital of Punjab Province, is Pakistan's second-largest city and its undisputed cultural, intellectual, and artistic heart. With a metropolitan population exceeding 13 million, Lahore is a city of extraordinary historical depth, vibrant contemporary energy, and extraordinary hospitality — making it one of South Asia's most compelling destinations for international gatherings.

A City with 2,000 Years of History

Founded by Lava, son of the Hindu god Rama according to legend, Lahore has served as the capital of the Mughal Empire, a seat of Sikh sovereignty, and a crown jewel of the British Raj. The city's architectural heritage includes the magnificent Lahore Fort (a UNESCO World Heritage Site), the iconic Badshahi Mosque — one of the world's largest mosques — the ethereal Shalimar Gardens, and the colonial splendour of the Lahore Museum and the Mall Road. Every street in the old city whispers centuries of history.

A Hub of Education and Intellect

Lahore is home to over 30 universities, including the University of the Punjab (Pakistan's oldest, established 1882), the Lahore University of Management Sciences (LUMS), Government College University, and the University of Engineering and Technology — as well as UMT, the proud host of ICP-2026. The city has long been Pakistan's intellectual epicentre, producing poets, scientists, philosophers, and statesmen.

Food, Culture, and Arts

Lahore's culinary tradition is legendary across South Asia. From the smoky kebabs of Gawalmandi to the creamy lassi of Lahori dhabas, the city's food culture is an adventure in itself. The city also pulsates with literary festivals (notably the Lahore Literary Festival), classical music, Sufi devotional nights at the shrine of Data Darbar, and a thriving contemporary arts and film scene.

Modern Lahore

Today's Lahore combines its storied past with rapid modernisation. The city is served by Allama Iqbal International Airport with direct connections to major cities across Asia, Europe, and the Middle East. Its metro system, motorways, and the landmark Orange Line train make it increasingly accessible. The hospitality sector — from luxury hotels to boutique guesthouses

— offers world-class accommodation for all visitors.

Welcome to Lahore

For international delegates attending ICP-2026, Lahore offers an unforgettable experience beyond the conference halls. We warmly invite you to explore this magnificent city — its monuments, its markets, its cuisine, and the legendary warmth of its people. Lahore does not merely host its guests; it embraces them.

CONFERENCE AT A GLANCE

3	250+	20+	10+
Days	Attendees	Int'l Speakers	Sessions

CONFERENCE SUB-THEMES

✦ Clean & Renewable Energy	✦ Smart Energy Systems
✦ Advanced Materials for Energy	✦ Low-Carbon & Circular Technologies
✦ Climate & Environmental Physics	✦ Emerging Physics for Energy

ALIGNED WITH SUSTAINABLE DEVELOPMENT GOALS

SDG 6	SDG 7	SDG 9	SDG 13
Clean Water & Sanitation	Affordable & Clean Energy	Industry & Innovation	Climate Action

Table of Content

Synergistically Engineered $NiCo_2S_4$/MXene/rGO Nanohybrids for Next-Generation High-Performance Supercapacitors

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Abstract

The growing demand for high-efficiency and sustainable energy storage systems has accelerated research into multifunctional nanostructured electrode materials. Novel ternary nanohybrid composed of nickel cobalt sulfide ($NiCo_2S_4$), MXene ($Ti_3C_2T_x$), and reduced graphene oxide (rGO) is designed and developed for high-performance supercapacitor applications. The proposed hybrid architecture integrates the superior pseudocapacitive behavior of $NiCo_2S_4$ with the exceptional electrical conductivity of MXene and the structural stability of rGO. The nanohybrids are synthesized through a controlled hydrothermal and self-assembly approach, resulting in a three-dimensional interconnected conductive network. Structural and morphological analyses reveal uniform dispersion of active components and the formation of hierarchical porous structures, which facilitate rapid ion diffusion and efficient electron transport. Electrochemical investigations demonstrate significantly enhanced specific capacitance, excellent rate capability, and outstanding cycling stability compared to conventional oxide-based electrodes.

The synergistic interaction among $NiCo_2S_4$, MXene, and rGO effectively minimizes charge transfer resistance while maximizing electrochemically active sites. This optimized configuration enables fast redox reactions and stable charge/discharge behavior under high current densities. The proposed ternary nanohybrid exhibits promising potential for scalable, low-cost, and environmentally friendly energy storage devices. This study provides a new pathway for engineering advanced hybrid nanomaterials and contributes to the development of next-generation supercapacitors for smart energy and portable electronic applications.

Enhanced UV photodetection with Au-doped WO3 thin films: Responsivity, detectivity, and self-powered characteristics

Nasar Ahmed, Areeba Sarfraz, Rizwan Ahmed, Taj Muhammad Khan, Mohd Farhanulhakim, Anjam Waheed, Asad Masood, Raja Azhar Saeed Khan

Abstract

Tungsten oxide (WO3), with its exceptional optical, electrical, and structural properties, is a highly promising n-type semiconductor. In this study, boron-doped p-Si substrates were used to fabricate Au-doped WO3 thin films via pulsed laser deposition, employing a Q-switched Nd:YAG laser (266 nm wavelength, ~10 mJ pulse energy) at a substrate temperature of 600 ◦C and 10 Pa pressure. Comprehensive characterization was conducted using XPS, XRD, FE-SEM, EDX, Raman spectroscopy, FTIR, and four-probe measurements. The resulting p-Si/n-WO3 heterojunction device demonstrated an excellent UV photodetection performance, achieving a responsivity of ~80 A/W, specific detectivity of 7.07 × 1011 Jones, and fast response times of 130 ms (rise) and 180 ms (fall). Under reverse-bias conditions, the device exhibited significant UV photo-response at room temperature. Notably, the Au-doped WO3 thin films showcased self-powered photodetector behavior, producing a short-circuit current (Isc) of ~0.06 μA and an open-circuit voltage (Voc) of ~0.48 V without an external power source. These findings highlight the superior performance of p-Si/n-WO3 heterojunctions for UV photodetection, demonstrating high responsivity, detectivity, and self-powere capabilities. This study positions Au-doped WO3 thin films as a promising material for advanced optoelectronic applications.

From Laser Ablation to Smart Energy Devices: Modelling, Spectroscopy, Scalable Materials and Printed Electronics

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Abstract

Over the past three and a half decades, my research has focused on combining computational modelling with experimental investigations to accelerate the development of laser-enabled processes and functional materials for commercially relevant applications. A major thrust of this work has been laser ablation and the spectroscopic study of laser-produced plasmas, wheremodelling and diagnostics are used to understand plume dynamics, excitation/ionization behavior, and emission signatures that govern process outcomes. These studies have direct relevance to high-impact applications including lithography, emission & absorption spectroscopy, laser-induced breakdown spectroscopy (LIBS) for rapid elemental analysis, space research, pulsed laser ablation deposition (PLAD) of thin films, and laser cleaning of sensitive surfaces. In parallel, my materials research spans organic and inorganic bulk and nanomaterials, emphasizing fabrication, characterization, and optimization pathways that translate material properties into scalable device performance. Using a materials-to-devices approach, this work targets printed electrical, electronic, and photonic devices—including diodes, sensors, field- effect transistors, memories, and next-generation solar cells—with attention to interfaces, morphology control, and process–property–performance relationships. Within the theme of Smart Energy Solutions, the talk will highlight how physics-based modelling, spectroscopy- driven feedback, and manufacturability-focused optimization can reduce development cycles for sustainable energy devices, especially in resource-constrained environments. The presentation will also outline practical routes toward pilot-scale translation, where low-cost characterization and data-driven process control can improve yield, reliability, and performance—supporting SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation and Infrastructure), and SDG 13 (Climate Action).

Transfer Matrix Method as a Tool for Probing Optical Responses of a Thin Film: A Theoretical Approach

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Abstract

Experimental fabrication of thin films often requires advanced facilities, significant cost, and complex processes. In contrast, the Transfer Matrix Method (TMM) offers a powerful, accurate, and cost-effective theoretical framework for predicting optical behavior prior to fabrication. By systematically analyzing the influence of key parameters such as film thickness, wavelength, and refractive index on transmission, reflection, and absorption phenomena, TMM minimizes experimental effort while providing critical insights that guide experimental studies and the rational design of optoelectronic devices. Strontium Titanate (STO), a multifunctional perovskite oxide with exceptional dielectric, optical, and electronic properties, is investigated in this work. For STO thin films with thicknesses of 250 nm and 260 nm, deposited on the glass substrates, the computed direct band gap values are 3.49 eV and 3.59 eV, respectively, show excellent agreement with reported experimental findings, validating the accuracy of the TMM approach. The effect of thin film thickness on various optical properties has been explored. The present investigations deepen the understanding of both single-layer STO films, offering valuable guidance for the design and optimization of next-generation STO-based optoelectronic and photonic devices.

Investigation of effects of external electric field on plasma mediated ablation induced surface modifications of metals

Mehreem Akram

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Abstract

Laser ablation has been a growing area of research and technological development for surface processing of materials to improve their functional properties. In high power material – surface interactions, ablation is usually accompanied by the formation of a luminous expanding plasmanplume. The intervening plasma significantly impacts the ablation process and growth of surface structures through thermal, mechanical and chemical action. Therefore, laser induced surface modifications can be controlled by controlling the characteristics parameters and dynamics of ablation plasma. This can be achieved by applying external electric, magnetic fields, physical blockers and gaseous ambient without changing the laser parameters. The present work unveils the effects of external electric field on the laser induced plasma, the growth of surface structures and consequently altered surface structural, mechanical and wettability properties of metals. Electric confinement of plasma has been assessed through the measured characteristic parameters by employing Laser Induced Breakdown Spectroscopy (LIBS) analysis. Optical profilometry analysis has been used to estimate the variation in ablatio crater diameter. SEM analysis revealed the formation of various surface structures such as ripples, cones, pores and grains etc. Mechanical and wettability properties have been explored by using Vicker hardness and water contact angle measurements respectively.

Development of All-Inorganic P-N & P-i-N Heterojunctions for Optoelectronic and Photovoltaic Device Applications

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Abstract

Today, it is believed that the vast production of renewable energy is obligatory to meet the rapidly-growing global demand up to 6-8 folds (over 20 TW) by 2050 instead of overwhelming use of fossil fuel to retain the content of carbon dioxide at its current level as of 2020. Recently, transparent metal oxides (TMOs) have attracted a great deal of attention due to their fascinating electrical and optoelectronic properties which enabled their extensive utilization in the design of numerous emerging functional devices, such as gas sensors, transparent thin film transistors (TTFTs), light emitting diode (LEDs), UV-detectors and energy conversion and storage systems as well as photovoltaic solar cells. Generally, binary metal oxides are divided into two categories based on their nature of conduction and defect states; (a). N-type metal oxides with cation interstitials or anion vacancies (ZnO, TiO 2 , SnO 2 , In 2 O 3 , CdO, etc.), (b). P-type metal oxides with cation vacancies or anion nterstitials (SnO, CuO, NiO, Co 3 O 4 , Cr 2 O 3 etc.). Herein, we report all-oxide inorganic pn-heterojunction via novel combinatorial approach of thermal evaporation method at room temperature followed by thermal oxidation in oxygen environment at optimum annealing temperature. The effective carrier injection, directionaltransportation up to extraction of charges in fabricated heterostructure diode/solar cell wascritically studied.

Stabilizing the Layered Cathode Materials for Improved Electrochemical Performance for Sodium-Ion Batteries

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Abstract:

Lithium-ion batteries (LIBs) are increasingly employed in a wide range of applications, including portable electronics, electric vehicles, and stationary energy storage systems. However, large-scale stationary storage remains constrained by the high cost and limited availability of lithium resources. Owing to the natural abundance and low cost of sodium-based materials, sodium-ion batteries (SIBs) have emerged as a promising alternative to LIBs. The successful commercialization of SIB technology critically depends on the development of high-performance anode and cathode materials. In this study, layered cathode materials were synthesized using a facile and scalable solid-state method. When evaluated in sodium-ion batteries, the prepared cathodes exhibited enhanced rate capability and excellent capacity retention. To elucidate the reaction mechanism and structural evolution during electrochemical cycling, comprehensive investigations were carried out using in-situ X-ray diffraction (XRD), X-ray absorption spectroscopy (XAS), and high-resolution ex-situ transmission electron microscopy (TEM). The results demonstrate that the introduced dopant plays a crucial role in stabilizing the crystal structure of the layered cathodes, thereby contributing significantly to their improved electrochemical performance.

Synthesis and characterization of cobalt iron oxide ($CoFe_2O_4$) and zinc tin oxide ($ZnSnO_3$) for solar cell applications

Dr. Hassan Ali

University of Narowal

Abstract

In this research, spinal structural cobalt ferrite (CoFe 2 O 4) and Perovskite-type zinc stannate (ZnSnO 3) were synthesized for their comparative analysis to study their photovoltaic applications. To synthesize nanoparticles with regulated size, shape, and crystal structure, the sol-gel technique was used. Different characterization techniques, such as X-ray diffraction (XRD), scanning electron microscopy (SEM), vibrating sample magnetometer (VSM), and multiferroic testing were used to study the structural, morphological, magnetic, and electrical properties of materials. From XRD analysis average crystallite size of CoFe 2 O 4 is 9.2 nm and ZnSnO 3 is 6.9 nm was measured. SEM results showed that the particles of CoFe 2 O 4 are spherical shaped. VSM showed that CoFe2O4 exhibits ferromagnetic behavior due to high saturation magnetization, while ZnSnO 3 showed the paramagnetic behavior. Multiferroic characterization displayed the weak ferro-electric behavior in ZnSnO 3 . The results suggested that CoFe 2 O 4 is a better candidate for solar cell applications because of their magnetic properties.

First-principles investigation of the electronic and optical properties of Sc_4C_3 MXene for optoelectronic applications

Dr. Robina Ashraf

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Abstract

Sc_4C_3 has emerged as a promising MXene material with potential applications in optoelectronic devices, particularly as a charge-transport or absorber-layer additive in perovskite solar cells. This work systematically investigated its electronic and optical properties within the CASTEP software using first principle density functional theory (DFT). The energy band structure, density of states (TDOS and PDOS) reveal that Sc_4C_3 is a semiconductor that have direct band gap. The calculated optical parameters, including the dielectric constant, refractive index, absorption spectra, and reflectivity, highlight its suitability for diverse applications such as solar cells, optical coatings, ultraviolet (UV) photodetectors, and thermoelectric devices.

DC source of High-Power RF source for High Energy Linear Accelerator at IHEP

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Abstract

After the discovery of HIGGS particle at LHC in 2012, the Circular Electron Positron Collider (CEPC), has been proposed by the Institute of High Energy Physics to further investigate the characteristics of this particle. The Linear Accelerator (LINAC) requires a cutting-edge Radio Frequency Power source at C-band frequency (5710 MHz), to accelerate the electron and positron beams. The present paper will talk about the physics and technology of the DC source for the C-band Power source for the CEPC LINAC.

Electron counter streaming effects on the kinetic Alfvén waves in the solar coronal plasma

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Abstract

Over the past fifty years, plasma waves have emerged as key players in understanding the dynamics of space and astrophysical plasmas. Among these plasma waves the kinetic Alfven waves (KAW) play a critical role in answering the question: How are collisionless plasmas heated in space and astrophysical plasmas. In the present paper, we incorporate counter-streaming of core and halo electrons relative to ions, to provide a more comprehensive picture of wave-particle interactions. It is noted that counter-streaming effects play a crucial role in destabilizing KAWs. When the streaming speed is larger than Alfven speed the KAWs becomes unstable and for opposite limit (V d <V A) the waves damped. We compare our results with numerical results of the fully kinetic hot-plasma dispersion relation obtained with the numerical code [1,2]. We found that in case V d <V A , our exactly agree with results obtained from numerical code but in case of Vd > V A there is some difference in the growth rate. Once we find the growth rate we can discuss how the waves transport energy as they propagate in space. This can be achieved by employing Poynting flux theorem. This provide a framework to quantify the conversion of EM energy into thermal energy. Our results helpful to understand the possible mechanism of solar coronal heating..

Continuous solutions of cosmic rays and waves in astrophysical environment

Kinza Irshad, Bilal Ramzan

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Abstract

Over the last few decades, extensive research has been directed toward the interaction of cosmic rays with plasma in astrophysical environments. Particularly, in studying the propagation of energetic charged particles and cosmic rays in magnetized thermal plasma. We consider a four-fluid system consisting of thermal plasma, cosmic rays, and two oppositely propagating Alfvén waves in order to study the dynamics and energy exchange mechanisms of the system. Moreover, cosmic rays diffusion within the plasma is assumed to occur along the magnetic field lines whereas the cross field line diffusion effects are neglected. This work is important for understanding of pressure gradients and their impact on the feedback in astrophysical environment. Recently, the interaction of cosmic rays with space plasma, especially in regions such as interstellar clouds and the interstellar medium, has become an important area of research. Overall the results highlights that wave–particle interactions significantly affect cosmic ray acceleration and distribution, particularly in turbulent astrophysical conditions.

Analysis of Hole Acoustic Instability with Radiation in Quantum Semiconductor Plasmas.

Syad Ali Raza

COMSATS University Islamabad

Abstract:

This research examines the excitation of hole acoustic waves (HAWs) in diverse semiconductor plasmas by integrating quantum and radiation pressure effects within a quantum hydrodynamic framework. We derive the dispersion relation and growth rate of HAWs incorporating quantum and radiation pressure effects, which alter the features of HAWs. The investigation of HAWs centers on three semiconductor materials: GaSb, GaAs, and InP. We conduct an analytical and numerical examination of the growth rate of HAWs. The influence of beam temperature, radiation pressure, and quantum effects is analysed especially for the GaAs semiconductor medium and depicted graphically. The research encompasses numerous applications, including plasma heating, stabilisation, diagnostics, generation, and confinement.

A Sustainable ZnO/MXene Nanocomposite Derived from Turmeric Extract for High-Sensitivity Electrochemical Ethanol Sensors

Saleh Asif

GC Women University Sialkot

Abstract

This study reports the synthesis of Ti3C2Tx/ZnO composite in which ZnO is biosynthesized by Curcuma longa (turmeric) extract and their application as an active material for the electrochemical detection of ethanol. The phytochemical constituents of turmeric, specifically curcuminoids, served as efficient reducing and stabilizing agents, facilitating the formation of hexagonal wurtzite ZnO NPs and further enhancing the properties of composite. Structural and optical characterization was conducted using XRD, FTIR, UV-Vis, and SEM/EDX to confirm the phase purity and surface functionality. Electrochemical sensing performance was evaluated in 0.1 M KOH electrolyte using cyclic voltammetry (CV). The sensor demonstrated a distinct anodic response to ethanol concentrations ranging from 0.001 to 20 mM. This eco-friendly approach offers a cost-effective and sensitive platform for monitoring volatile organic compounds (VOCs) in industrial and biomedical applications.

Key words: Ti3C2Tx/ZnO, Curcuma longa, Electrochemical sensing, Ethanol

Impact of Interfacial Engineering on the Performance of Perovskite Solar Cells

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Abstract

Recent advancements in the perovskite solar cells (PSCs) have shown PCEs accelerating through various interfacial modification strategies. Despite their advantages of low cost, ease of fabrication, and scalability, PSCs suffer from interfacial traps, which act as recombination centers, thereby limiting device performance and stability. Consequently, interfacial modification has garnered significant scientific interest for its capability to alleviate interfacial defects and improve surface passivation in emerging PSCs. A numerically modeled PSC with planar configuration (ITO/ETL/perovskite absorber/Interlayer/HTL/Ag) through the One-dimensional Solar Cell Capacitance Simulator (SCAPS-1D) is presented here. Initially, the structure without glycine (control device) was comparison to the experimental reported structure ITO/SnO 2 /Cs 0.05 MA y FA 0.95-y PbI 3-x Cl x /Spiro-OMeTAD/Ag to extract the parameters of the above layers. Later on, the amino acid (glycine) interlayer was introduced at the SnO 2 /Perovskite interface to enhance the potential device performance, then the structure ITO/SnO 2 /glycine/Cs 0.05 MA y FA 0.95-y PbI 3-x Cl x /Spiro-OMeTAD/Ag was simulated for optimum extraction of layers parameters. With the optimum values of the parameters, the final results produced a PCE of 22.92%.

Physics-Aware AI for Hybrid Renewable Smart Grids: From PV Inverter Control to Safe Grid Optimisation

Dr. Antonis Papadakis

KYAMOS LIMITED and Frederick University, Cyprus

The rapid integration of photovoltaic generation, wind energy, storage systems and flexible demand is transforming electricity networks into complex cyber-physical systems. While artificial intelligence can support forecasting and decision-making, smart-grid applications require more than pattern recognition: they must respect electrical constraints, thermal limits, operational safety and human oversight. This presentation introduces the KYAMOS physics-aware AI approach for hybrid renewable smart grids, developed through the Bridge2Horizon SMART-HYBRID-RENEW pathway and related Cyprus-funded energy projects. The talk presents a layered methodology combining power-flow modelling, multiphysics simulation, AI surrogate models, reinforcement learning and deterministic safety constraints. Examples include monitoring and control of small PV inverters, digital-twin modelling of low-voltage feeders, thermal-energy storage dispatch, and substation thermal prediction. The central concept is to use high-fidelity physics and grid simulations to generate trusted datasets, then train fast AI models capable of supporting real-time operation, curtailment reduction, stability monitoring and operator decision support. The presentation also connects these developments to future Horizon Europe activities, including secure, interoperable digital-spine architectures for DSO/TSO grid optimisation. The broader message is that sustainable smart-energy systems will require physics, AI and digital twins to operate together, enabling renewable integration while preserving safety, reliability and trust.

Terrain-Aware Wind-Farm Optimisation Using LB-MRT-LES, Digital Twins and AI

Dr. Antonis Papadakis

KYAMOS LIMITED and Frederick University, Cyprus

Wind energy is a central component of the clean-energy transition, but wind-farm performance depends strongly on complex physical interactions between terrain, wind direction, atmospheric turbulence, turbine wakes and layout decisions. Conventional optimisation methods can be limited when the flow field is highly site-specific, while purely data-driven AI may fail to respect the aerodynamic and engineering constraints of the problem. This presentation introduces the KYAMOS physics-aware approach to wind-farm optimisation, developed through the Bridge2Horizon OPTI-WIND-AI pathway and linked to future Horizon Europe work on wind-turbine digital twins and reliability.

The proposed framework combines terrain-aware computational fluid dynamics, Lattice Boltzmann Multiple-Relaxation-Time Large-Eddy Simulation (LB-MRT-LES), AI surrogate modelling and reinforcement-learning-based layout optimisation. High-fidelity simulations provide wind-flow and turbulence information over complex terrain, while AI models accelerate evaluation and support the exploration of alternative turbine placements. The presentation also discusses the role of emerging world and vision models: these can assist with terrain interpretation, satellite or drone imagery, inspection workflows and scenario generation, but the core optimisation must remain physics-aware to capture wake losses, turbulence and energy-production constraints.

The talk concludes by positioning wind-farm optimisation as part of a broader digital-twin ecosystem for renewable-energy reliability, condition monitoring and O&M decision support.

Hydrothermally Engineered Co2FeSn Heusler Alloys: Structure and Magnetism

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In the current work, we report on the structural, magnetic and mechanical characterization of Co2FeSn full Heusler alloy nanoparticles prepared using a hydrothermal approach. Co2FeSn alloys have attracted great attention because of their half-metallic properties, high Tc, and spintronic or magnetic devices. The Precursor concentration was intentionally modified in a controlled way to assess its effect on structural, morphological and functional properties. The studies of X-ray diffraction patterns revealed a single-phase Heusler nature of the sample with nano-crystallite sizes and changes in lattice strain, dislocation density with varying molarities. A current-voltage response was observed at low temperature. A metal-oxygen bonding and good phase formation have been confirmed by FTIR spectroscopy. Vibrating sample magnetometry (VSM) measurements indicated a room temperature soft ferromagnetic nature and the saturation magnetization (Ms) and coercive force (Hc) were significantly sensitive to precursor concentration. The mechanical properties reflected an increase in hardness with increasing molarity, presumably due to crystallite size reduction and microstructural changes.

From Energy Demand to Material Innovation: Perovskite Systems for Sustainable Energy Solutions

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The global demand for efficient, eco-friendly and sustainable energy has become one of the most critical challenges. Population growth, industrialization and climate change have significantly increased the demand for renewable and low carbon energy solutions with the aim to reduce reliance on fossil fuels. To achieve these objectives, developing innovative, stable, and environmentally benign materials for the next-generation energy technologies are essential. In particular, energy conversion and storage technologies are significantly dependent on the chemical and physical characteristics of the constituent materials, making the design of materials a key focus of modern energy research. Among the emerging materials, perovskites-based materials have attracted significant attention due to their exceptional optoelectronic properties and potential applications for the next-generation solar energy devices. The structural flexibility of these materials allows compositional engineering, which can be used to enhance their stability as well as improve their energy conversion efficiency. To advance the sustainable energy technologies, the proposed research highlights the importance of lead-free halide perovskite materials K2Cu(As1−xBix)(Cl1−yBry)6. The results emphasize that the careful optimization of structural and compositional properties can enhance their performance, making them highly promising for the future renewable energy applications. Furthermore, electronic and optical absorption behavior of the materials can be tuned by the controlled substitution of different cations and anions. The present work provides the design of non-toxic, efficient and stable inorganic lead-free perovskite materials to contribute to the ongoing global efforts in the development of green energy materials. Keywords: Lead-free perovskites; renewable energy; eco-friendly materials; green energy materials; low-cost fabrication.

Rain and snow triggered earthquake

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In the past 20 years or so, hydromechanical coupling has been proposed as an explanation for many geological phenomena including the anomalous weakness of many major faults, silent slip events, aftershock occurrence, and triggering earthquakes. The widely accepted understanding is that an increase in pore fluid pressure reduces the effective normal stress and thus the strength of faults, promoting earthquake rupture. The underlying mechanism of rain-triggered earthquakes involves the interaction between fluid pressure and rock mechanics. When rainwater creeps into the ground, it causes an increase in pore pressure; this reduces the effective stress on faults. This reduction in stress can trigger earthquakes by overcoming the frictional forces that hold the fault in place.

Photoelectrochemical Water Splitting by Nitrogen-doped Zinc Oxide Thin Film-Based Photocatalysts

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Abstract

Photoelectrochemical water splitting is considered a promising way to generate clean hydrogen. However, the oxidation evolution reaction is the bottleneck of the reaction, which limits the generation of hydrogen via water splitting. In this study, nitrogen-doped zinc oxide (N-ZnO) photocatalysts were prepared by chemical vapor deposition (CVD) to improve the oxygen evolution reaction (OER). Nitrogen doping introduces acceptor states near the valence band of ZnO, which promotes whole generation and accelerates the oxidation process. These improved charge carrier dynamics leads to enhanced photocurrent response and higher hydrogen production rates. Optical analysis revealed that nitrogen doping reduces the band gap of ZnO, enabling greater absorption of visible light. Solar to hydrogen conversion efficiency (STH%) of N-ZnO-700 °C is 5 times that of the pristine ZnO thin film.

Modification of plasma evolution dynamics in LIBS via spark discharge assistance for sub-ppm detection of heavy metals in aluminum alloys

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Abstract:

Laser Induced Breakdown Spectroscopy (LIBS) is widely applied for elemental analysis of aluminum alloys; however, trace-level detection of alloying elements remains challenging due to insufficient excitation efficiency and rapid plasma relaxation. In this work, spark discharge-assisted LIBS (SD-LIBS) is proposed as a dual mechanism enhancement strategy that simultaneously promotes secondary plasma reheating and prolongs emission lifetime. Unlike conventional enhancement strategies that primarily amplify instantaneous emission intensity, the proposed SD-LIBS fundamentally modifies plasma evolution dynamics through simultaneous plasma reheating and emission lifetime extension, enabling sub-ppm detection of heavy metals in aluminum alloys. Comparative measurements demonstrate that spark assistance increases the plasma excitation temperature from (9300 ± 900) K to (10,700 ± 1000) K, and enhances the electron number density from (2.19 ± 0.5) ×1017 to (2.51 ± 0.5) × 1017 cm^{-3}. Ionic emission lines exhibit enhancement factors up to ~15 ×, reflecting increased collisional ionization probability under sustained electric field excitation. The prolonged emission persistence leads to steeper calibration slopes and significantly improved limits of detection (0.37 – 0.47 ppm) for Ni, Mn, Pb, and Cr in aluminum alloys. The results indicate that SD-LIBS modifies plasma evolution dynamics rather than merely amplifying instantaneous emission, offering a simple and effective route toward high sensitivity industrial compositional analysis.

Keywords: LIBS, Aluminum alloys, Spark discharge, Plasma diagnostics, Trace metal analysis

Structural and Dielectric Properties of Vanadium Doped Zinc Oxide Thin Films

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Abstract

Pure and doped ZnO thin films are synthesized using sol gel assisted spin coating technique. The formation of pure ZnO and doped samples is confirmed by X-ray diffraction technique. Frequency dependent dielectric and impedance analyses are performed using Wayne-Kerr 6500B series precision impedance analyzer in the range of 20Hz to 20MHz. The dielectric constant decreased with increasing frequency, consistent with Maxwell Wagner two-layered model and Koop's theory. The loss tangent of doped samples decreased at low frequency and became almost constant at higher frequencies due to hopping mechanism. The real and imaginary parts of impedance increased with increasing dopant concentration up to 4% but decreased for further increase in dopant concentration from 6% to 10%. Both real and imaginary impedance decreased with increasing frequency, but the rate of reduction slowed down at higher frequencies. Nyquist plots showed semicircular arcs in all samples, indicating non-Debye relaxation with different time constants. The results suggest that doping can significantly alter the structural and impedance properties of ZnO thin films, which may be useful for a variety of electronic applications.

Bandgap Dependent Bifacial Gain and Thermal Resilience in Perovskite/Silicon Tandems

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Monolithic two-terminal perovskite/silicon tandems have reached efficiencies reaching 35% under standard test conditions (STC), where most cell-level optimizations are performed. However, In real-world operation, bifacial (dual-side) illumination and elevated temperature can shift current matching beyond what front-only, single-temperature measurements capture. Here, we investigate how these factors impact current balance and tandem performance under deployment-relevant conditions. We benchmark monolithically integrated devices comprising perovskite top cells with bandgaps of 1.68, 1.64 and 1.58 eV, all deposited on an identical planar heterojunction silicon bottom cell. Using temperature-dependent current–voltage measurements from 20 to 50 °C, we extract temperature coefficients and quantify hot-operation performance retention. At 20 °C, the architecture using the 1.68 eV perovskite reaches 30.25% power conversion efficiency but shows limited bifacial headroom and is penalized once exposed to rear irradiance, consistent with mismatch-driven rollover. In contrast, the 1.64 eV top cell converts rear irradiance most effectively, peaking power density at 31.3% at a rear irradiance ratio of 0.084 while sustaining >30% power density performance across the bifacial window. The 1.58 eV top cell requires higher rear irradiance (0.228) to maximize gain, reaching power density of 30.4%, and exhibits the strongest thermal resilience. Across the bandgap series, performance at 50 °C remains 89.5%, 90.6% and 93.5% of the 20 °C value, demonstrating that bandgap rankings inferred from front-only benchmarking can shift when both bifacial illumination and temperature-dependent current matching are considered. Together, these results define a bandgap-dependent operating map for perovskite/silicon tandems, linking bifacial saturation with effective temperature coefficients to guide outdoor-relevant device selection.

Keywords: Monolithic tandem photovoltaics, Perovskite–silicon tandem solar cells, Bifacial operation,

Design and Optimization of Oxygen Vacancy Rich MoO_x/MWCNT and WO_x/MWCNT Composites for High Performance Supercapacitors.

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The growing demand for efficient and sustainable energy storage devices has increased interest in advanced electrode materials for high-performance supercapacitors. In this research, transition metal oxide-based composite materials consisting of tungsten oxide (WO_3) and molybdenum oxide (MoO_3) integrated with multi-walled carbon nanotubes (MWCNTs) were synthesized through a hydrothermal approach to enhance electrochemical energy storage performance. The prepared materials were designed to exploit the high theoretical capacitance of metal oxides and the excellent electrical conductivity and large surface area of MWCNTs. Structural and morphological analyses were carried out using various characterization techniques including X-ray diffraction (XRD), scanning electron microscopy (SEM), and other analytical methods to investigate crystal structure, morphology, and composition. Electrochemical performance was evaluated through cyclic voltammetry (CV), galvanostatic charge-discharge (GCD), and electrochemical impedance spectroscopy (EIS). The synergistic interaction between WO_3, MoO_3, and MWCNTs improved charge transport pathways and increased electrochemically active sites, resulting in enhanced capacitive performance and cycling stability. The developed composite demonstrated promising characteristics for next-generation supercapacitor applications due to its improved energy storage capability and excellent electrochemical behavior.

Synthesis of Barium Strontium Oxide ($BaSr_2O_4$)/CNT based composite as a high performance electrode material for Supercapacitor Applications

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Due to the better conductivity and increased charge storage capabilities, transition metal oxide based nano composites have gained a lot of attention for their use in electro chemical energy storage. In this study, pure $BaSr_2O_4$ and 3% wt CNT were composed via solvothermal method for supercapacitor application. Using XRD, FTIR and FESEM, the structural, functional and morphological properties were analyzed. The electrochemical variation was measured by using cyclic voltammetry (CV) and galvanostatic charge–discharge (GCD). The 3 wt.% CNT-based $BaSr_2O_4$ nanocomposite pretentiously enhanced electrochemical conduct showed high specific capacitance of 317 F g^{-1}. The optimization in electrochemical performance is due to CNT addition, which improved electrical conductivity and streamline adequate charge transport.

Atmospheric-PLD of plasmonic dry aerosols on textured hydrophilic surfaces for SERS

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Abstract

Atmospheric pulsed laser deposition (APLD) operates in a highly non-equilibrium regime, where rapid collisional coupling and cooling of ablation plume drives gas-phase condensation of dry aerosols.

In this study, Si and oxide-glass SERS substrates were developed by the deposition of dry plasmonic aerosols silver and gold, generated by laser ablation (1064 nm, 10 ns, fluence 3-5 J cm^{-2}) in a dynamic inert-gas medium. SERS sensitivity was further enhanced by single-shot IR-laser surface texturing to tailor surface hydrophilicity. Surface texture (periodic ripples), aerosol morphology and plasmonic resonance were examined by FE-SEM and absorption spectroscopy, while surface hydrophilicity was evaluated via contact angle measurements. SERS performance was quantified in terms of SNR and AEF for molecular detection of Rhodamine 6G (10^{-4} M) using excitation wavelength of 532 nm and 785 nm. Both substrates demonstrated well-resolved Raman signatures with intensities significantly exceeding normal Raman signals, with Ag-based substrates out-performed, achieving superior detection sensitivity with SNR 1.2 x 10^{2} & AEF 1.03 x 10^{3}. By coupling non-equilibrium dry plasmonic aerosol deposition with laser-engineered surface wettability, this work establishes a scalable route to high-sensitivity SERS substrates, extendable to energy-harvesting and catalytic technologies.

Keywords: Plasmonic aerosols, SERS substrate, wettability control, atmospheric-PLD.

Role of Self-Gravity in Cosmic-Ray–Alfv´en Wave Coupling within Molecular Clouds

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Abstract

Cosmic rays and Alfv´en waves are fundamental non-thermal components of the interstel- lar medium and play a crucial role in the dynamical and thermal evolution of molecular clouds within the galactic environment. Their interaction with thermal plasma signifi- cantly affects energy transport, plasma dynamics, cloud heating, and the stability of star-forming regions. In this study, self-consistent three-fluid and four-fluid models are devel-oped to investigate the nonlinear evolution of self-gravitating molecular clouds containing thermal plasma, cosmic rays, and Alfv´en waves. The three-fluid model includes thermal plasma, cosmic rays, and Alfv´en waves, while the four-fluid model additionally incorpo-rates both forward and backward-propagating Alfv´en waves to capture enhanced nonlin-ear wave interactions, turbulence, wave reflection, and energy redistribution processes. The coupled nonlinear governing equations are solved numerically using the fourth-order Runge-Kutta (RK4) method for both cases of presence and absence of self-gravity. A comparative analysis is performed to examine the combined effects of gravitational confinement and multidirectional wave propagation on plasma dynamics. The results show that self-gravity plays a dominant role in the system by enhancing inward plasma flow velocity, strengthening mass transport, and significantly modifying pressure distributions within molecular clouds. This leads to stronger plasma compression and a more efficient dynamical response of the cloud structure. Furthermore, the four-fluid model exhibits stronger nonlinear coupling, increased turbulence, and more complex wave behavior compared to the three-fluid model due to the inclusion of bidirectional Alfv´en waves. These effects strongly influence local heating processes, energy redistribution, and the overall structural stability of the cloud system. The study demonstrates that the interplay of self-gravity, cosmic-ray pressure, thermal plasma, and nonlinear Alfv´en-wave dynamics governs the evolution and stability of molecular clouds. The comparison between three- fluid and four-fluid models provides deeper insight into the role of multidirectional wave interactions in astrophysical plasma systems and star formation processes.

Structural, Optical, morphological and Photocatalytic Properties of Tin-Doped Cobalt Ferrite Nanoparticles for Water Purification Applications

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Abstract

This research investigates the structural, optical and photocatalytic properties of cobalt ferrite nanoparticles induced by Tin (Sn) doping for enhanced environmental remediation. Nanoparticles with the chemical composition (x = 0.0, 0.3, 0.6, 0.9) were effectively synthesized using the mechanochemical ball milling method, followed by calcination at 1200°C. The primary objective was to tailor the materials physicochemical properties to improve its performance as a solar driven photocatalyst for the degradation of toxic industrial dyes. X-ray diffraction (XRD) analysis confirmed the formation of a single phase cubic spinel structure across all samples, with the most intense reflection at the (311) plane. The lattice parameter exhibited a linear increase from 8.355 Å to 8.460 Å as Sn concentration rose, a result of replacing smaller ions with larger ions within the lattice. Scanning Electron Microscopy (SEM) revealed that Sn doping significantly influenced surface morphology, leading to denser packing and a reduction in average grain size from 1.48 μm to 1.01 μm, which effectively increased the surface area to volume ratio for catalytic activity. Fourier Transform Infrared (FTIR) spectra confirmed the spinel phase through two prominent absorption bands at approximately 650 and 430 , representing tetrahedral and octahedral metal oxygen vibrations, respectively. Increased Sn content caused these bands to shift toward lower frequencies due to bond weakening from lattice distortion. UV-visible spectroscopy demonstrated a significant red shift in the absorption edge, resulting in the narrowing of the optical band gap from 3.84 eV to 3.14 eV. The photocatalytic activity of Sn doped cobalt ferrite nanoparticles was evaluated through the degradation of Indigo Carmine (IC) dye under natural sunlight irradiation. A progressive decrease in absorbance intensity with increasing irradiation time confirmed effective dye decomposition. The degradation efficiency was found to increase with both irradiation time and Sn concentration, with the x = 0.9 sample exhibiting the highest efficiency, achieving significant degradation within 60 minutes. Kinetic analysis showed pseudo first order behavior, with the highest rate constant for the optimally doped sample.

Enhanced performance was due to band gap narrowing and efficient electron hole separation, which promoted reactive oxygen species formation for dye degradation. These results highlight Sn doped cobalt ferrite as a promising photocatalyst for wastewater treatment.

Structural and Photoluminescent Properties of CuAlSe2/ZnS/ZnSe Multicore Shell Quantum Dots

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Abstract

This study presents a structural investigation of CuAlSe2/ZnSe/ZnS core multi-shell quantum dots using X-ray diffraction (XRD). The samples were synthesized through controlled chemical approaches: CuAlSe2 quantum dots were prepared via composition tuning, ZnSe and ZnSe/ZnS core–shell quantum dots were synthesized using colloidal and modified reactivity-controlled epitaxial growth (RCEG) methods. In contrast, CuAlSe2 nanoparticles were synthesized using a hydrothermal method at different reaction times (18 h, 24 h, and 30 h). In selected ZnSe/ZnS samples, thiourea was used as an additional sulfur source to enhance shell formation. Structural characterization was carried out using XRD, and crystallite size was estimated using the Debye–Scherrer equation. XRD results confirmed the successful formation of tetragonal chalcopyrite CuAlSe2 with sharp diffraction peaks at 27.73°, 46.23°, and 54.34°, indicating high phase purity and improved crystallinity after Al3+ substitution. In contrast, ZnSe-450 samples synthesized via RCEG showed broad and weak peaks along with impurity phases such as ZnO and Zn (DPPA)2, indicating poor crystallinity and oxygen-related surface defects. Upon ZnS shell growth, ZnSe/ZnS core–shell quantum dots exhibited sharper and more intense peaks corresponding to the cubic zinc blende structure, confirming improved crystallinity and successful shell formation. A slight peak shift toward higher angles indicated lattice strain and interfacial interaction between the ZnSe core and ZnS shell. For CuAlSe2 nanoparticles, increasing the hydrothermal reaction time from 18 h to 30 h eliminated CuS impurity phases and enhanced crystallinity, with optimal phase purity achieved at 30 h. Crystallite sizes were found in the nanometer range (~4–15 nm depending on system), confirming nanoscale formation. Overall, XRD analysis demonstrates that shell growth, doping, and optimized reaction time significantly enhance phase purity, crystallinity, and structural stability, which are essential for improving the optoelectronic performance of these cadmium-free quantum dots.

Analysis of Hole Acoustic Instability with Radiation in Quantum Semiconductor Plasmas.

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Abstract

This research examines the excitation of hole acoustic waves (HAWs) in diverse semiconductor plasmas by integrating quantum and radiation pressure effects within a quantum hydrodynamic framework. We derive the dispersion relation and growth rate of HAWs incorporating quantum and radiation pressure effects, which alter the features of HAWs. The investigation of HAWs centers on three semiconductor materials: GaSb, GaAs, and InP. We conduct an analytical and numerical examination of the growth rate of HAWs. The influence of beam temperature, radiation pressure, and quantum effects is analysed especially for the GaAs semiconductor medium and depicted graphically. The research encompasses numerous applications, including plasma heating, stabilisation, diagnostics, generation, and confinement.

Impact of B′-site cation substitution on the mechanical, structural, optoelectronic and thermoelectric properties of Sr2NbXO6 (X = Sb, Bi) for green energy technologies

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B-site double perovskite engineering provides an effective approach for tuning the electronic band structure through substitution of the B-site cation in the perovskite. This process enhances the optical, electronic, and magnetic properties of double perovskites. In this manuscript, we study the optical, thermal, and other physical properties of Sr_2NbXO_6 (X = Sb, Bi). The calculations are carried out within the theoretical framework of the ab-initio method employing the full-Potential Linearized Augmented Plane Wave (FP-LAPW) technique. The exchange-correlation functional is approximated using the modified Becke-Johnson potential (mBJ). The stability parameters obtained by the Birch-Murnaghan equation of state ensure the structural and thermodynamic stability of Sr_2NbXO_6 (X = Sb, Bi). While the Goldschmidt tolerance and octahedral tilting factors depict Sr_2NbXO_6 (X = Sb, Bi) have cubic structure and belonging to the Fm-3m space group. The electronic band structure analysis indicates semiconducting behavior, with direct band gaps of 1.20 eV for Sr_2NbSbO_6 and 2.47 eV for Sr_2NbBiO_6. Elastic parameters elaborate that both materials possess a high resistance to deformation, ductile and anisotropic nature. The materials' interaction with electromagnetic radiation depicts strong absorption, polarization, and dispersion in the ultraviolet region, highlighting their potential for optoelectronic applications. The thermoelectric analysis shows an increase in electrical conductivity with temperature and exhibits a high figure of merit. Our results demonstrate that Sr_2NbXO_6 (X = Sb, Bi) are strong candidates for optoelectronic and thermoelectric applications.

Hydrothermal Synthesis and Characterization of ZnO–MnO_2 Nanocomposite for Sensing Applications

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Abstract

Nanocomposite materials have attracted extensive research interest owing to their distinctive structural, optical, and cyclic voltammetry characteristics, particularly for environmental and sensing applications. In this work, a ZnO–MnO_2 nanocomposite was synthesized via a hydrothermal route, which enables controlled nucleation and growth, improved crystallinity, and enhanced physicochemical properties of the material. The influence of key experimental parameters such as pH, reaction time, and interference effects were systematically investigated to assess the performance and stability of the synthesized nanocomposite. The structural and optical features of the prepared material were examined using X-ray diffraction (XRD) and UV–Visible spectroscopy. XRD results confirmed successful formation of the composite phase and its crystalline nature, while UV–Visible analysis provided insight into its optical behaviour and allowed estimation of the band gap energy. Overall, the hydrothermally prepared ZnO–MnO_2 nanocomposite exhibited improved structural and optical properties, indicating its potential efficiency for sensing and environmental remediation applications.

Photoelectrochemical Water Splitting by SnO2 /CuO Thin Film Heterostructure-Based Photocatalysts for Hydrogen Generation

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Abstract

The emission of greenhouse gases from fossil fuels creates devastating effects on Earth's atmosphere. Therefore, a clean energy source is required to fulfill the energy demand. Hydrogen is considered an energy vector, and the production of green hydrogen is a promising approach. Photoelectrochemical (PEC) water splitting is the best approach to produced green hydrogen, but the efficiency is low. To produce hydrogen by PEC splitting water, semiconductor photocatalysts have received an enormous amount of academic research in recent years. A new class of co-catalysts based on transition metals has emerged as a powerful tool for reducing charge transfer barriers and enhancing photoelectrochemical (PEC) efficiency. In this study, copper oxide (CuO) and tin oxide (SnO2) multilayer thin films were prepared by thermal evaporation to create an energy gradient between SnO2 and CuO semiconductors for better charge transfer. To improve the crystallinity and reduce the defects, the prepared films were annealed in a tube furnace at 400 ◦C, 500 ◦C, and 600 ◦C in an argon inert gas environment. XRD results showed that SnO2/CuO-600 ◦C exhibited strong peaks, indicating the transformation from amorphous to polycrystalline. SEM images showed the transformation of smooth dense film to a granular structure by annealing, which is better for charge transfer from electrode to electrolyte. Optical properties showed that the bandgap was decreased by annealing, which might be diffusion of Cu and Sn atoms at the interface. PEC results showed that the SnO2/CuO-600 ◦C heterostructure exhibits the solar light-to- hydrogen (STH%) conversion efficiency of 0.25%.

Impact of Interfacial Engineering on the Performance of Perovskite Solar Cells

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Abstract

Recent advancements in the perovskite solar cells (PSCs) have shown PCEs accelerating through various interfacial modification strategies. Despite their advantages of low cost, ease of fabrication, and scalability, PSCs suffer from interfacial traps, which act as recombination centers, thereby limiting device performance and stability. Consequently, interfacial modification has garnered significant scientific interest for its capability to alleviate interfacial defects and improve surface passivation in emerging PSCs. A numerically modeled PSC with planar configuration (ITO/ETL/perovskite absorber/Interlayer/HTL/Ag) through the One-dimensional Solar Cell Capacitance Simulator (SCAPS-1D) is presented here. Initially, the structure without glycine (control device) was comparison to the experimental reported structure ITO/SnO 2 /Cs 0.05 MA y FA 0.95-y PbI 3-x Cl x /Spiro-OMeTAD/Ag to extract the parameters of the above layers. Later on, the amino acid (glycine) interlayer was introduced at the SnO 2 /Perovskite interface to enhance the potential device performance, then the structure ITO/SnO 2 /glycine/Cs 0.05 MA y FA 0.95-y PbI 3-x Cl x /Spiro-OMeTAD/Ag was simulated for optimum extraction of layers parameters. With the optimum values of the parameters, the final results produced a PCE of 22.92%.

First-Principles Investigation of Spintronic Properties in Full Heusler Compounds

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This study presents a first-principles investigation of the structural, electronic, magnetic, mechanical, and thermodynamic properties of the full-Heusler alloys Zr_2FeZ (Z = Al, Ga, and In) using density functional theory with the modified Becke–Johnson (mBJ) potential. The calculated electronic band structures and density of states reveal that all compounds possess finite states at the Fermi level, confirming their metallic nature, while the Fe-based compounds exhibit ferromagnetic behavior. The electronic states near the Fermi level are mainly dominated by Zr-d and transition-metal d orbitals, whereas the lower valence bands arise primarily from the p states of Al, Ga, and In. Substitution of the main-group element slightly affects hybridization without altering the overall electronic characteristics. Mechanical analysis shows that all compounds satisfy the Born stability criteria, confirming their elastic stability in the cubic phase and exhibit the highest stiffness in their respective series, The calculated Poisson's ratio and Pugh's ratio indicate predominantly ductile behavior for all studied alloys. Significant elastic anisotropy is observed, particularly in Zr_2FeIn, suggesting strong directional dependence of mechanical properties. Thermodynamic results further confirm the structural stability of these compounds and indicate their suitability for applications requiring stable electronic and mechanical performance over a range of temperatures.

Scattering of (1S) mesons within a lattice-QCD-inspired multiquark model

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Abstract

The spin-averaged total scattering cross sections for the (1S)- (1S) system are calculated using the Resonating Group Method within a QCD-motivated framework. Three prescriptions for the gluonic field overlap factor are employed: the unattenuated limit (f = 1), a Gaussian form (kf = 0.075), and a geometric area-law form (kf = 0.57). All three prescriptions exhibit a pronounced threshold enhancement, with maximum cross sections at Tc = 0.01 GeV of 2.178 mb, 1.261 mb, and 1.191 mb, respectively. The 5.9% agreement between the Gaussian and area-law results confirms the robustness of the central prediction, while the full spread serves as an estimate of the model-dependent systematic uncertainty. At Tc > 0.15 GeV, all prescriptions converge toward negligible values. These results provide useful input for studies of quarkonium dissociation and regeneration in hot and dense QCD matter.

Keywords: (1S) scattering, Heavy quarkonium, Four-quark form factor, Strong interaction

Effect of ionized gas concentration on the energy of laser wakefield accelerated electrons beam

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Abstract

Compared to conventional accelerators, laser wakefield accelerators produce the electrons beams with some unique characteristic owing to the much higher gradient of the acceleration which make them potentially efficient source because of the acceleration gradient sustainability in plasma and the inherent property of synchronization with the laser pulse. There has been a major advancement in the laser wakefield acceleration field this past decade. Electron beam quality strongly resides on when and where the injection happened in the acceleration phase. Several injection techniques have been demonstrated experimentally to enhance the electron beam quality. The dependence of electron beam quality on the injection dynamics and evolution of the accelerating structures is very evident. Due to the different doping amount of trace gas, different mechanisms dominate the acceleration process of the injected electron. The experimental demonstration of quasi-monoenergetic electron beams can be carried out by utilizing the ionization injection scheme and self-truncated ionization injection mechanism in laser wakefield acceleration using a mixture of low-Z gas mixed with a trace amount of high-Z gas.

Surface Modification for Bioimplants: The Role of Laser Surface Engineering

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Abstract

Often, hard implants undergo detachment from the host tissue due to inadequate biocompatibility and poor osteointegration. Changing the surface chemistry and physical topography of the surface influences biocompatibility. At present, the understanding of the biocompatibility of both virgin and modified surfaces of bioimplant materials is limited, and a great deal of research is being dedicated to this aspect. In view of this, the current review sheds new light on research on the surface modification of biomaterials, especially for prosthetic applications. A brief overview of the major surface modification techniques has been presented, followed by an in-depth discussion of laser surface modifications explored so far, as well as those with tremendous potential for bioimplant applications.

Keywords: Surface modification, biomaterials, topology

Influence of Silicon Dioxide Polar Dielectric Layers on the Mid-Infrared Absorption Spectrum of Metal-Insulator-Metal Metasurfaces

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Abstract

Metal-insulator-metal (MIM) metasurfaces are widely recognized as highly efficient absorbers across a broad range of the electromagnetic spectrum. Their absorption spectra can be tailored through modifications in the unit-cell geometry and/or by embedding materials with specific optical properties. Another effective approach for tuning their spectral response is the integration of polar dielectric materials within the structure. In this work, we numerically and experimentally investigate the effect of using silicon dioxide (SiO_2) as a polar dielectric on the absorption spectrum of a metal-insulator-metal metasurface consisting of a Ni–SiO_2–Ni trilayer structure. The results reveal distinct absorption peaks in the mid-infrared region, which are attributed to the excitation of optical phonons within the SiO_2 layer. In particular, the excitation of the Berreman mode in the SiO_2 spacer layer is observed, and its contribution to the overall absorption spectrum is studied in detail. The effects of the top patterned Ni layer, incident angle, and polarization on the absorption spectra are also investigated. This study offers useful engineering opportunities for the design and development of mid-infrared absorbers and reflection filters.

Investigating Temperature Effects on the Performance of Perovskite Based Solar Cells via Numeric Simulation

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University of Management and Technology

The escalating demand for sustainable energy solutions, driven by increasing environmental deterioration and persistent electricity shortages, has intensified global interest in renewable energy technologies. Among the available alternatives, solar energy has emerged as one of the most viable and sustainable resources due to its abundance, environmental compatibility, and long-term availability. In this context, the present study investigates the development and optimization of a high-performance perovskite solar cell (PSC) architecture based on FASnI 3 and MAGeI 3 absorber materials. Owing to their exceptional optoelectronic properties, tuneable bandgaps, high absorption coefficients, and superior charge-transport characteristics, PSCs have recently attracted considerable attention as one of the most promising next-generation photovoltaic technologies. In this work, a novel ZnO/FASnI 3 /MAGeI 3 /GO heterostructure solar cell is proposed and systematically simulated using COMSOL Multiphysics. The simulation results demonstrate that the maximum short-circuit current density (J sc) of 28.612 mA/cm 2 is achieved at an optimized FASnI 3 absorber thickness of 280 nm, whereas the optimum fill factor (FF) of 69.59%, while power conversion efficiency (PCE) of 25.19% obtained at an operating temperature of 320 K. These findings provide valuable insights into the advancement and practical implementation of environmentally friendly perovskite solar technologies, thereby contributing to the ongoing global transition toward sustainable and renewable energy systems.

Cosmic-ray dominated Astrophysical jets in Supersonic Alfvénic conditions

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Ultra High energy cosmic rays carrying energies beyond PeV scale are widely suspected to be originated from extreme astrophysical environments such as astrophysical jets. In such sites the ejected plasma flowing at supersonic speeds from accretion source such as black-holes embedded with the helical and twisted magnetic fields provides the grounds for shock and MHD turbulence that facilities the conditions for the generation of cosmic-ray acceleration. In this work we present the MHD fluid hydrodynamic model approach to study the cosmic-ray governed plasma flow in the astrophysics jets under supersonic speeds in distinct Alfvénic conditions. By adopting the cylindrical magnetic shell geometry the magnetic fields configuration are defined of toroidal and poloidal components that project the helical motion of the cosmic ray plasma flow in the astrophysical jets. Within this framework we employ steady state two fluid system incorporates the thermal plasma, cosmic-ray components and their interactions, angular momentum transport, confinement and control of plasma rotation by toroidal fields and constant diffusion coefficient. With the appropriate conditions and admissible criterion, the morphological profile produces monoticaly decreasing supersonic flow in two distinct regimes (i) sub- Alfvénic flows (ii) super- Alfvénic flows. We disucss the implicaitons of these regimes in the astrophysical jets and their effects for the cosmic-ray acceleration

Design and Simulation of a Contactless Electromagnetic-Based Sleep Monitoring System

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Abstract

This project presents the design and simulation of a contactless electromagnetic-based sleep monitoring system capable of detecting breathing rate and heart activity without physical sensors attached to the human body. The proposed system utilizes low-power, non-ionizing electromagnetic waves to monitor periodic chest movements associated with respiration and heartbeat. Mathematical models were developed to analyze phase variations in reflected electromagnetic signals caused by physiological motion. The study further demonstrates how these phase-modulated signals can be processed to estimate vital sleep parameters and classify sleep quality levels. A complete conceptual framework consisting of a wave source, waveguide, receiver, and signal processing unit was designed and simulated. The results highlight the feasibility of using electromagnetic wave propagation and reflected signal analysis for reliable, non-invasive sleep monitoring applications. The proposed approach offers a promising solution for healthcare and smart monitoring systems due to its safety, comfort, and continuous monitoring capability.

Parameter Space Exploration of a Four-Fluid Cosmic-Ray-Driven Galactic Outflow Model

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We explore the parameter space of a four-fluid, cosmic-ray-driven galactic outflow model, extending previous transonic wind studies. Analytical stability criteria derived from the governing equations are evaluated across 2,000 parameter combinations using Latin Hypercube Sampling, with uncertainties estimated via bootstrap resampling. By systematically varying six physical parameters (cooling strength, wave damping, magnetic and mass fluxes, and adiabatic indices), we map the complete solution topology of physically motivated transonic galactic winds. Our analysis reveals four distinct outflow regimes: smooth transonic winds (84.7%), re- coupling flows (4.2%), failed winds (0.1%), and trajectories with multiple critical points (11.1%). We demonstrate that high magnetization (ψ_B / ψ_m > 2) completely stabilizes smooth transonic solutions against radiative losses. Furthermore, comparing model complexities reveals a progressive enrichment of solution regimes from one- to four-fluid frameworks. The reduction in the smooth wind fraction in the four-fluid model (84.7%) compared to the three-fluid model (97.6%) reflects the opening of new physical regimes (re-coupling and multiple critical points) rather than instability. These results provide predictive criteria for outflow behavior across diverse galactic environments, offering crucial insights for calibrating sub-grid wind models in cosmological simulations.

Hydrothermal Synthesis and Characterization of ZnO–MnO_2 Nanocomposite for Photocatalytic Applications

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Abstract

Nanocomposite materials have attracted extensive research interest owing to their distinctive structural, optical, and catalytic characteristics, particularly for environmental and photocatalytic applications. In this work, a ZnO–MnO_2 nanocomposite was synthesized via a hydrothermal route, which enables controlled nucleation and growth, improved crystallinity, and enhanced physicochemical properties of the material. The influence of key experimental parameters such as pH, reaction time, and interference effects were systematically investigated to assess the performance and stability of the synthesized nanocomposite. The structural and optical features of the prepared material were examined using X-ray diffraction (XRD) and UV–Visible spectroscopy. XRD results confirmed successful formation of the composite phase and its crystalline nature, while UV–Visible analysis provided insight into its optical behavior and allowed estimation of the band gap energy. Overall, the hydrothermally prepared ZnO–MnO_2 nanocomposite exhibited improved structural and optical properties, indicating its potential efficiency for photocatalytic processes and environmental remediation applications.

Temperature-Dependent CVD Selenization of MoO_3 Thin Films for Enhanced Photoelectrochemical Hydrogen Generation

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Abstract

The development of efficient and stable photoelectrodes is crucial for advancing solar-driven hydrogen production through photoelectrochemical (PEC) water splitting. In this work, $MoSe_2/MoO_3$ heterostructure photoelectrodes were synthesized via a controlled selenization of thermally evaporated MoO_3 thin films using a chemical vapor deposition (CVD) at temperature ranging from 500 to 700 °C. X-ray diffraction analysis confirmed that some portion of the MoO_3 had been converted to $MoSe_2$, thus creating the vertically stacked $MoSe_2/MoO_3$ heterostructures. The field-emission scanning electron microscopy showed a large amount of morphological evolution such as grain growth and surface densification as the selenization temperature was increased. Optical Properties showed that the optical bandgap of MoO_3 was reduced substantially from 3.46 eV to 3.12 eV by selenization, which was correlated with greatly improved visible-light absorption. Electrochemical impedance spectroscopy (EIS) results indicated that with increasing selenization temperature, there was a significant decrease in charge transfer resistance at the interface of the electrode/electrolyte, thus demonstrating that the selenization treatment improved the kinetics of charge transfer at the interface. Photoelectrochemical measurements demonstrated exceptionally large increases in the photocurrent density of selenized photoelectrodes, with the $MoSe_2/MoO_3$–700 °C photoelectrode having approximately 31 times greater a photocurrent response than for the pristine MoO_3 thin films.

Band Edge Engineering of WO_3 via Hf Doping toward Enhanced Photocatalytic Water Splitting: A First-Principles Study

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Abstract

Photocatalytic water splitting represents a sustainable approach for hydrogen production; however, its efficiency is often constrained by unfavorable band edge alignment and limited light absorption in semiconductor photocatalysts. Tungsten trioxide (WO_3) is a chemically stable, visible-light-active oxide, yet its conduction band minimum (CBM) is positioned below the H^+/H_2 reduction potential, hindering hydrogen evolution. In this work, density functional theory (DFT) calculations based on the HSE06 hybrid functional are employed to investigate hafnium (Hf)-doped monoclinic WO_3 for band-edge engineering toward efficient photocatalytic water splitting. The results demonstrate that Hf incorporation significantly alters the electronic structure, leading to a band gap expansion from 2.94 eV to 4.29 eV and a substantial upward shift of the CBM from +0.71 eV to −0.36 eV versus the normal hydrogen electrode (NHE). This shift enables thermodynamically favorable hydrogen evolution, effectively overcoming the intrinsic limitation of pristine WO_3. These findings establish Hf-doped WO_3 as a promising candidate with favorable band alignment for efficient solar-driven photocatalytic water splitting.

Enhanced electrochemical performance of $MnSr_2O_4$/CNT nanocomposite for high-efficiency supercapacitor applications

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Abstract

Transition metal oxides are among the most promising candidates for energy storage applications, offering an effective approach to overcoming environmental pollution and the global energy crisis. In this study, $MnSr_2O_4$ was synthesized via an environmentally benign solvothermal method with different CNT loadings (0, 3, 6, 9, and 12 wt%). The synthesized nanocomposite was identified and its shape and structure were examined using XRD, and FESEM. Electrochemical behavior of the fabricated material used as an active electrode material, was evaluated using CV, GCD and EIS. At 3 A/g, the $MnSr_2O_4$/CNT-12% has a higher specific capacitance (C_{sp}) of 840 F/g, while $MnSr_2O_4$ has a lower C_{sp} of 303 F/g. Furthermore, $MnSr_2O_4$/CNT-12% exhibits outstanding electrode analysis with a power density (Pd) of 750 W/kg and excellent cycling durability beyond the 5000^{th} cycle. The solution resistance (Rs) of the $MnSr_2O_4$/CNT-12% composite is 1.12 Ω, lower than that of $MnSr_2O_4$/CNT (1.62 Ω). These findings suggest that the $MnSr_2O_4$/CNT-12% nanocomposite may be a good choice for a reliable and quick supercapacitor.

Synthesis of $MgFe_2O_4$/CNT-Based Composite as a High-Performance Electrode Material for Supercapacitor Applications

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Abstract

The increasing demand for high-performance and sustainable energy storage systems continues to challenge the development of electrode materials that offer both high energy density and specific capacitance. Supercapacitors often suffer from low energy densities, limiting their applicability in advanced technologies. To address these challenges, this study explores the synthesis and characterization of $MgFe_2O_4$/CNT nanocomposites using a controlled chemical method and thermal treatment, with varying ratios of $MgFe_2O_4$ to CNTs. XRD analysis confirmed the formation of a crystalline spinel $MgFe_2O_4$ phase with well-defined peaks and average crystallite sizes of 20–35 nm. Morphological investigations via SEM and TEM revealed uniform dispersion of $MgFe_2O_4$ nanoparticles on a porous and interconnected CNT network, facilitating efficient ion transport and enhanced electroactive surface area. FTIR analysis validated the retention of metal–oxygen bonds and surface functional groups crucial for electrochemical performance. Electrochemical studies demonstrated that the optimized composite achieved a specific capacitance of ~1900 F g^{-1} at 4 A g^{-1} . These results underscore the potential of $MgFe_2O_4$/CNT nanocomposites as next-generation supercapacitor electrodes, offering a viable strategy to overcome energy density limitations in conventional devices.

Solar-Simulated Photocatalysis with MoS_2@WO_3 Heterostructures: An Efficient Strategy for RhB Degradation

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Abstract

In this study, a novel hydrothermal ex situ synthesis approach was employed to synthesize MoS_2/WO_3 heterostructures, utilizing two distinct molar ratios of 1:1 and 1:4. The successful implementation of a 'bottom-up' assembly method resulted in the synthesis of heterostructures with spherical and flaky shapes. Comprehensive structural, morphological, compositional, and bandgap characterizations were conducted through XRD, EDX, SEM, UV-Visible spectroscopy, and FTIR analysis. These analyses provided valuable insights into the agglomerated nature of MoS_2/WO_3 heterostructures, elucidating their potential applications in photocatalysis. Subsequently, the prepared heterostructures underwent testing for RhB photodegradation under solar light irradiation. The percentage efficiency of MoS_2/WO_3 composites after 30 minutes of irradiation was 91.41% for the 1:1 ratio and 98.16% for the 1:4. Similarly, the percentage efficiency of 1:1 MoS_2/WO_3 heterostructures after 60 minutes of exposure was 92.68%, while for the 1:4, it was 98.56%. Extending the exposure time to 90 minutes, the percentage efficiency was 92.41% for 1:1 and 98.48% for 1:4 composites. Furthermore, these heterostructures exhibited stability over three cycles, Moreover, indicating their future applications for other photocatalytic applications. **Keywords: MoS_2/WO_3, heterostructures, solar simulator**

Beyond the Horizon: Rare Decays as a Window to New Physics

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Abstract

Recent B-physics anomalies at LHCb and Belle II suggest a potential violation of Lepton Flavor Universality, challenging a core tenet of the Standard Model. This presentation **intends** to establish the theoretical and historical framework necessary to navigate these tensions and other similar aspects in current and future talks, providing the groundwork for subsequent inquiries into specific high-energy phenomenologies.

The talk briefly discusses the historical introduction of particle physics leading to mesons. Focusing on pseudo-scalar mesons as "clean" experimental laboratories, it **introduces** basic concepts with a primary focus on rare decays—events so infrequent they serve as precision "null-tests" for the Standard Model, where statistical deviations act as a smoking gun for hidden physical laws. Ultimately, the discussion **bridges** these observations with Beyond Standard Model (BSM) theories, specifically Super-symmetry (SUSY) and the Minimal Super-symmetric Standard Model (MSSM). By exploring the phenomenology of R-parity Violation (RPV), the talk illustrates how the rarest flickers in meson decay provide a window into a more symmetric layer of reality, setting the stage for future specialized inquiries.

Synergistically Engineered $NiCo_2S_4$/MXene/rGO Nanohybrids for Next-Generation High-Performance Supercapacitors

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Abstract

The growing demand for high-efficiency and sustainable energy storage systems has accelerated research into multifunctional nanostructured electrode materials. Novel ternary nanohybrid composed of nickel cobalt sulfide ($NiCo_2S_4$), MXene ($Ti_3C_2T_x$), and reduced graphene oxide (rGO) is designed and developed for high-performance supercapacitor applications. The proposed hybrid architecture integrates the superior pseudocapacitive behavior of $NiCo_2S_4$ with the exceptional electrical conductivity of MXene and the structural stability of rGO. The nanohybrids are synthesized through a controlled hydrothermal and self-assembly approach, resulting in a three-dimensional interconnected conductive network. Structural and morphological analyses reveal uniform dispersion of active components and the formation of hierarchical porous structures, which facilitate rapid ion diffusion and efficient electron transport. Electrochemical investigations demonstrate significantly enhanced specific capacitance, excellent rate capability, and outstanding cycling stability compared to conventional oxide-based electrodes.

The synergistic interaction among $NiCo_2S_4$, MXene, and rGO effectively minimizes charge transfer resistance while maximizing electrochemically active sites. This optimized configuration enables fast redox reactions and stable charge/discharge behavior under high current densities. The proposed ternary nanohybrid exhibits promising potential for scalable, low-cost, and environmentally friendly energy storage devices. This study provides a new pathway for engineering advanced hybrid nanomaterials and contributes to the development of next-generation supercapacitors for smart energy and portable electronic applications.

Keywords: Supercapacitors, MXenes, Reduced graphene oxides, Charge transfer kinetics, Sustainable energy.

Three Wave Instability in Semiconductor Plasma Waveguides

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Abstract

Three waves interaction of electrostatic modes in semiconductor plasmas for a cylindrical geometry is presented here. The fields of plasma modes couple through second ordered ponderomotive force. For analytical analysis, we applied quantum Hydrodynamics , Fluid Model for the electrons and holes in semiconductor systems. For the convenience we consider only high frequency regime. We derive and analyze the dispersion relations for the electron plasma wave (EPW), hole plasma wave (HPW), and the excited beat wave. Under phase-matching conditions, the growth rate of the beat wave is evaluated. Numerical simulations demonstrate that the growth rate is enhanced by lower temperatures, higher electron densities, shorter wavelengths, and increased pump wave potentials. These conditions optimize wave coupling and energy transfer, highlighting the role of quantum effects in modulating nonlinear interactions.

Synthesis of $CeFeO_3$/rGO nanocomposite for enhanced oxygen evolution reaction (OER) performance

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Developing efficient and stable electrocatalysts for sustained energy transformation is still a critical issue for scholar. To address this challenge, perovskite oxides have emerged as promising OER electrocatalysts owing to their highly tunable catalytic activity and electronic characteristics connected with their nanocomposites. This work occurs a facile hydrothermal method to prepare $CeFeO_3$/rGO nanocomposite in order to accelerate for electron transfer method. The $CeFeO_3$/rGO was prepared by hydrothermal process. According to the physical analysis, the $CeFeO_3$/rGO nanocomposite has a surface area (SA) of 188.06 $m^2 g^{-1}$.$CeFeO_3$/rGO nanocomposite shown a reduced overpotential (192 mV) and low Tafel gradient (37 mV dec^{-1}) at current density (j) (10.0 mA cm^{-2}).The nanocomposite shown lowest R_{ct} by EIS tests. Chronoamperometry test displays that composite is highly durable for 27 h

Development of All-Inorganic P-N & P-i-N Heterojunctions for Optoelectronic and Photovoltaic Device Applications

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Abstract

Today, it is believed that the vast production of renewable energy is obligatory to meet the rapidly-growing global demand up to 6-8 folds (over 20 TW) by 2050 instead of overwhelming use of fossil fuel to retain the content of carbon dioxide at its current level as of 2020. Recently, transparent metal oxides (TMOs) have attracted a great deal of attention due to their fascinating electrical and optoelectronic properties which enabled their extensive utilization in the design of numerous emerging functional devices, such as gas sensors, transparent thin film transistors (TTFTs), light emitting diode (LEDs), UV-detectors and energy conversion and storage systems as well as photovoltaic solar cells. Generally, binary metal oxides are divided into two categories based on their nature of conduction and defect states; (a). N-type metal oxides with cation interstitials or anion vacancies (ZnO, TiO_2, SnO_2, In_2O_3, CdO, etc.), (b). P-type metal oxides with cation vacancies or anion interstitials (SnO, CuO, NiO, Co_3O_4, Cr_2O_3, etc.). Herein, we report all-oxide inorganic pn-heterojunction via novel combinatorial approach of thermal evaporation method at room temperature followed by thermal oxidation in oxygen environment at optimum annealing temperature. The effective carrier injection, directional transportation up to extraction of charges in fabricated heterostructure diode/solar cell was critically studied.

Keywords: Inorganic heterojunction; Annealing; Directional carrier transportation; Energy band diagram; Band alignment engineering, Metal oxide-heterostructure; Thin-film solar cell.

Surface Modification of Materials Using Ion Beam

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ABSTRACT

Surface modification refers to a process of changing the surface properties of a material while keeping its bulk properties unchanged. Ion implantation is a versatile and controllable surface modification technique widely used to tailor the structural, mechanical, optical, and electrical properties of different materials. In this work, the effects of ion implantation in three major classes of materials (metals, alloys, semiconductors, and polymers) are discussed with an emphasis on technological applications. In the case of metals, carbon ion implantation in aluminum significantly enhanced its surface hardness and corrosion resistance, while argon ion implantation in Ti6Al4V alloy improved the corrosion resistance of the alloy due to the formation of ion-induced surface nanostructures. For semiconductors, ion implantation in ZnS, NiO, and ZnO was employed to investigate modifications in their optical and electrical properties for photodetection application. Finally, ion implantation in polymeric PTFE (Teflon) was investigated for triboelectric nanogenerator (TENG) applications, where gold ion implantation significantly enhanced its triboelectric performance. These results demonstrated that ion implantation is an effective approach for tuning the material properties across diverse material systems for advanced technological applications.

Analysis and Applications of Conformable, Fractional, and Fractal Derivatives

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Abstract

The fractional, fractal, and conformable derivatives will all be examined in this work. We will present a few innovative engineering-related applications. We will perform some integral transformations. These integral transforms will yield some novel transfer functions. We will use a few figures to illustrate the simulations.

Interface Engineering in Advanced Thin-Film Heterostructures for Low-Power Electronic Devices

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Abstract

Thin-film heterostructures have emerged as a key platform for next-generation electronic and optoelectronic devices, where interface engineering plays a decisive role in controlling charge transport, defect states, and device reliability. This invited talk highlights recent advances in thin-film technology with a particular emphasis on engineered oxide interfaces for low-power memory and sensing applications.

The presentation will discuss the fabrication and characterization of bilayer metal-oxide thin films, focusing on how interface-driven phenomena such as oxygen vacancy distribution, band alignment, and surface morphology influence electrical performance. Special attention will be given to β-Ga_2O_3/WO_3 heterostructure memristor devices, where optimized interfaces enable stable bipolar resistive switching, high resistance ratios, and reduced power consumption.

Overall, the talk demonstrates how rational interface design in thin-film systems can significantly enhance device functionality, offering promising pathways for future resistive memory, neuromorphic computing, and multifunctional thin-film electronics.

Multifunctional Electrochromic Supercapacitor Windows for Net-Zero and Smart Infrastructure

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Abstract

As the world is shifting toward sustainable and energy-efficient building practices, the use of smart windows is becoming prevalent in modern construction, especially in the areas of Passivhaus. These windows can dynamically regulate the access of light and heat in buildings, efficiently control indoor temperatures, and minimize reliance on artificial heating and cooling systems, resulting in a more sustainable and comfortable living environment. This talk will provide the fundamentals of electrochemical energy storage systems and highlight the current confusion between battery-grade and capacitive-grade electrode materials. Further, a detailed summary of current developments of our electrochromic electrode materials for smart windows will be presented. Current challenges and future considerations of the integrated energy storage and conversion devices will be covered.

Lignocellulosic Carbon Architectures and Hybrid Interfacial Engineering for High-Energy All-Solid-State Supercapacitors

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Abstract

All-solid-state supercapacitors that combine high energy density with intrinsic safety and long cycle life require electrode systems that enable rapid ion transport and high-density charge storage. This talk presents a feedstock-to-device strategy that connects precursor chemistry, interfacial engineering, and solid-electrolyte design through three representative case studies. First, jute-stick-derived activated carbon nanosheets produced via two-step pyrolysis (≈2600 m^2/g) are coupled with in situ grown NiCo layered double hydroxide (LDH) nanoflowers. The resulting asymmetric device, assembled with PVA/KOH gel electrolyte, achieves an energy density of 100 Wh kg^{-1} with strong cycling stability. Second, sakura-derived carbon is sulfur-functionalized to improve electronic conductivity and surface wettability, then integrated with NiCo-LDH through a one-step synthesis route. Using a PVA/KOH/ionic-liquid gel electrolyte, the all-solid-state device delivers 160 Wh kg^{-1} at power densities up to 4.5 kW/kg, retains 90% capacitance after 20,000 cycles, and demonstrates practical capability by powering 27 LEDs for 30 minutes. Third, tomato-leaf-derived carbon with hierarchical porosity (≈1440 m^2/g) is paired with electrochemically deposited polyaniline to construct an asymmetric cell achieving 270 μWh/cm^2 at 1400 μW/cm^2, with ≈95% retention after 10,000 cycles. This platform further enables battery-free heart-pulse monitoring under indoor solar illumination. Collectively, these results establish transferable design principles across renewable carbon precursors: maximize accessible surface area and multiscale porosity, engineer redox-active and conductive hybrid interfaces, and pair electrodes with mechanically and electrochemically robust solid electrolytes. The outcome is a scalable and cost-effective pathway that advances supercapacitors toward practical high-energy applications.

Comparative Dosimetric Analysis of Automatic and Manual Optimization in Eclipse-Based Stereotactic Radiosurgery

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Abstract

Stereotactic radiosurgery (SRS) demands exceptional dose conformity and gradient sharpness to effectively ablate intracranial targets while preserving adjacent critical structures. This study presents a comparative dosimetric analysis of automatically optimized and manually optimized treatment plans generated within the Eclipse treatment planning system for SRS applications. A cohort of patients with intracranial lesions was retrospectively planned using both the Photon Optimizer (PO)/Progressive Resolution Optimizer (PRO) with automated parameter tuning and conventional manual optimization workflows. Dosimetric endpoints including Paddick Conformity Index (PCI), Gradient Index (GI), isodose selectivity, target coverage (V_{100}%), and doses to organs at risk (OARs) were systematically evaluated and compared between the two approaches. Preliminary results indicate that automatic optimization yields statistically comparable or superior plan quality metrics relative to manual optimization, with a significant reduction in planning time, suggesting its potential to standardize and streamline SRS planning workflows without compromising Dosimetric integrity. These findings support the broader clinical adoption of automated optimization strategies in Eclipse-based SRS, particularly in high-volume radiosurgery programs where planning efficiency and consistency are paramount.

Comparative Evaluation of Machine Performance Check and Daily Beam Quality Assurance Tools for High Dose-Rate Flattening Filter-Free Beams

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Abstract

Daily quality assurance (QA) and machine performance verification are critical components of a robust radiation therapy program, particularly for high dose-rate flattening filter-free (FFF) beams, which present unique dosimetric challenges due to their non-uniform, forward-peaked beam profiles and elevated dose rates. This study presents a comparative evaluation of two widely employed QA tools — the Machine Performance Check (MPC) and daily beam quality assurance (DQA) systems — for monitoring beam constancy, flatness, symmetry, output, and positional accuracy in FFF beams delivered by modern linear accelerators. Measurements were performed using both systems under identical clinical conditions across a defined evaluation period, and results were analyzed for sensitivity, reproducibility, and agreement with reference baseline values established through conventional dosimetric methods. Statistical analysis revealed [significant/comparable] concordance between the two systems in detecting beam parameter deviations, while notable differences were observed in their sensitivity to specific dosimetric perturbations inherent to FFF beam geometries. The findings highlight the complementary strengths of each tool and provide evidence-based guidance for clinical medical physicists in selecting and optimizing daily QA workflows for FFF beam modalities, ultimately contributing to improved treatment safety and consistency in modern radiotherapy departments.

Solitary Waves in Current Driven Sheard Flow in Dusty Magnetoplasma

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Abstract

We study how plasma waves behave in stationary, negatively charged dust grains, with current driven sheared flow. Using fluid model equations which balances the wave steepening and spreading which support stable, localized solitons, which are described by the Korteweg–de Vries (KdV) equation. We write down the exact shape of these solitons and show how their height and width change when we adjust the strength of the shear, the amount of dust, and the direction of the magnetic field. By choosing laboratory produced plasma parameters, we investigate how these solitons can grow to noticeable sizes and might be an important way that particles and energy move across magnetic field lines, both in laboratories and in space plasmas.

Morphological and structural behavior of ZnO thin films deposited through chemical bath.

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Abstract

Zinc oxide (ZnO) thin films were successfully deposited on glass substrates using the chemical bath deposition (CBD) technique, and their morphological and structural properties were systematically investigated. The surface morphology of the as-deposited films was examined using scanning electron microscopy (SEM), which revealed the formation of well-defined nanostructures with uniform distribution across the substrate surface. X-ray diffraction (XRD) analysis confirmed the polycrystalline nature of the deposited films, exhibiting a wurtzite hexagonal crystal structure with a preferential orientation along the (002) plane, indicating c-axis growth perpendicular to the substrate. The average crystallite size was estimated using the Scherrer equation, and the calculated lattice parameters were found to be in good agreement with the standard JCPDS data for ZnO. The results demonstrate that the CBD method offers a cost-effective and low-temperature route for the synthesis of structurally ordered ZnO thin films, making them promising candidates for optoelectronic and photovoltaic device applications.