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ABSTRACT BOOK

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Preface

Welcome to the Abstract Book of the UMT 1st International Conference on Emerging Trends in Physics (ICP-2024), organized by the Department of Physics at the University of Management and Technology, Lahore. This abstract book serves as a compilation of the diverse research contributions presented at ICP 2024, offering a snapshot of the exciting advancements and discussions that took place during the conference.

The field of physics is continuously evolving, driven by curiosity, innovation, and collaboration among researchers worldwide. ICP 2024 provided a dynamic platform for physicists from academia, industry, and research institutions to converge, exchange ideas, and explore emerging trends across various branches of physics.

This abstract book features a wide range of topics, spanning condensed matter physics, particle physics, astrophysics, quantum mechanics, biophysics, and beyond. Each abstract represents a unique contribution to our understanding of the fundamental principles governing the universe and the innovative applications of physics in solving real-world challenges.

We extend our sincere appreciation to all the authors who submitted their abstracts, as well as the reviewers who provided valuable feedback and ensured the quality of the contributions. Additionally, we are grateful to the organizing committee members, session chairs, sponsors, and volunteers for their tireless efforts in making ICP 2024 a success.

As you peruse through the abstracts in this book, we hope you will find inspiration and insights that stimulate further inquiry and collaboration in the field of physics. May the knowledge shared at ICP 2024 contribute to the advancement of science and the betterment of society.

We look forward to welcoming you to future iterations of ICP and witnessing the continued growth and innovation in emerging trends in physics.

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High-quality laser Wakefield accelerators and compact free-electron lasing at SIOM

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Abstract

The acceleration gradient achieved through laser Wakefield acceleration (LWFA) surpasses that of state-of-the-art radio-frequency accelerators by 3 to 4 orders of magnitude. This has significant implications for the development of compact particle accelerators and novel radiation sources, making it a prominent research focus globally. The growing demand for tabletop radiation sources, particularly in light of the rapid advancement of free electron lasers, imposes higher standards on the quality and stability of electron beams generated in LWFA. This talk will provide a comprehensive overview of the strategies, achievements, and future development plans pursued by the relevant research teams in electron acceleration at the Shanghai Institute of Optics and Fine Mechanics (SIOM), Chinese Academy of Sciences, over the past decade in the development of tabletop laser Wakefield accelerators and compact free-electron lasing based on LWFA.

Controlling the characteristics of laser-driven proton beams and acceleration of heavier ions by advanced acceleration mechanisms

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Abstract

Ion accelerators are of significant interest due to their widespread societal applications, for example, in clinical cancer therapy, as they target the tumors with negligible damage to the surrounding tissues. High capital and operational costs associated to conventional accelerators make proton therapy less accessible, which triggered interest in reduced cost and compact alternatives. In this context, ion acceleration using high-power lasers recently emerged as a promising alternative to conventional accelerators, which in addition to the compactness and possible cost-effectiveness, deliver a high dose in an extremely short time span (one billionth of the second). Several projects worldwide are devoted to developing laser-based accelerator technologies and assessing their potential for potential applicative usage in industrial and biomedical applications, e.g. pan-European Extreme Light Infrastructure and EPAC project at Rutherford Appleton Laboratory. After giving an overview of the current state of the art and perspective of ion acceleration using high-power lasers, I will present a novel scheme for controlling the characteristics of laser-driven proton beams and acceleration of heavier ions by advanced acceleration mechanisms such as radiation pressure acceleration (RPA).

Plasmon-enhanced gold-heterostructures of tungsten disulphide nanoflakes (Au/WS_2 NFS) from nonlinear and photodetector applications

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Abstract

High yield production of tungsten disulphide stacked of 2D materials (such as MoS_2 and WS_2) will be prepared using chemical exfoliation process without any phase transition for nonlinear and photodetector applications. In this work, we report the study on the quality of heterostructure 2D-MoS_2/WS_2 decorating with the structure of gold (Au) nanoparticles using electron beam evaporation followed by dewetting process. The quality of MoS_2, WS_2 and Au/WS_2 deposited was structurally characterized using Raman Spectroscopy, X-Ray Diffraction (XRD) and field emission scanning electron microscopy (FESEM). It is crucial to identify the contribution of 2D materials from linear and nonlinear point of view. From the linear optical properties, UV-Vis and Tauc plot of WS_2 will be obtained for its bandgap value. As for the nonlinear optical properties, Z-scan measurements will be carried out where the performance analysis will be characterized from nonlinear absorption coefficient, β, nonlinear refractive index, γ, and third order nonlinear susceptibility, χ. These quantitative values are important to identify the suitability of these Au/WS_2 nanostructures in photodetector application under visible range illumination. By coupling with Au nanoparticles, we do expect the interactions between MoS_2 and WS_2 and incident photons are significantly enhanced through surface plasmon resonance properties.

Progress of laser Wakefield electron acceleration and its applications at CoReLS/APRI

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Research on laser Wakefield accelerators (LWFA) has made a great progress with the development of ultrahigh intensity lasers around the globe, enabling the generation of electron beams with energy as high as possible [1]. In addition, many groups focused to produce monoenergetic, low divergence electron beams [2], essential for applications such as free electron laser (FEL) [3], very high energy electron (VHEE) therapy, positron generation and nonlinear Compton scattering (NCS) [4,5]. Center for Relativistic Laser Sciences (CoReLS) and Advanced Photonics Research Institute (APRI), one of the pioneering institutes for development of PW lasers [6], recently recorded the highest laser intensity (1023 W/cm2) [7], and has worked on electron acceleration, producing high quality, multi-GeV electron beams and its applications. Here we present our recent progress in the laser Wakefield electron acceleration and radiation production from a He plasma wake driven by a PW laser pulse and its applications.

High-field QED in the laboratory: current status and near-term opportunities

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Abstract

The fast-paced advance in the high-power laser technology has recently allowed reaching focused intensities exceeding 1021 Wcm−2, with realistic plans to reach > 1023 Wcm−2 in nearterm largescale laser facilities worldwide. While these intensities are still orders of magnitude lower than those needed to produce an electron-positron pair from the vacuum, this limitation can be overcome by focusing the laser pulse onto an ultra-relativistic electron beam. In this case, the electric field in the rest frame of the electron is relativistically boosted by its Lorentz factor. As an example, a 1 GeV electron beam interacting with a laser focused intensity of 1021 Wcm−2 will experience, in its own rest frame, an electric field of the order of 20% of the Schwinger field. GeV-scale electron beams suitable for these experiments can be provided either by Laser-Wakefield or radio-frequency accelerations. At these unique field intensities, a plethora of exotic processes can be triggered and studied, including highly non-linear Compton scattering, quantum radiation reaction, and BreitWheeler pair production. Detailed experimental characterization of these phenomena will not only advance our fundamental understanding of this branch of fundamental physics but will also be instrumental for astrophysics, cosmology, and plasma physics. An international collaboration led by UK scientists has recently performed the first experiments in this area at the Rutherford Appleton Laboratory, unveiling quantum signatures of radiation reaction [1,2]. Several other campaigns at different world-class physics laboratories, including the E-320 experiment at SLAC [3], the LUXE experiment at the Eu-XFEL [4], and experiments at the Extreme Light Infrastructure and the Astra-Gemini laser, are currently in their preparation stage and aim at pushing our experimental capabilities even beyond the Schwinger field. In this talk, an overview of the current status and near-term opportunities in this area of physics will be given, with a particular focus on the experimental challenges in studying this fascinating area of physics.

Emerging Trends in Laser-Induced Breakdown Spectroscopy Research

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Abstract

Laser-Induced Breakdown Spectroscopy (LIBS) is a powerful analytical technique that has garnered significant attention in recent years. In this talk, we will explore the fundamental principles of LIBS, its applications, and the exciting trends shaping its future. Recent research in Laser-Induced Breakdown Spectroscopy (LIBS) has demonstrated a significant focus on advancing the technique's applications and methodologies. Studies have highlighted the diverse applications of LIBS, including space exploration, environmental monitoring, Forensics and biomedicine. NELIBS is a notable addition to LIBS toolkit, specifically for transparent samples and even for explosive detection and protein analysis. LIBS has also been explored for direct analysis of raw bile juice to screen for gallbladder cancer, showcasing its potential in medical diagnostics. Moreover, there have been considerable advancements in LIBS quantification, transitioning from fundamental understanding to improved data processing techniques. Additionally, the integration of chemometrics and machine learning algorithms has been emphasized to enhance the qualitative and quantitative analysis capabilities of LIBS. Additionally, studies have focused on enhancing the sensitivity and detection limits of LIBS for applications like hazardous element profiling and heavy metal sensing. Furthermore, the development of novel approaches and instrumental advancements in LIBS has been a key area of interest, with a particular emphasis on in-line analysis of industrial materials. Overall, the recent research activities indicate a growing interest in expanding the capabilities of LIBS through innovative applications, methodological developments, and interdisciplinary collaborations, positioning LIBS as a versatile and powerful analytical technique for various fields.

Thin film materials for photovoltaics: state of the art and new perspectives.

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Abstract

Binary alloys like CdTe, Sb_2Se_3 or Sb_2S_3 as well as quaternary compounds such as CuInGaSe2 -CIGS-and Cu2SnZn(S,Se)4 -CZTS-can be deposited on different substrates (glass, polymers, ultra-thin glass) and deliver high-efficiency flexible devices. With a band gap that ranges from 1.2 to 1.7 eV and with an exceptionally high absorption coefficient, they have optimal photovoltaic characteristics. In particular, CdTe has reached an efficiency of 22.4% and has demonstrated a remarkable robustness that allows mass-scale production. On the other hand, Sb_2Se_3 has a unique ability for 1-D conduction along a ribbon-like structure whose orientation strongly affects electronic transport and a champion absorption coefficient that allows for sub-micrometer thick absorbers. On the other hand, more complex compounds assure high efficiencies (CIGS) or good performance with non-vacuum techniques (CZTS). In this work, we will present all the latest developments for the production of these materials, together with their based window layers and contacts. In particular, we will show the fine engineering of $CdSe_xTe_{1-x}$ graded band gap for CdTe which brings to an efficiency of about 16% for a 2-micrometer thin CdTe layer, a new CdSe buffer layer for Sb_2Se_3, and a novel spraying technique for CZTS.

Laser-based compositional analysis compared with the other analytical techniques

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Abstract

A Laser-based compositional analysis technique has been developed to study any sample in the form of gaseous, liquid, or solid. This technique, Laser-Induced Breakdown Spectroscopy (LIBS), is very simple, robust, and less time-consuming as the qualitative analysis can be achieved within a fraction of a second. Another Laser-based technique, Laser Ablation Time of Flight Mass Spectrometry (LA-TOFMS), has also been indigenously developed for the isotopic abundance measurements and for the quantitative analysis of any sample in the solid form. Several striking results on the types of cement, stones, gold ores, and rare earth ores will be presented and results will be compared with the other analytical techniques such as X-ray Fluorescence (XRF), Energy Dispersive X-Ray Emission, (EDX), Proton Induced X-Ray Emission (PIXE).

Artificial Intelligence Generative and its Role in Higher Education

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Abstract

Artificial Intelligence (AI) has played a significant role in higher education, not only in teaching and learning but also in institutions' set up/development. The overview of AIs' multidimensional role in higher education is mainly focused in the present work. It also includes the applications of AI in personalized learning, student support, and research progress as well as administration efficiency. AI has not only a deep impact on the thinking and working of researchers but also assists them in understanding, processing and analyzing large datasets, repetitive tasks and to enhance their vision across several fields. Researchers are well supported by the designed AI apps in several aspects of their work, from literature surveys to data analysis. Eventually, the pace of developments and discoveries in almost all walks of life is commendable and sets high yardsticks to follow. AI deeply impacted the administrative operations inside higher education institutes. Administrative tasks are streamlined using IA, including the admission process, course preparation and financial aid distribution, leading to better efficiency and cost savings. Moreover, AI support empowers institutions to make data-informed decisions, predict enrollment trends, and optimize resource allocation. There are many challenges as well as ethical considerations of AI as well. These challenges are related to data privacy, algorithmic bias and the potential for job displacement among staff and educators. In conclusion, artificial intelligence is playing a significant role in shaping the future of higher education. Its applications hold the potential to boost the quality and accessibility of education while keeping in view the ethical and societal consequences. This should be welcomed as a blessing.

Transfer Matrix Method and Transmission Spectra of Thin Films

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Abstract

to manufacture nanostructured thin films for many optical applications, there are several physical and chemical deposition techniques have been used over the last few decades. the optical band gap of materials is very important parameter that determines the application of thin films and this parameter can be extracted from the transmission spectra using several methods. in this talk, i shall describe transfer matrix method (tmm), a theoretical method that predicts the transmission spectra of thin films and then it is applied on some semiconductor thin films to find transmission spectra and finally optical band gaps. this study helps to design a new numerical technique that leads us to explore the optical properties of multilayered structures like photonic hyper crystals.

Controllable tuning of physical properties of 2D materials

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Abstract

Finding approaches capable of tuning material properties in a controlled manner are highly desirable for obtaining next generation devices. Controllable tuning of physical properties of 2D materials has emerged as a pivotal area of research with profound implications across various scientific and technological domains. These atomically thin materials, such as graphene, transition metal dichalcogenides (TMDs), and hexagonal boron nitride (h-BN), offer unparalleled opportunities for tailoring their properties through external stimuli. Presentation demonstrates the use of electric field induced resonance effect and layer-sliding to induce new propertied. In case of application of electric field, owing to the unique implementation of the oscillating electric bias, a monotonous increase in the vibrational amplitude of the attached hydroxyl functional group (OH), resulting in its complete desorption from the carbon plane. This novel method of surface modification can be applied to any material surface in general. While for the case of layer-sliding, interfacial electronic properties of two-dimensional vdW heterostructure consisting of silicene and indium selenide (InSe) have been varied by sliding silicene over InSe layer in the presence of Li intercalation.

Achieving high capacity by Ni and Sn based Chalcogenides composites Composites as Anodes for Na-Ion Batteries

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Abstract

Lithium-ion batteries (LIBs) are one of the most prominent electrical storage devices. LIBs are used in many electronic devices and are on their way to being used in electric vehicle (EV) and stationary storage (stationary storage). However, the barriers to being used for large-scale stationary storage are the high cost of LIBs and the low availability of lithium resources. Sodium-ion batteries (SIBs) are emerging as an alternative to LIBs with the benefit of abundant and low-cost sodium materials. SIBs require high performance cathode & anode materials to be commercially viable. In this study, a scalable and eco-friendly hydrothermal process resulted in the formation of a heterogeneous Ni_3S_4/SnS hetero-assembling nanosheet (NTS) composed of reduced Graphene Oxide (NTS–rGO) and Carbon Nuts (NTS–CNT). The sulfide ions produced by the sodium sulfide reaction react with nickel/tin ions during the next hydrothermal treatment, resulting in the formation of NTS heterostructures with synergistic effects. The morphology shows the nucleation of many nanoseeds that develop into NTS nano-sheets with rGO as the template for growth and the CNT as the connection between heterostructures of NTS. Initial charge capacities of NTS–rGO and NTS – CNTs NCs are measured at 402 mAh g^{-1} and 447 mAh g^{-1} at 0.05 C.

QED and QCD Feynman diagrams

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Abstract

Photon propagator is Fourier transform of the Coulombic potential as well as the Green function for Maxwell equations. Multiplying charge (probability) density with the electromagnetic potential results in an interaction that becomes photon-electron vertex after second quantization. Feynman amplitude contains vacuum expectation values of products of interactions terms in the relevant order of perturbation theory. Whereas photon carries no charge, the gluon propagator in quantum chromodynamics (QCD) carries color charge; the resulting gluon-gluon vertex makes QCD much different to quantum electrodynamics (QED).

Quantum Initiatives: Inspire, Engage and Educate Pakistani Youth for Pushing the Boundaries of Quantum Physics

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Abstract

Quantum physics has played a leading role in the shaping of modern civilization. The word quantum was coined by Max Born, Werner Heisenberg, and Wolfgang Pauli etc. in the early 1920's but Max Born was the one who used it for the first time in his research paper, published in 2025. Considering the substantial contributions of quantum mechanics in the development of modern science and technology, the UNESCO Executive Board has endorsed the resolution, submitted by 57 countries, to recognize 2025 as the International Year of Quantum Science and Technologies. "100 years of Quantum is just the beggin", hence it is the right time to educate, inspire and engage youth of the Developing countries like Pakistan by channelizing their energies in quantum physics for pushing the boundaries of quantum science and technology.

Kelvin–Helmholtz instability in magnetically quantized dense plasmas

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Abstract

On employing fluid model of quantum hydrodynamics, we will focus on the spatial drift instability in quantum magneto plasmas. This study deals with the instability of shear waves, also known as Kelvin–Helmholtz instability, propagating with a complex frequency “ω” in magnetically quantized dense gyro-viscous plasmas. The instability arises from the transverse spatial shear of the streaming velocity, which evolves from the DC electric and magnetic fields. In dense plasmas, quantum effects contribute through magnetically quantized statistical Fermi pressure, tunnelling potential and exchange-correlation potential. The set of magneto hydrodynamic equations will be solved to derive the dispersion relation. Numerical data will be applied to plot the graphs on varying different parameters. This work has its applications in laboratories as well as space plasmas.

Laser Induced breakdown spectroscopy of magnetically confined water residue plasma

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Abstract

In this study, the laser-induced water residue plasma is produced in the presence of magnetic field (B) of 0.8T. A Q-switched Nd: YAG pulsed laser (λ=1064nm, E=100mJ, pulse duration 8ns) is focused to produce the water residue plasma with and without a magnetic field, and plasma emissions are recorded using LIBS spectrometer. The plasma parameters such as electron temperature (Te), electron number density (ne), plasma frequency have been increased by using magnetic field. Furthermore, thermal beta (βt) is also calculated, and its value is smaller than one , which confirmed the evidence of confinement of plasma in magnetic field. According to the analysis of the water residue emission spectrum, several elements were detected (Ca, Mg, Cr, Mn, As, Fe, Si) among which chromium, arsenic, manganese are toxic elements. Improved spectroscopic results of magnetic field -assisted LIBS demonstrate it as a promising tool for the detection of multi-elements in water residue samples.

Enhancing Cold Storage Efficiency through Physics-Driven Design Optimization

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Abstract

The advancement of physics-based technologies has opened new avenues for optimizing cold storage facilities through Computational Fluid Dynamics (CFD). Inefficient storage techniques contribute to food wastage, food insecurity, and an increased carbon footprint. This research focuses on Computational Fluid Dynamics (CFD) to enhance the design of cold storage rooms and optimize the positioning of cooling units. The CFD analysis to evaluate and refine the cold storage design for fruits and vegetables. Traditional storage solutions have been found lacking in providing thermal uniformity, leading to food spoilage. Through the application of optimization tools such as the design of experiments, the research aims to develop a more efficient cold storage room design that ensures airflow velocity and cooling temperature on cooling efficiency and uniformity is accentuated through literature. The Cooling Unit Positioning is adjusted to streamline airflow, facilitating optimal dissipation of energy produced during respiration and temperature changes in stored produce. This study thus demonstrates the use of CFD methods to study the to reduce energy consumption in storage facilities, contributing to find sustainable design solutions for different horticulture products.

Spectroscopy of Heavy Mesons

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Abstract

In the Quark Potential Model, we solve the Schrödinger equation numerically utilizing a shooting method paired with a bisection approach to determine the bound state energies for heavy quark-antiquark pairs. The results provide novel theoretical predictions for the spectroscopy and properties of various heavy meson states, with different quantum numbers. Quantitative results are presented for masses in comparison with the known experimental data. This work helps to expand understanding of heavy meson physics and provides testable predictions for experimental searches and identifications of new undiscovered heavy meson resonances.

Comparative study of CO_2 conversion to useful products

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Abstract

As world is industrialized, carbon dioxide emission is increased which imposes drastic effect on environment. Therefore, development of unique techniques to reduce carbon dioxide into useful product is need of hour. Electrochemical reduction of CO_2 (ERC) is advanced technology that utilizes CO2 and convert it into beneficial chemicals and fuels through electrochemical reactions. Among various products that are produced from ERC, carbon monoxide is a potential product which is used to prepare methanol. It is strong reducing agent which prevents metal from rusting. It is necessary to address stability of electrocatalysts related to Faradaic efficiency, current density, and overpotential to implement the electrochemical CO_2 conversion technology in practical. herein, impact of different factors such as electrolyte, electrocatalysts and operating conditions on ERC have been compared. Out of all electrocatalysts that have been discussed, polymeric Co(II) phthalocyanine@graphitic carbon nitride nanosheet electrocatalyst selectively transformed CO2 to CO having Faradaic efficiency of 95 ± 1.8%.

Epsilon-near-zero Response in Magnetron Sputtered Zinc Oxynitride Thin Films

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Abstract

Epsilon-near-zero (ENZ) materials show vanishing permittivity in specific spectral regimes and have gained a lot of research interest because of their outstanding optical characteristics. These materials are potential candidates for numerous applications, such as optical absorbers and nanophotonics. The main objective of current study is to prepare zinc oxynitride thin films using reactive magnetron sputtering for the quest for ENZ behavior. X-ray diffraction analysis displayed the formation of the ZnO hexagonal wurtzite phase of each sample. Field emission scanning electron microscopy revealed that the grain morphology of prepared thin films significantly changes with doping. Optical parameters estimated by spectroscopic ellipsometry (SE) demonstrated a notable improvement in doped compositions; moreover, the measured bandgap of the pure and doped ZnO thin films was found to be reduced with a rise in N content. ENZ behavior was successfully achieved experimentally at higher dopant concentrations. In current work, oxynitride thin film with higher dopant content exhibits ENZ behavior, which could be considered a promising candidate for enhanced optoelectronic applications.

Synthesis and characterization of transition metal oxide nanoparticle by Co-precipitation technique

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Abstract

Nanotechnology and its applications revolutionize every field of life from life sciences to living style. With the advent of nanotechnology, all the industry sectors such as homeland safety, food safety, energy, medicine, transportation, environmental science are improved. Manganese cobalt oxide is being less toxic and used in batteries, energy storage devices and super capacitors. In this study, we will synthesize the nanostructures based on manganese cobalt oxide by using the chemical co-precipitation method. Co-precipitation protocol is very useful to synthesize different nanostructures. It is environmentally friendly and room temperature synthesis method with availability of abundant amount of nanopowder. In this synthesis method, pH dependent reactions take place between the precursors. Cobalt and manganese precursors were used as cobalt and manganese sources. The synthesized nanoparticles were be characterized by using X-ray diffraction, scanning electron microscopy and UV-Vis's spectrophotometer. These techniques help in getting information about crystal structure, morphology and optical properties of the synthesized nanomaterials. Manganese cobalt oxide was prepared by using different concentrations. The XRD result showed that the structure of manganese oxide was cubic and having the size of 11.870001nm, 35.58nm for S_1 and S_2 35.8999nm for S_3 and S_4. The lattice strain for the S_1 and S_2 was o.o192 and 0.064 for S_1 and S_2 respectively and 0.065 and 0.064 for s3 and s4 respectively. The UV visible spectrum of resulted material showed the absorptSion spectrum at 790nm. The scanning electron microscopy showed that the scale length of S_1 is 10, 5, and 5µm and for S_4 5 and 4µm.

Preparation of WSe_2/WO_3 Heterostructure thin films-based Photocatalysts for Hydrogen Generation

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Abstract

Solar-driven hydrogen production by water splitting using a photocatalyst is considered the most effective approach to produce hydrogen. Hydrogen is the most suitable renewable energy source. The efficiency of hydrogen production is still low because of the high recombination rate, poor solar light harvesting ability, and low oxidation dynamics. The efficiency of hydrogen production through photocatalysis can be enhanced by preparing a suitable and efficient photocatalyst. In this work, WO_3/WSe_2 heterostructure-based photocatalysts is prepared by the salinization of WO_3 thin filmsto minimize the high recombination rate by creating the energy gradient between the energy bands, enhance the solar light harvesting ability by making heterostructure of WO_3 with small band gap WSe_2, and enhance the oxidation dynamics by nanostructuring of the prepared photocatalyst. Solar light to hydrogen conversion efficiency of WO_3/WSe_2 – 800 °C is 12 fold higher than the pristine WO_3 thin film.

Ternary metal oxide carbon composite as high-performance electrode material for supercapacitor applications

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Abstract

Ternary metal oxides ZIF 67 have gained attention for supercapacitor electrode material due to high surface area, porosity, chemical stability, tunable properties, redox activity, and eco-friendly material. In this study, metal-organic frameworks (MOFs) derived ternary iron-nickel–cobalt ZIF-67 composite (FeNiCo ZIF-67) is synthesized via co-precipitation method with the variation in molar concentration of FeO, NiO, and CoO and evaluated as the electrode material for supercapacitors. Electrode fabrication has been carried out for these three samples. The porous polyhedral structure of FeNiCo ZIF-67 with different compositions consisting of interconnected nanoparticles is found to play an important role in increasing the charge storage capacity of the material. Several physical methods, including X-ray diffraction (XRD), Raman, energy dispersive X-ray (EDX), transmission electron microscopy (TEM), and X-ray photoelectron spectroscopy (XPS) were used to characterize the morphology, structure, and composition of this material. Electrochemical methods, such as cyclic voltammetry (CV), galvanostatic charge and discharge (GCD), and electrochemical impedance spectroscopy (EIS), were also used to evaluate the fabricated electrode performance. The ternary metal oxide electrode material FeNiCo ZIF-67 (1:2:1) showed superior capacitance, giving a specific capacitance of 532 F/g at a current density of 1 A/g. FeNiCo ZIF-67 (1:2:1) with an electrochemically active surface area of 89.12cm 2 /g could display the material's porous polyhedral structure, which is composed of linked nanoparticles of varying shell compositions. Electrode material demonstrated an outstanding high energy density of 95.88 Wh/kg at a power density of 1.8 kW/kg and retained 91% capacitance after 10000 cycles. This work could provide a simple strategy to fabricate nanostructured ternary metal oxide-based electrode FeNiCo ZIF-67 (1:2:1).

Magneto dielectric Anomalies and Spin Reorientation in Fe_xO_{1+x} (x=2,3) Thin Films-Effects of Microwave oral

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Abstract

Microwave assisted sol-gel route is used to synthesize iron oxide thin films with microwave powers of 180W-1000W. Ferromagnetic response of sol is observed at 360-450W, 630W and 720W powers, while super paramagnetic behavior is obtained at 810W-1000W. Films prepared using sols synthesized at 180W, 270W and 540W exhibit amorphous nature. α-Fe_2O_3 phase is observed at microwave (MW) power of 360W-450W. γ-Fe_2O_3 phase is observed at MW of 630W and 720W and Fe_3O_4 phase is observed at 810-1000W. Highest saturation magnetization of 45.23emu/cm^3, 248.403emu/cm^3 and 419.43emu/cm^3 are observed for α-Fe_2O_3, γ-Fe_2O_3 and Fe_3O_4, respectively. The transition of Verwey in Fe_3O_4 thin film is observed at ~115.2 K while no such variation is observed for γ-Fe_2O_3 phase. Further, α-Fe_2O_3 phase shows spontaneous magnetization at low temperatures from FC/ZFC curves. Highest dielectric constant of ~54.26, 84.19 and 121.34 (log f = 5.0) are observed for α-Fe_2O_3, γ-Fe_2O_3 and Fe_3O_4, respectively. Magneto dielectric coupling (MDC) of ~ -3.9%, -5.1% and -7.8% is obtained for α-Fe_2O_3, γ-Fe_2O_3 and Fe_3O_4 thin films. As Fe_3O_4 phase is found to exhibit peculiar MDC with respect to other phases so the Fe_3O_4 phase reveals exotic magnteodielectric coupling anomalies.

High Surface Area Metal-Organic Framework (MOFS) Derived Mesoporous Carbon As An Electrode For Supercapacitors

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Abstract

Supercapacitors, a pivotal component in modern energy storage systems, has inspired this investigation into the possibility of employing high surface area metal-organic framework (MOFs) derived mesoporous carbon as an electrode material. This study presents the synthesis and analysis of ZIF-67 and mesoporous carbon composites with varying ratios of Zn and Ni. X-ray diffraction (XRD), Raman spectroscopy, Brunauer-Emmett-Teller (BET), Barrett-Joyner-Halenda (BJH), Field Emission Scanning Electron Microscopy (FESEM), Fourier Transform Infrared Spectroscopy (FTIR) and Galvanostatic charge-discharge (GCD), Cyclic voltammetry (CV), Electrochemical Impedance Spectroscopy (EIS) is used for the characterization and electrochemical study of the new material as an electrode in supercapacitor devices. Notably, a remarkable specific capacitance value of 279.2 F/g is achieved. Brunauer-Emmett-Teller (BET) analysis clarifies the mesoporous nature of the materials, with a specific surface area of 228 m^2/g for the 1:1 Zn-Ni ratio composite. Barrett-Joyner-Halenda (BJH) analysis further confirms a pore size distribution centered around 2 nm in the 1:1 sample. These collective findings strongly signify the suitability of the synthesized materials for application in supercapacitors and highlights their promising role in advanced energy storage system.

Fabrication of $Co_xV_{1-X}O_8$ with Sulphur Doped Graphitic Carbon Nitride for Energy Storage Devices

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Abstract

Metal vanadates has received great attention as ideal anode materials for energy storage devices due to high capability of lithium ions storage. However, their low capacity makes them less useful in industrial applications. In order to increase their storage capacity, the $Co_3V_2O_8$ were fabricated with S-g-C_3N_4, a series of $Co_3V_2O_8$@S-g- C_3N_4 nanocomposites were successfully synthesized by single step hydrothermal method. Annealing temperature changes the surface area of the bulk CVO@SGCN samples. The surface morphology and structure of synthesized material were characterized by scanning electron microscopy (SEM), X-ray diffraction (XRD), Fourier transform infrared (FT-IR) spectroscopy. The XRD patterns showed the synthesized is of high crystallinity. The SEM images revealed that CVO@SGCN has a uniform structure with a particle area of ~52 μm. The electrochemical performance of CVO@SGCN was investigated by cyclic voltammetry (CV), galvanostatic charge-discharge (GCD), and impedance spectroscopy (EIS). The CVO@SGCN shows a high discharge specific capacity of 432 mA h g^{-1} at a current density of 1.0 A g^{-1} and 326 mA h g^{-1} at a current density of 2.0 A g^{-1}. Thus synthetic approach provides a solution to enhance the cyclic stability and specific capacity of the electrode for lithium-ion batteries.

Influence of temperature on the magnetic properties and exchange interaction of rapidly quenched La/Ce or LaCe substituted nanocrystalline NdFeB alloys

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Abstract:

The effects of La and Ce substitutions for Nd on the magnetic properties and intergrain exchange coupling interaction of nanocrystalline $(Nd_{1-x}M_x)_yFe_{94-y}B_6$, (M=La and Ce; y= 12; x=0-0.4) alloys have been studied and reported in order to improve room temperature and elevated temperature magnetic properties and reduce the rare earth content for NdFeB based alloys. Optimum magnetic properties such as remanent magnetization M_r, maximum energy product $(BH)_{max}$ and coercivity H_c up to 104 emu/g, 151 kJ/m^3 and 9.0 kOe respectively have been obtained for direct quenched melt-spun single phase $(Nd_{0.95}La_{0.05})_{12}Fe_{82}B$ alloy. The fall in M_r for La/Ce substituted alloys is ascribed to the decrease in saturation magnetization. An unusual increase in H_c for 5% La substituted single phase alloy is speculated to the change in microstructure and magnetic phase separation. Elevated temperature behavior in the temperature range of 300 to 400K was studied for single phase alloys. The elevated magnetic properties with La substitution for Nd are higher compared to Ce substitution at 400 K. The analysis of remanence ratio and recoil loops reveal that La substituted alloys exhibit strong ferromagnetic exchange coupling than Ce substituted alloys due to the increase of exchange length and refine microstructure by La substitution. The present outcomes indicate that partial substitution of Nd by La or Ce leads to numerous change behaviors for magnetic properties at room temperature, elevated temperature and inter-grain coupling.

Designing of Carbon-based Bismuth Vanadate Nanocomposite with Superior Photocatalytic and Anti-Bacterial Activity

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Abstract

To improve photocatalytic performance of materials and address contemporary environmental or energy-related problems, the structure design of semiconductor photocatalysts is crucial. In this work, we create a direct Z-scheme photocatalyst consisting of g-C_3N_4/$BiVO_4$ for environmental photocatalytic application, led by the design principle for direct Z-scheme photocatalytic system. Characterizations are used to thoroughly study the chemical structures, morphologies, and photo- electrochemical characteristics. According to the photocatalytic tests, the degradation performance of the t-g-C_3N_4/$BiVO_4$ Functioned MWCNTS is noticeably better than that of the pure $BiVO_4$. $BiVO_4$ and graphitic carbon nitride (g–C_3N_4) hetero structure was built in order to create a novel, highly active photocatalyst. The 10 % t-g–C_3N_4/$BiVO_4$ composites exhibit noticeably better visible-induced photocatalytic activity in MB degradation for the increased electron and hole transport capacity as compared to the bare g–C_3N_4 and $BiVO_4$. The great structural stability of the composite is demonstrated by the recyclability of the 10 % t-g–C_3N_4/$BiVO_4$ Functioned MWCNTS photocatalyst. The higher adsorption to MB, the heterostructure's stability, and energy level match that promotes charge separation and transport were all credited with the enhanced photocatalytic activities. The ideal 10 % t-g-C_3N_4/$BiVO_4$ Functioned MWCNTS sample degrades 97% of MB in 120 minutes when exposed to visible light, which is significantly more than pure $BiVO_4$. The enhanced photocatalytic performance of g-C_3N_4/$BiVO_4$ can be attributed primarily to its enhanced capacity to utilize visible light, unique morphology, close interface, and effective Z- Scheme type heterojunction production. This work is research based approach to the investigation of g-C_3N_4-based heterojunction photocatalytic materials.

Preparation and Characterizations of Molybdenum Oxide and Reduced MoO_3 Thin Films for Hydrogen Generation

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Abstract

Photoelectrochemical water splitting is a clean and continual method for hydrogen production. Many photoelectrode materials are under consideration for the purpose of getting better conversion efficiency from solar to hydrogen, depending upon their kinetic and thermodynamic requirements. Molybdenum oxide is strongly tunable to dispense optical, electronic and catalytic properties. MoO_3 is auspicious material in many current and emerging technological applications. In this work, MoO_3 thin films were prepared on glass substrate at various temperatures in vacuum and also in oxygen environment by using the physical vapor deposition and chemical vapor deposition technique respectively. It is noticed that the band gap of MoO_3 thin films was decreased by increasing the annealing temperature. SEM results showed the nanowires like structure in oxygen ambient at 500°C. Annealing in vacuum entirely changed the morphology which turned into flower like structure and formation of nanoneedles on this structure. The annealed films have better photocurrent response as compared to as-deposited MoO_3. The solar to hydrogen conversion efficiency STH% of oxygen-annealed MoO_3 at 500 °C is higher than pure MoO_3.

Ground state energy of hydrogen atom using shooting method

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Abstract

In this study, we focus on the radial part of the Schrödinger equation for hydrogen atom. The potential for hydrogen atom is coulomb potential and we'll work in center of mass frame of reference. To determine the solution of radial Schrödinger equation, we use a numerical technique named "shooting method" paired by bisection method to calculate the ground state energy of hydrogen atom. We use a mathematical software Mathematica to find the ground state energy. Then this energy is used to calculate the reduced mass of hydrogen atom. This technique can be used further for the spectroscopy of mesons to find their ground state and excited state energies and their masses.

Galactic Transonic Winds with Cosmic-rays and Waves

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Abstract

Cosmic rays are energetic charged particles and their transport plays an important role in the feedback processes in the interstellar and intergalactic medium. Cosmic rays couple to plasma via hydromagnetic waves which could in turn to be excited by cosmic ray streaming instability. Cosmic rays and waves can modify the plasma flow via their pressure gradient. We are interested in cosmic ray driven galactic winds. Our system comprises thermal plasma, cosmic rays and one forward propagating self-excited Alfven wave. Possible steady flow solutions in divergent flux-tube formulation is presented. Understanding the behaviour of sonic points in astrophysical accretion flows is crucial to understand. In this study, we employ a sophisticated three-fluid model implemented in MATLAB to investigate the impact of mass flux variations on sonic points under the galactic potential well. Our analytical results incorporate thermal plasma, cosmic rays and Alfven waves pressure components, allowing for a comprehensive examination of the stability of the sonic point near the base of the potential well. By systematically varying mass flux parameters, we elucidate the intricate interplay between different pressure sources and mass accretion rates, shedding light on fundamental aspects of accretion disk dynamics. Our findings offer valuable insights into the mechanisms governing energy release, outflow generation, and observational signatures of astrophysical accretion phenomena. This study highlights the utility analytical results with a three-fluid model in MATLAB for advancing our understanding of accretion processes in extreme astrophysical environments.

Theoretical study of structural properties of KMO 2 (M = Sm, Tb, Dy) for spintronics applications.

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Abstract

The structural and electric characteristics of potassium-based rare earth oxides are discussed in this paper. The density functional theory (DFT) is based in a full-potential linear augmented plane wave plus local orbital (FP-LAPW+lo) system within Wien2K software was used; for the exchange correlation energy, (PBE+GGA) approximation was carried out. Crystal structural of these materials have a hexagonal form within a space group (166 R-3m). The volume optimized graph results depicted that studied compounds are more energetically stable in ferromagnetic states than in anti-ferromagnetic and non-magnetic states. Moreover, spin polarize band structural and density of state DOS of studied materials shows metallic and semiconductor nature for corresponding spin channels. Therefore, studied materials have half metallicity nature with 100% spin polarization at fermi energy.

Photoluminescence Response and Magnetic Character of Iron Doped Ceria Thin Films

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Abstract

The application of iron doped Ceria (CeO_2) thin films in optoelectronic devices has drawn the interest of the research society. Iron (Fe) doped Ceria thin films are fabricated via an application-focused sol-gel technique. The variations of Fe dopant concentration range as 0.0, 0.02, 0.04, 0.06 and 0.08. At all dopant concentrations, the production of a pure cubic phase of CeO_2 is confirmed by an analysis of X-ray diffraction (XRD). Because of the increased crystallinity of thin films, an increase in dopant concentration is correlated with an increase in crystallite size. Mixed para-ferro behavior is observed at undoped condition. All dopant concentrations exhibit soft ferromagnetic behavior. Photoluminescence (PL) spectrum has been used to study the shallow electronic defect levels. Tangent loss and the dielectric constant exhibit normal behavior. Cole-Cole plots have a single semicircle, which denotes a high degree of grain boundary resistance. In conclusions, Fe doped ceria thin films proved to be promising candidate for optoelectronic devices.

Deposition of materials using plasma devices

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Abstract

The lecture is an overview of diverse film deposition techniques utilizing various plasma devices is presented. The presentation describes the deposition of hard films employing a dense plasma focus device which is a pulsed source of high-energy ions. We also employed a magnetron sputtering device for depositing semiconductors tailored for applications in photo-detection and optical properties. We used the unique approach of employing a discharge under water to fabricate nanoparticles, showcasing the versatility of plasma-based methodologies in material deposition.

Galactic Winds in Variable Geometries

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Abstract

The movement of gas, in the form of ionized or neutral particles, away from a galaxy into its surrounding intergalactic or interstellar medium makes up the galactic outflows. These outflows emerge from the galactic Centre, perpendicular to the galactic rotational axis, and can acquire different morphologies depending on the energy inflow rate. These outflows can be divided categorically into three geometrical structures i.e. constant flux tube, divergent and extreme divergent flux tubes. In the gravitational potential well of a galaxy, the behaviour of outflows has been studied in these geometries. We approach the outflows system using the hydrodynamic model. This model treats the gas components (cosmic rays, thermal plasma & Alfvén wave) as fluids having different pressure profiles, and also describes various interaction mechanisms among them. The solution of the system is divided into three branches, supersonic, subsonic, and unphysical solutions. But we are particularly interested in the transonic solution, a solution that evolves from subsonic to supersonic. The point at which the solution shifts from subsonic to supersonic is known as the sonic point. First, we consider only thermal plasma outflows and explain their evolution in different geometries, followed by the addition of cosmic waves and Alfvén waves. After discussing three fluid outflows in different structures, we compared the results of thermal outflows with three fluid outflows and articulated how the addition of waves in the system affects the dynamics of the system. Initially, we chose a simpler (Kuzmin) gravitational potential, but later we adopted a complex potential model (Miyamoto & Nagai) to account for different mass distribution in the galactic bulge and disk, thus inferring the shift in the sonic points position subjected to change in the potential strength.

Facile Assembly of Graphite-on-Paper based Strain Sensors for Security Applications

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Abstract

Here we report the fabrication of graphite pencil coated cellulose paper-based strain sensors with notable sensitivity. Pencil drawing method is employed to apply the graphite coating on paper- substrate. SEM and EDS analyses of the samples are performed to respectively study the surface morphology and elemental compositions of the samples. Later, the graphite-coated cellulose paper is cut into pieces with a size ~4×4 cm^2 , and thinner copper wires are attached to it along two opposite edges of the sample. Bending strain is provided on the sensor which causes variations in resistance of the sensor. The sensor delivers an exceptional sensitivity of 122,701 and faster response of 0.59 s. The sensor is pasted on a door at its axis of motion for which it gives response as the door is moved. The findings show that the fabricated sensor could be worthful for variety of security applications involving the physical deformations and bending movements.

Biodistribution of Iron Oxide Stabilized 99m Tc-ZrO_2 Nanoparticles in Rabbit Using Honey as a Capping Agent

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Abstract

Tumor identification and therapy is one of the most pressing biological issues confronting the world today. This illness has the potential to cause a catastrophic outbreak with higher fatality rates. As a result, advanced tools/methods for prompt tumor diagnosis are required in this era. The current work aims to assess the cytotoxicity and biodistribution of iron-oxide-stabilized zirconia (IOZH) nanoparticles capped with honey. The biodistribution of nanoparticles in rabbits is used to examine in vivo-targeted diagnostic uses of stabilized ZrO_2 nanoparticles. The microwave-assisted sol-gel process is used to synthesize nanoparticles (NPs). Microwave radiation powers (100-900 W) are modulated to synthesize stabilized zirconia NPs. During synthesis, honey is used as an organic capping agent. Without any additional heat treatments, structural data show the development of a stable tetragonal phase of zirconia at 700 and 900 W. Stabilized zirconia samples have a smaller crystallite size of 20 nm. At 700 and 900 W, pure tetragonal phase exhibits higher X-ray density. Zirconia produced at 900 W has a high dielectric constant (55.8 at log f = 4) and a low tan loss. Magnetic studies demonstrate that the materials produced at 700 and 900 W are superparamagnetic. In normal rabbits, radiolabeling and biodistribution of iron-oxide-stabilized zirconia nanoparticles with technetium-99m are examined. It is worth noting that research on high-yield effectiveness and stability, as well as biodistribution and scintigraphy, have been conducted. The high absorption of radiotracer in rabbit bladder is discovered to be a viable candidate for its usage in tumor therapy. Urination and physical properties of rabbit, after the post injection of nanoparticles, are checked periodically for many months and found normal.

Preparation and Characterization of Fe and Cr co-doped ZnO by Sol-gel Method

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Abstract

Fe and Cr co Doped ZnO thin films have attained the attention of research community because of its application in spintronic devices. An application-oriented sol gel method is used for the preparation of Fe and Cr co doped ZnO thin films. Dopant concentration of Fe and Cr is varied as 1wt%, 2wt%, 3wt%, 4wt% and 5wt%. Structural, and magnetic properties are obtained with the help of X-ray diffractometer (XRD), and vibrating sample magnetometer (VSM). Slight shift of peak positions to higher diffraction angles in XRD indicates that the dopant has been successfully incorporated in the host lattice. As the dopant concentration is increased to 5wt%, diffraction peaks corresponding to iron oxide phase emerge thus distorting the crystal structure of ZnO. VSM results show soft ferromagnetic behavior for all of the synthesized samples. Dielectric constant and tangent loss show normal dispersion behavior. Cole-Cole plots show single semicircle indicating high resistance of grain boundaries. In conclusions Fe and Cr co doped ZnO thin films proved to be promising candidate for spintronic devices.

Structural and Dielectric Properties of $MgFe_2O_4$ Nanoparticles

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Abstract

Magnesium iron oxide nanoparticles have sparked the interest of scientists due to their possible applications in spintronic devices. The hydrothermal technique is used to prepare Magnesium iron oxide nanoparticles with varying molarity as 0.1M, 0.2M, 0.3M, 0.4M & 0.5M. The prepared samples are characterized by X-ray Diffractometer (XRD), Vibrating Sample Magnetometer (VSM) and Impedance Analyzer. Mixed phases of ($MgFe_2O_4$ + Fe_2O_3) are observed for 0.1M, 0.2M and 0.5M. Whereas, cubic MgFe2O4 phase is observed at molar concentration of 0.3M and 0.4M. The highest value of crystallite size i.e. 19.5 nm with lowest value of dislocation density and strain are observed for the pure magnesium iron oxide nanoparticles cubic phase at 0.4M. M-H loop exhibits the soft-ferromagnetic behavior for all the samples. Dielectric constant and tangent loss show normal dispersion behavior. Cole-Cole plots show single semicircle indicating high resistance of grain boundaries. The magnesium iron oxide nano powders can be used as potential candidate in spintronics and data storage devices.

Investigation of Curie Temperature, Ferroelectricity, Spin Polarization, and Transport Properties in $BiFeO_3$ for Spintronic and Electronic Applications

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Abstract

Double perovskites (DPs) are now attractive options for spintronic applications because of their multifunctionality and intrinsic stability. We present a brief review of our investigation into the effects of 5d-electrons in BiFeO3 on ferroelectricity and thermoelectric behavior. The ideal values of the phonon dispersions, formation energy, and tolerance factor are reported in the study, explaining the lattice dynamic, thermodynamic, and structural stabilities. We emphasize the high Curie temperature and spin polarization in BiFeO3, using spin density calculations and the Heisenberg model. For both spin up and spin down configurations, the ferroelectric behavior is fully explained by analyzing metallic and insulating channels taking hybridization, exchange energies, and exchange constants into account. The ferroelectric connection is established via electron spin exchange rather than clustering, as demonstrated by the redistribution of magnetic moments from Fe and Bi sites to adjacent O sites and interstitial places. Additionally, the study explores the influence of thermoelectricity on electron spin degree and uses the BoltzTraP code to characterize transport parameters. Through investigating the relationship between ferroelectricity and transport properties, this research adds significant understanding to the possibilities of $BiFeO_3$ in spintronic applications.

Energy dependence of laser Wakefield accelerated electron beams on the dopant gas

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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.

Improved Performance of Metal Oxide based MSM Photodetectors by Annealing treatment

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Abstract

Metal-semiconductor-metal (MSM) photodetectors are fabricated by depositing two metal contacts on a semiconductor. Metal Oxide semiconductors are considered to be potential candidates for the fabrication of such devices due to their ease of fabrication, high current gain, large responsivity, and fast response. These photodetectors exhibit a wide range of commercial and civil applications in the field of optical communications, pollution monitoring, and missile plume detection. These can be used in monitoring UV radiations that are harmful to human beings. Also, these can be employed in various electronic circuits. This work presents the fabrication and characterizations of metal oxides-based MSM photodetectors. Metal oxides films (such as MoO3, ZnO, and CuO) were deposited on silicon substrate using magnetron sputtering technique and were subsequently annealed at different temperatures to obtain optimum physical properties. The MSM photodetectors were fabricated by depositing metal contacts on these films using an interdigitated mask. The fabricated devices exhibited high sensitivity and responsivity under the exposure of light having wavelength corresponding to the band gap of the films.

Energy materials and Resource recovery-A pathway for sustainable development

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Abstract

Since the industrial revolution the climate issues especial global warming has been increased because of greenhouse emission which leads to the many concerns all over the world. The CO_2 has the major contribution among other greenhouse gases. Secondly, the speedy consumption of Li-Ion batteries (LIBs) for portable smart devices i.e. Laptops, Tablets, cell phones and electric auto mobiles give rise to increased number of discarded batteries. Discarded LIBs involves poisonous chemicals and hazardous heavy metals that cause a significant menace to ecosystems. Therefore, the recycling process of LIBs is very essential now days. There is huge potential for recovery and recycling of materials such as batteries, solar cells, etc. in Pakistan. Waste and resource recovery can become a major industry that promotes employment and positive investment in the economy. It has been also reviewed that the country would greatly benefit from clean energy devices e.g. Fuel Cells and Fuel cell hybrid system (environmentally friendly technology), which could be the best solution for electricity production as well for automobile industry. This provides the high performance for the electrochemical energy devices e.g. fuel cells and solar cells with ultra-low cost, which practically provides sustainable energy for many sectors while decreasing CO_2 emission. Therefore, fuel cell technology offers a great opportunity to meet the demand of energy and for the sustainable development of Pakistan.

Two-dimensional mapping of laser-induced Mg plasma parameters along with self-generated electric and magnetic fields

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Abstract

An optical-field ionized plasmas produced by intense laser pulses are an excellent candidate for studying Weibel-type instabilities and laser wake-field accelerators because uniform under dense plasmas and predictable temperature anisotropies can be formed during the ionization process. Two-Dimensional mapping of laser-induced Mg plasma parameters along with Self-Generated Electric and Magnetic Fields (SGEMFs) has been performed. The plasma was generated by irradiating Mg target with Nd: YAG laser (532 nm, 10ns, 10Hz) under vacuum condition. For the used laser irradiances (1.8 GW/cm^2 to 4.5 GW/cm^2), axial distances (1cm - 4 cm) and a corresponding fixed radial distance of 2 cm, the minimum and maximum of evaluated ion number densities (n_i) and electron number densities (n_e) vary from 0.1 x 10^{13} cm^{-3} to the 1.9 x 10^{13} cm^{-3} and from 0.5 x 10^{12} cm^{-3} to 6 x 10^{12} cm^{-3} respectively. The density of ions exceeds that of electrons in axial direction whereas, n_e dominates in the radial direction. The ion and electron kinetic energies vary from a minimum of 0.1 keV to the maximum of 13 keV and 0.03 eV to 7.5 eV respectively. More energetic ions are detected at axial position whereas, more energetic electrons are detected at radial positions. The quadrupole structure and electronic currents in plasma are considered responsible for SGEMFs. The magnitude of SGEF and SGMF vary from 0.3 V/cm to 20 V/cm and from 978 Gauss to 3300 Gauss respectively. Higher values of SGEF are observed in region of higher n_i (axial), whereas, spatial positions exhibiting higher values of n_e corresponded to higher magnitude of SGMF. Moreover, a linear dependency of magnitude of SGEMFs on ∇n_e uncovers the importance of this correlation for useful possible applications of plasma in wake field accelerators.

Femtosecond laser-induced surface structuring of Titanium and Stainless-Steel alloys for biomedical implant

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Abstract

Biomedical implants have revolutionized the field of medicine, providing patients with life-changing interventions that improve their quality of life. They are used to replace or support damaged or lost tissues and organs, e.g. hip, knee and dental implants. Biomedical implants are typically composed of metallic alloys, which provide the essential properties of strength, durability and biocompatibility. However, surface modification of these alloys is required to improve their bioactivity, osteointegration and decrease bacteria adhesion. Femtosecond laser-induced surface structuring has emerged as a promising technique that can produce precise and well-controlled micro/nano surface structures on metallic alloys. The biocompatibility and bioactivity of biomedical implants depend on their surface properties such as roughness, wettability, and chemistry. Therefore, laser-induced surface structured materials are highly beneficial for cell adhesion, biological fluids spreading, osseointegration and the strength of the implant-bone joint. Today, stainless steel, titanium and titanium alloys, tantalum, CoCr-based alloys and biodegradable magnesium alloys are the metallic materials used successfully in orthopedic, dental, and in a variety of other biomedical applications. Ti-based alloys have outstanding tensile strength, better corrosion resistance, high specific strength, rigidity, fracture toughness, and biocompatibility which make them appropriate for bone replacement. Whereas, stainless-steel is a group of ferrous alloys made up of iron metal which shows good resistance to corrosion, superior mechanical strength, including high tensile and elastic strength. In the present research work, two metallic alloys i.e. Ti-alloy (Ti6Al4v) and stainless steel (SS-314) will be treated by femtosecond laser to grow variety of micro/nano structures on the surface of the metallic alloys, resulting in a significant increase in surface area, roughness and mechanical strength. Ti: Sapphire laser with 800nm wavelength, pulse duration of 100 fs and pulse energy ranging from µJ to mJ will be employed as an irradiation source under the ambient environment to modify the metallic surface structure.

Investigating the Structure of Cosmic-Ray Modified Shocks: A Hydrodynamic Study

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Abstract

Cosmic rays are the energetic charged particles and their transport plays an important role in the feedback processes in the intergalactic as well as interstellar medium. Cosmic-ray modified shock structures are caused by the interactions between thermal plasma and cosmic rays. This model encompasses cosmic rays, thermal plasma, and forward/backward propagating self-excited Alfvén waves. We refer this model as four-fluid (MHD) hydrodynamic model. In this contribution we are highlighting the several energy exchange mechanisms which are responsible for cosmic-ray modified shocks noted as stochastic acceleration, cosmic ray streaming instability, advection, and diffusion. We are interested to apply this model to understand the mechanisms behind the cosmic ray's acceleration within shock environments, particularly in supernovae. By comparing theoretical predictions with observational data, we aim to bridge theoretical understanding with empirical evidence, shedding light on fundamental astrophysical processes and their implications for cosmic ray astrophysics.

Assimilation of Emerging Physics Perceptions in Forensic Science

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Abstract

This abstract investigates the elementary merging of physics concepts within forensic science, featuring their critical involvements across different forensic disciplines. Ballistics is itself a physics from the manufacturing of firearms to the comparison of bullets to the weapon. Physics is the substrate to build the ballistics in all the fields of ballistics like internal, external and terminal ballistics. Physics plays its role as the backbone for precise analyses in ballistics, trajectory analysis, shooting scene reconstruction, helping in firearm examination and the confirmation of firearm signatures necessary for firearm identification. Forensic Physics helps in calculating the estimated energy liberate by the blast concerning to the shockwave. Moreover, fluid dynamics laws shed light on bloodstain pattern examination, permitting the decoding of complicated blood spatter patterns to disclose particular insights into crime scene dynamics, like angles of impact and crime scene reconstructions. In vehicle collision scene reconstruction, the uses of Newtonian mechanics permit for an overall examination of vehicular accidents, integrating the evaluation of vehicle kinematics, collision dynamics, and the finding the causality by comprehensive examination of physical evidence. Furthermore, forensic science influences physics to inspect structural morality, conclude fire dynamics and identify root causes of collapses, therefor motorized in finding fire origin and transmission mechanisms. Moreover, cosmopolitan physics-based methodologies like spectroscopies and different microscopies improve trace evidence analysis, permitting the interpretation of material composition and the insight of split-second evidentiary traces. The General integration of physics laws within forensic science permits scientific obstacle, accuracy, and impartiality and objectivity in crime scene analysis, reconstruction of crime scenes, and physical evidence illustration. This collaboration cultivate upgradation in forensic methodologies, eventually enriching the effectiveness of criminal investigations.

Tuning the Multiferroicity of BFO with Potential Dopants

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Abstract

Energy storage devices play a vital role in modern technology. A single device can perform multi-functions if fabricated using a multifunctional material like $BiFeO_3$. For this purpose, a series of La and Cr doped $BiFeO_3$ was synthesized using a cheap and popular technique named sol-gel auto combustion. Urea and glycine were used as chelating agents to ignite and robust the combustion process in order to improve the purification of the residue. A single phase rhombohedral distorted perovskite crystal structure related to bismuth ferrite with space group R3c (161) was confirmed from the X-ray diffraction patterns. Doping of La/Cr at Bi/Fe lattice sites in $BiFeO_3$ did not affect the crystal symmetry of the parent compound. Analysis of surface morphology of all the samples through field emission scanning electron microscope exhibited homogeneous micro structures showing uniform distribution of multi-shaped grains as well as a decreasing trend in porosity and grain sizes with increasing Cr contents. The energy dispersive X-ray spectrum of each composition depicted all the elements in accordance with its stoichiometric formula. Enhanced saturation magnetization was observed with increasing doping concentration in the parent compound. Improved polarization versus electric field loops were observed in Mn and Sr co-doped $BiFeO_3$ nanoparticles. All the properties in the present research work have been explained on the basis of dopants and their concentrations, phase purity, microstructures and grain sizes.

J/ ψ -J/ ψ scattering cross sections of quadratic and Cornell potentials

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Abstract:

We study the scattering of J/ ψ -J/ψ mesons using quadratic and Cornell potentials in our tetraquark (cc) system. The system's wave function in the restricted gluonic basis, which is written by utilizing the adiabatic approximation and Hamiltonian, is used via a quark potential model. The resonating group technique is used to obtain the integral equations, which are solved to obtain the unknown inter-cluster dependence of the total wave function of our tetraquark system. T-Matrix elements are calculated from the solutions, and eventually, the scattering cross sections are obtained using the two potentials. We compare these cross sections and find that the magnitudes of the scattering cross sections of quadratic potential are higher than the Cornell potential.

KYAMOS Multiphysics Software: Instant, Real Live Simulations of Green Technologies

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Abstract:

In this presentation, KYAMOS, an innovative multiphysics engineering software company that specializes in High Performance Computing (HPC) using InfiniBand GPU, will be presented. The session will provide an overview of KYAMOS vision and mission, along with its targeted focus within the Computer Aided Engineering (CAE) industry. Various state-of-the-art technologies in HPC encompassing both software and hardware, including innovative mathematical algorithms, numerical methods, and practices for parallel distributed computing, will be highlighted. The utilization of parallel libraries combined with in-house practices to optimize computational performance will be presented. This session will also describe KYAMOS' team, projects, and achievements, such as funding. The various applications of green technologies will be discussed, such as wind turbines, batteries, electromagnetics, radio frequency filters, thermal, semiconductors and oil spills. The deployment of Artificial Intelligence in the CAE market and its potential impact on producing high-fidelity instant, real live results, will be explored. Moreover, the development of InfiniBand GPU servers, encompassing cost analysis, capabilities, power consumption and tradeoffs will also be discussed. The presentation will also cover the development and characteristics of a Graphical User Interface (GUI) and the innovation behind translating the choices of the user to meaningful programming code through the usage of an interpreter. Finally, the future industry trends, such as digital twins, the 4th industrial revolution and the potential impacts of quantum computing will be presented.

Synthesis and Characterization of $Cr_xV_{1-x}O@S\text{-}g\text{-}C_3N_4$ composites for Supercapacitors

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Abstract:

The escalating demand for supercapacitors as energy storage devices and the superior electrochemical characteristics of metal oxide have prompted a comprehensive analysis of Chromium vanadate and its composite with Sulphur-doped graphic carbon nitride for Supercapacitor applications. The present study synthesizes CrVO4 and composite CrVO4@S-gCN using a simple one-pot hydrothermal method and evaluates their structural, morphological, and electrochemical characteristics using techniques such as XRD, SEM, Cyclic Voltammetry (CV), Electrochemical impedance (EIS), and Cyclic Charge Discharge (CCD). Analysis of the XRD spectra of the CrVO4 sample reveals that the synthesized nanocrystallites fall under the orthorhombic structure. The CV, GCD, and EIS measurements were performed in an aqueous 3M KOH electrolyte, and the CrVO4-based electrode exhibits an impressive specific capacitance of 554.035F/g at a current density of 1A/g. On the other hand, the composite CrVO4@S-gCN- based electrode displays a specific capacitance of 717F/g at 1A/g current density. This increase in specific capacitance is attributed to the augmentation of surface area and porosity by adding Sulphur-doped graphic carbon nitride. Furthermore, the EIS plots demonstrate excellent conductivity and minimal charge transfer resistance of the parent sample and composite. Therefore, we conclude that CrVO4 and its composite are suitable electrode materials for fabricating Supercapacitor devices, owing to their exceptional electrochemical properties.

Knowledge is in many things and can have many different garbs and can have many different directions and dimensions but the knowledge that is gained by seeking the truth and knowledge that comes out of the pursuit of truth, unbiased, unprejudiced, based upon crystalline reasoning and logical understanding and rational thinking is the one that we care for and we should value. So knowledge is actually consisting of truth and nothing but truth.

(Dr Hasan Sohaib Murad)