SAIP2025

Monday 7 July 2025 - Friday 11 July 2025

University of the Witwatersrand, Johannesburg

Book of Abstracts

Contents

Astrophysics & Space Science / 7

Exploring the correlations between galaxy properties and environment in the large-scale structure of the Universe

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Galaxies are gravitationally bound systems composed of stars, gas, dust, and dark matter. Various galaxy properties—such as luminosity, stellar mass, and star formation rate—are significantly correlated with their local environment, such as whether they reside in dense clusters or more isolated regions. Understanding these environmental correlations is crucial for studying galaxy evolution within the large-scale structure of the universe. Traditionally, such studies rely on local density measurements defined at a specific separation scale around galaxies. However, to fully capture the impact of environment, it is essential to examine correlations across a wide range of scales. This approach helps investigate environmental effects that operate at different scales while minimising the impact of an arbitrarily chosen density estimation scale.

In this talk, I will demonstrate how marked correlation functions effectively trace the environmental correlations of various galaxy properties as a function of separation scale. I will present results from our studies on the correlations of luminosities (from optical to mid-IR bands), stellar mass, and star formation rate with local environment. Additionally, I will show how marked correlation functions offer advantages over traditional two-point correlation functions in probing the environmental dependence of galaxy mergers. Our analysis is based on stellar-mass-selected, volume-limited galaxy samples from the Galaxy And Mass Assembly (GAMA) survey. We also compare our measurements from GAMA with those from CosmoDC2, a simulated sky catalogue designed for the Rubin Observatory LSST Dark Energy Survey Collaboration. Finally, I will present our recent results on the environmental correlations of low-surface-brightness galaxies (LSBGs) identified in the Dark Energy Survey and North Ecliptic Pole Wide field.

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None

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Poster Session / 9

Novel Eye Goggle Configuration Icterometer For Neonatal Jaundice Screening in Low Resource Settings

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ABSTRACT
Neonatal jaundice, also known as neonatal hyperbilirubinemia, is a common condition among newborns in the first week after birth. Notable, it is a leading cause of death and disability for newborns in low-resource nations, including Southern Africa nations. Persistent challenges due to inadequate, inefficient or financially inaccessible diagnostic alternatives for its management in resource-constrained settings leads to ongoing and unacceptable rates of morbidity, disability and mortality. Therefore, a need exist for low-cost low-tech diagnostics means for neonatal jaundice screening in low resource settings. Here, we present preliminary result with a novel eye-goggle configuration icterometer for neonatal jaundice screening exploiting the yellow discoloration of the sclera, effectively avoiding the interference effects of melanin in skin color determination. For in-situ real-time visual assessment of the eye sclera color, the eye-google configuration icterometer integrates a color card. Verification of visual assessment is by image analysis involving processing the pixel colour values of the sclera to predict the total serum from the digital photographs of newborn infants'eyes. We envisage the screening tool will be useful in meeting the need to improve referrals from home, community or peripheral health centers to higher-level facilities with capacity for bilirubin testing and/or phototherapy.

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None

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Poster Session / 11

Probabilistic Risk Assessment for Calculating Health Effects Associated with a Potential Nuclear Accident in the Vicinity of a Nuclear Facility

Author: Mbulelo Dondolo[None]

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The study aims to presents the results of a probabilistic risk assessment that was conducted to replicate the MACCS code model and data analysis typical of the South African Nuclear Power Plant (NPP) environment. This was done to determine the potential atmospheric release and consequence of radioactive material for postulated severe accident case based on current NPP configuration. This work was done to aid the South African nuclear regulator to perform independent verification of the code that is employed by the nuclear licence holder. The MACCS code was successfully customised to perform probabilistic risk assessment and the approach and the procedure that can be followed in this development has been fully described elsewhere. Some of the discerning specific data used to perform the assessment included source term, meteorological dataset, site dataset, and other important plant specific datasets to complete the full scope of the Level 3 probabilistic risk assessment.
Radiation exposures and health issues following a nuclear accidents and emergency procedures are of great concern to the public and to the local authorities tasked with emergency preparedness and response with ensuring public health, safety, and well-being. The study presents the results of off-site consequences due to radiation release from a typical NPP sited in South Africa. The analysis of implementing the protective measures to counteracts the health effects anticipated was also taken into consideration. Therefore, the study outlines the full assessment that is done in anticipation and to counteract the risk associated with the release of radioactive material by the aforementioned NPP during postulated severe accident scenario resulting in radiological releases to the site and environment.

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PhD

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Poster Session / 14

A computational fluid dynamics study of turbulence flow in a heat-pipe-heat exchanger for application in micro reactor

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Co-authors: Emmanuel Igumbor [1]; Johann Slabber [2]; Mbolahasina Ralijaona [1]; Simon Connell [1]

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High Temperature Reactors (HTRs), particularly the very high temperature reactor (VHTR), represents a significant advancement in nuclear reactor technology. Reactors operate at temperatures exceeding 1000 ℃, which enhance the thermal efficiency and allow the potential for hydrogen production through thermochemical processes. In a VHTR, the generated impurities in the helium coolant can lead to an environmental degradation of high-temperature alloys used in the reactor. These impurities, which may include water vapor and carbon compounds, can cause oxidation, carburization, or decarburization of the alloys. The heat pipe heat exchanger (HPHE) is a specific solution that can be implemented to eliminate the tritium contamination to enter the secondary cycle by balancing the temperature equilibrium between the hot and cold fluids in the micro reactor. Computational fluid dynamics (CFD) numerically solves the Navier-Stokes equation and predicts the thermal energy transfer in the HPHE. In this study we compared the performance of the HPHE based on the five different turbulence models, offering valuable insights into their accuracy and reliability in predicting the flow and temperature distribution of a HPHE. Results show that the k-ω model has the most comprehensive temperature range, where He has been reduced from 1000 K to 593 K and air increased from 403 K to 723 K. The k-ω Standard turbulence model (STD) is suitable for wall bounded flows with high Reynolds number flows and Shear stress transport (SST) is a hybrid model which combines the strengths of K –epsilon (k-ε) and k-ω transition models showed a higher turbulence kinetic energy values. While the Reynolds stress showed lower turbulence kinetic energy, the Large Eddy Simulation is computationally expensive. While all the turbulence models can influence heat transfer and thermal equilibrium in a HPHE, the k-ω improve the rate of heat convection in a HPHE. The results of this study highlight the importance of turbulence model selection in accurately predicting the HPHE performance in a micro reactor. Furthermore, valuable insights for optimizing heat exchanger design in VHTR using CFD is provided.

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MSc

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Photonics / 15

Comparative Theoretical Analysis of Entangled Quantum States for Enhanced Sensing Application

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Quantum sensing leverages the distinct characteristics of quantum states to surpass classical measurement precision limits. We propose a theoretical study which provides a comparative analysis of various entangled quantum states, specifically NOON states, twisted NOON states, entangled coherent states, and BAT states, for advanced sensing applications. We evaluate each state's phase estimation precision, and robustness to noise and decoherence. NOON states offer remarkable phase sensitivity but face significant challenges with photon loss and decoherence. Twisted NOON states introduce angular momentum modes, potentially enhancing sensitivity and noise resistance in structured sensing scenarios. Entangled coherent states provide flexibility with adjustable amplitudes and resilience to photon loss, while BAT states balance enhanced sensitivity with improved noise tolerance through hybrid quantum states. The comparative assessment includes theoretical noise modeling and considers losses to the environment.

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None

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Photonics / 16

Nanoformulation of Pheophorbide-a for Photodynamic Therapy in a Human Lung Cancer Spheroid Model

Author: Kave Moloudi[1]

Co-authors: Blassan George [1]; Heidi Abrahamse [1]

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Pheophorbide a (PPBa) is a natural compound derived from chlorophyll, and its photophysical and photochemical properties makes it useful as a photosensitizer for photodynamic therapy (PDT). However, PPBa stability in biological environments and its bioavailability are crucial for effective therapy. Nanoparticle formulation of PPBa can improve its solubility and stability. The aim of this study is to make use of liposomal nanocomplex of PPBa as photosensitizer in PDT (at 15 J/cm2 fluency) on A549 spheroid cells. Thin-film hydration method was used for synthe-sis of NPs. Characterization of Lipo@PPBa were carried out using UV-Vis spectroscopy, TEM, SEM, FTIR and DLS. Moreover, cytotoxicity of NPs was evaluated at various concentrations via MTT assay. The IC50 dose was calculated for the evaluation of phototoxic effects under 660 nm laser irradiation at 15 J/cm2. UV-Vis spectroscopy showed a specific peak at 220 nm for lipids and two peaks for PPBa at 400 nm and 670 nm, respectively. TEM and SEM images il-lustrated that the size and shape of NPs were 45 nm and wavy crest, respectively. DLS data showed that the NPs have positive surface charge with zeta potential of 25 mV. MTT assay indicated that IC50 of Lipo@PPBa nanocomplex in PDT was 1 μM, which reduced the cell via-bility to 48%. In conclusion, Lipo@PPBa showed significant phototoxic effects on A549 sphe-roid cells. However, more investigations on targeted therapy using Lipo@PPBa is recommend-ed.

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PhD

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Poster Session / 18

An anomaly in a formula to calculate the refractive index of Al_xGa<sub x</sub>As

Author: Japie Engelbrecht[1]

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A formula to calculate the refractive index n of Al_xGa_{1-x}As was proposed by Adachi in 1985. This formula takes into account the variation of the band gap E_g of Al_xGa_{1-x}As as function of the Al mole fraction x. Consequently there are two equations for the calculation of the band gap, viz. for x less than 0.45 and x from 0.45 to less than 1. The refractive index is used to calculate the thickness of epilayers of Al_xGa_{1-x}As grown by metallorganic vapour phase deposition, whereafter infrared reflectance spectra were obtained from respective samples with various mole fractions. The mole fraction x can also be obtained from the reflectance spectra. When calculating the required refractive indexes, the applicable equation for the band gap should be used depending on whether x is less than 0.45 or whether x is greater than 0.45 but less than 1. An anomaly was observed when the epilayer thickness was calculated using the formulation of Adaci, and results will be presented to demonstrate the anomaly.

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None

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Nuclear, Particle and Radiation Physics-1 / 19

Radiological health risk assessment of powdered and liquid milk in South Africa: A study on activity concentration levels of 226Ra, 238U, 232Th, 40K and 137Cs

Authors: Samuel Odumu Ogana JOHN[1]; Stephen Friday OLUKOTUN[2]; Tebogo Gilbert KUPI[2]; Manny MATHUTHU[3]

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Our natural environment is endowed with natural radioisotopes to which humans are exposed through the ingestion of foodstuffs with consequent health implications. In this study, an assessment of the radioactivity levels in powdered and liquid milk available in South Africa was conducted to evaluate their associated radiological health risks. Both natural radioactivity sources such as 226Ra 238U, 232Th and 40K, as well as artificial radionuclides like 137Cs, were analyzed using gamma-ray spectroscopy. A total of twenty-eight frequently consumed milk samples were collected from the groceries stores in South Africa and measured using a high-purity Germanium detector. The results revealed varying levels of radioactivity in the milk products, with mean values of 29.940 ± 3.571 Bq/kg for 238U, 33.803 ± 4.655 Bq/kg for 226Ra, 29.508 ± 5.245 Bq/kg for 232Th and 573.553 ± 103.273 Bq/kg for 40K, for powdered milk. Liquid milk showed mean concentrations of 7.252 ± 1.215 Bq/L for 238U, 10.332 ± 0.731 Bq/L for 226Ra, 11.169 ± 1.137 Bq/L for 232Th and 137.072 ± 57.982 Bq/L for 40K. Artificial radionuclide 137Cs was not detected in the milk samples. The mean value of 40K for powdered milk exceeds guideline limit set by UNSCEAR for foodstuff. The mean annual effective dose was calculated to be 2.546×10-4 ± 0.189×10-4 mSv/y while the lifetime cancer risk was found to be 8.276×10-5 ± 6.170×10-5. The estimated mean values of radiological health risks of the milk samples are within the tolerable limit set by UNSCEAR and other global regulatory bodies. However, infants are at high risk by consuming up to 15 kg/year of powdered milk due to high radiation doses to vital organs of the range 1.659 ± 0.190 to 2.957 ± 0.339 mSv/y, but half the quantity is recommended. The findings of this study are comparable with those reported in the literature and provide valuable insights into the radioactivity levels in milk products in South Africa and their potential implications for human health. It shows that there is no significant radiological health impact due to the consumption of milk. However, continuous monitoring and further research on heavy metal contents are recommended to ensure the safety of milk consumption by the populace.

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Applied Physics / 20

Energy Balance Closure Analysis Based on Eddy Covariance Flux Tower Observations

Author: Lufuno Takalani[1]

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Energy balance closure is a fundamental principle in micrometeorology, ensuring that all energy fluxes within an ecosystem are properly accounted for. The eddy covariance (EC) method, widely used for measuring land –atmosphere exchanges of energy and mass, often exhibits energy closure discrepancies, particularly across different timescales. This study investigates ecological year energy closure using flux tower data collected over multiple years at Skukuza, Kruger National Park. Energy closure was assessed using the fundamental balance equation R_n-G=H+LE, where net radiation (R_n), soil heat flux (G), sensible heat flux (H), and latent heat flux (LE) were analyzed across different timescales. Radiation shields and soil heat flux sensors were employed to capture variations in energy fluxes. Statistical analysis of multiple ecological years revealed that energy closure varies significantly with seasons, with wetter years exhibiting lower energy imbalances compared to drier years.

The findings indicate that energy closure improves with increased turbulence (frictional velocity) but remains incomplete due to measurement uncertainties, sensor sampling scales, and ecosystem heterogeneities. Results highlight a persistent energy closure gap, with an average closure of approximately 80%, consistent with other EC studies globally. The study underscores the challenges in achieving full energy balance closure and emphasizes the need for improved sensor calibration, turbulence parameterization, and data correction techniques. These insights are crucial for refining EC methodologies and enhancing the accuracy of land-atmosphere energy exchange assessment in semi-arid ecosystems.

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Physics for Development, Education and Outreach / 21

INVESTIGATING THE EFFECT OF MATERIAL PROPERTIES ON THERMAL CONDUCTIVITY: AN INQUIRY-BASED APPROACH

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This study investigates the effect of material properties, specifically wood, plastic, and steel, on thermal conductivity through an inquiry-based approach. Thermal conductivity is a key factor influencing heat transfer in various applications, from construction to manufacturing. The research explores how the intrinsic properties of these materials, including density, structure, and composition, affect their ability to conduct heat. By focusing on common materials like wood, plastic, and steel, the study provides a comparative analysis of their thermal performance. Experimental and theoretical methods were employed to examine the heat transfer characteristics of each material under different conditions. The results reveal that steel, with its high density and metal structure, exhibits the highest thermal conductivity, while wood, being a natural insulator with a porous structure, shows the lowest thermal conductivity. Plastics exhibit intermediate thermal conductivity values depending on their type and molecular structure. The findings emphasize the significant role of material composition and structure in determining heat transfer efficiency, offering valuable insights for selecting materials in energy-efficient designs. This inquiry-based approach deepens the understanding of thermal conductivity in diverse materials and encourages further exploration into how these properties can be optimized for various industrial applications.

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PhD

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Photonics / 22

Photothermal Therapy Using Green-Synthesized gold Nanoparticles Derived from Senna didymobotrya: A Novel Strategy for Targeted Treatment of Melanoma Cells

Author: Mehak Zahra[1]

Co-authors: Blassan George [1]; Heidi Abrahamse [1]

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Melanoma, a highly aggressive and metastatic form of skin cancer, frequently exhibits resistance to conventional treatments such as chemotherapy, radiation therapy, and surgical excision, highlighting the necessity for novel therapeutic approaches. Recently, integrating nanotechnology with photothermal therapy (PTT) has emerged as a promising strategy, offering targeted, minimally invasive therapeutic benefits. This study investigates the photothermal potential and underlying cytotoxic mechanisms of gold nanoparticles (AuNPs) biosynthesized using an aqueous extract of Senna didymobotrya against human melanoma A375 cells. Successful synthesis and formation of AuNPs were confirmed through UV-visible spectroscopy analysis. The photothermal efficacy of these nanoparticles was evaluated by assessing cellular viability through the MTT assay, reactive oxygen species (ROS) production, mitochondrial membrane potential (MMP) disruption, and morphological changes via microscopic examination. Results revealed substantial photothermal efficiency, marked by significant temperature increases upon near-infrared (NIR) irradiation, leading to enhanced cytotoxicity in a dose-dependent manner. The cytotoxic mechanisms primarily involved ROS-induced mitochondrial dysfunction, ultimately resulting in apoptotic cell death. These findings underscore the significant potential of Senna didymobotrya-derived AuNPs as sustainable and potent photothermal agents, representing an encouraging advancement in melanoma treatment strategies.

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PhD

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Astrophysics & Space Science / 23

Update on the air quality dashboard development

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The climate crisis persists, as the global community has yet to fully embrace the actions needed to tackle it. The decade from 2010 to 2019 was the hottest on record, leading to devastating wildfires, hurricanes, droughts, floods, and other climate-related disasters worldwide. To limit global warming to 1.5℃ above pre-industrial levels, emissions must already be on the decline and need to be halved by 2030. Unfortunately, we are far from meeting this target. Sustainable Development Goal 13 emphasizes the need for urgent climate action, pointing to the rising global temperatures and increased air pollution that pose significant threats to human health. This highlights the importance of emission monitoring. In South Africa, however, emission data remains a challenge, making satellite data especially valuable. Satellites are increasingly used to monitor air quality and track atmospheric pollution. Around the world, studies are using data from the Tropospheric Monitoring Instrument (TROPOMI) to assess emissions and air quality. However, no air quality dashboard based on satellite data has been developed in South Africa using TROPOMI-Sentinel 5p data. This project aims to compute the Air Quality Index (AQI) using the Google Earth Engine (GEE) platform. Sulphur dioxide (SO2), nitrogen dioxide (NO2), and carbon monoxide (CO) will be the first pollutants used to calculate the AQI. A functional dashboard will be created to offer users easy access to standardised satellite data, enabling quick and effortless analysis.

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None

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Poster Session / 24

Structural and electrical transformations of Ag-implanted polyethylene terephthalate (PET) induced by swift heavy ion irradiation

Author: Jean Jules Mboukam[1]

Co-authors: Daniel C Chilukusha [1]; Morgan Madhuku [2]; Mandla Msimanga [3]

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The present study investigates the combined effects of ion implantation and swift heavy ion irradiation on the structural and electrical properties of polyethylene terephthalate (PET). Samples were first implanted with 150 keV Ag^{+}-ions at fluences of 1 x 10^16, 5 x 10^16 and 1 x 10^17, then irradiated with 30 MeV Au^{7+} ions. Atomic force microscopy (AFM) images and optical micrographs reveal blistering induced by swift heavy ions, especially at the highest implantation dose. Raman studies show two bands, with the larger band indicating the presence of amorphous and graphite-like structures in the samples. The band intensities decrease depending on the processing conditions, signifying optical and structural transformations in the implanted and/or irradiated PET. Current-voltage (I-V) measurements indicate an increase in the conductivity of the implanted samples, which is further enhanced upon irradiation, highlighting a transition from insulating to semiconducting behavior.

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None

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Poster Session / 25

Qualitative Study of Exhaled Breath in Lung Cancer Patients

Author: Tlotlo Setlhare[1]

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Lung cancer has highest mortality rate of all cancers worldwide and this is due to late detection of the disease. Current diagnostic techniques are invasive and expensive resulting in late diagnosis. Exhaled human breath offers an alternative rapid and non-invasive technique. This is because human breath has volatile organic compounds (VOCs) some which can be biomarkers of certain diseases. This study is aimed at identifying the specific biomarkers associated with lung cancer using the Gas chromatography-mass spectrometry (GC-MS). Appropriate software packages were used for the analysis and visualization of the data. The preliminary results indicate that there are new VOCs that are distinct to lung cancer in comparison with the controls which have not been observed before and can be possible biomarkers of lung cancer.

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PhD

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Nuclear, Particle and Radiation Physics-1 / 26

Alpha and Beta radiation effects on Re2MnCoO6 (Re = La, Sm, Nd)

Author: Tinashe Dhliwayo[1]

Co-authors: Buyisiwe. M Sondezi [1]; Martin. O Ntwaeaborwa [2]

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The rise in global demand for nuclear technology has resulted in an increase in radioactive waste and radioactive material. Some of these radioactive materials and nuclear waste undergo radioactive decay, emitting alpha and beta particles. Beta particles are energetic electrons with a single negative charge, while alpha particles are equivalent to a helium atom with a charge of +2. Both alpha and beta particles can cause significant damage along their path of travel. Therefore, there is a need for materials used for radiation shielding. This study was therefore aimed at simulating the effects of alpha and beta radiation on Re2MnCoO6 (Re = La, Sm, Nd) prepared by solid-state method.
The stoichiometric ratios of the starting materials were measured and ground into a fine powder then calcined at 900 oC for 12 hours before being annealed at 1200 oC for a further 48 hours. Finely ground samples were characterised by powder X-ray diffraction (XRD) to ascertain that the right structures were crystallized. A continuous scanning using Cu-Kα radiation (40 kV, 30 mA) was done, measuring between 10° and 90° with a step of 0.02° and speed of 0.145 s/step. The samples were indexed to the monoclinic phase of Re2MnCoO6 that belongs to a space group P21/n, number 14.
The continuous slowing-down approximation (CSDA) range of beta particles in the samples and the stopping power of the samples have been calculated using ESTAR. At 0.5 MeV, the beta particles have an CSDA range of 0.018 g/cm2 for Sm2MnCoO6, 0.2699 g/cm2 for Nd2MnCoO6 and 1.370 g/cm2 for La2MnCoO6. The mass stopping power of all the three samples decreases with energy up to about 1 MeV and then starts to increase again.
The ranges, energy deposition and displacement damages caused by alpha particles have been estimated using the ion transport Monte Carlo simulations using the Stopping and Range of Ions in Matter (SRIM) code with the Full Damage Cascades mode. A 4 MeV alpha particle has a range of about 23.53 µm in Sm2MnCoO6, 23.08 µm in Nd2MnCoO6 and 22.00 µm in La2MnCoO6. The mass stopping power for all the three samples ranged between 0.320 MeV.cm2/g and 0.414 MeV.cm2/g for a 0.1 MeV alpha particle.
The results show that double perovskites can be used as matrices for radioactive waste immobilization.

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PhD

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Nuclear, Particle and Radiation Physics-2 / 27

pQCD energy loss calculation for small systems

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Shortly after the Big Bang, the universe was in an incredibly hot and dense state, with particles moving at nearly the speed of light. During this brief period, lasting only a few microseconds, quarks and gluons were the dominant components. Due to the extremely high temperatures, these quarks and gluons—collectively known as partons—were only loosely bound and could move freely, forming a state called the quark-gluon plasma (QGP).

The QGP can be recreated in high-energy collisions at large particle colliders such as the Large Hadron Collider (LHC) at CERN. This is achieved by accelerating heavy ions, such as lead (Pb) and gold (Au), to trillions of electron volts (eV) before colliding them, resulting in an extremely hot state where matter dissolves into a QGP. This state cools rapidly, hadronizing within approximately 10 fm/c as quarks and gluons recombine into particles such as pions, kaons, protons, and neutrons. Physicists study the QGP to gain valuable insights into the conditions of the early universe and to better understand the fundamental building blocks of matter.

Jet quenching—the energy loss of high-energy partons traversing the QGP—is well-studied in large systems such as heavy-ion (AA) collisions. However, the observation of QGP-like signatures in small systems, such as proton-nucleus (pA) collisions, poses intriguing challenges. Current jet quenching models, such as the Gyulassy-Levai-Vitev (GLV) formalism, rely on several approximations valid for large systems, including the assumption of large separation distances between scattering centers. Extending these models to small systems requires re-evaluating these approximations in the context of energy loss formalisms.

This project aims to address these challenges by systematically relaxing key assumptions in the GLV framework to develop a more precise understanding of quenching in small systems. Specifically, we investigate transverse momentum broadening in the QGP using the GLV formalism. The primary goal is to determine the momentum distribution of a parton (quark or gluon) traveling through the QGP, focusing solely on broadening effects while excluding radiation.

The GLV formalism is a perturbative expansion in the number of scatterings, allowing for the systematic calculation of any finite number of scatterings. The standard GLV approach employs the eikonal approximation and the large separation distance approximation to simplify calculations. In this work, we relax the large system size approximation by incorporating all path length corrections into the GLV formalism, accounting for energy loss across all system sizes. Additionally, we relax the eikonal approximation by calculating next-to-leading order (NLO) corrections, which involve relaxing the assumption that E^+ is the dominant energy scale in the interaction and computing the corresponding correction terms.

We proceed by computing both the single scattering matrix element ($\mathcal{M}_1$) and the double scattering matrix element ($\mathcal{M}_2$). These results are then used to evaluate the color trace, which in turn allows us to compute the full momentum broadening distribution. Finally, we run numerical simulations to compare our theoretical predictions with experimental data, providing a deeper understanding of transverse momentum broadening in different system sizes.

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MSc

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Poster Session / 28

First-Principles Study of $ZrCo_2Y$/ZrCoY (Y=Sb, Bi, As)Interface for Thermoelectric Applications

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\begin{abstract}
Half-Heusler alloys such as ZrCoSb, ZrCoBi, and ZrCoAs are promising thermoelectric materials for recovering waste heat because of their favorable electronic and thermal properties\cite{reference1,reference2}. However, achieving low-resistance electrical contact at the hot interface between half-Heusler materials and metal electrodes remains a significant challenge. Recent experimental studies indicate that a coherent interface can form between full-Heusler and half-Heusler compounds by diffusion of transition metal atoms into the vacant sublattice of the half-Heusler structure\cite{reference3}.

In this study, we employ first-principles calculations to investigate the structural and electronic properties of the $ZrCo_2Y$/ZrCoY interface. Our results reveal that this interface exhibits low contact resistivity and nearly ohmic behavior at various temperatures and doping levels. The stability and favorable electronic characteristics of these interfaces suggest that full-Heusler compounds could serve as efficient electrical contacts for half-Heusler thermoelectric materials, enhancing the performance of thermoelectric generators.
\end{abstract}
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Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 29

POTENTIAL MANGANESE OXIDE (MNXOY) CATALYSTS FOR OXYGEN REDUCTION REACTION (ORR)

Author: Edwine Ntobe Matlou[1]

Co-authors: Khomotso Portia Maenetja [1]; Phuti Esrom Ngoepe [1]; Tshegofatso Michael Phaahla [1]

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Today, lithium ion batteries (LIBs) dominate the rechargeable battery market despite their limitations, including low energy storage density (100–200 Wh/kg), high cost, potential supply shortages, and safety risks due to the flammability of lithium and organic electrolytes. Metal-air batteries (MABs) offer a high energy density, ranging from 400 to 1700 Wh/kg. However, the Fe-air battery (764 Wh/kg) received more attention due to its cost-effectiveness, eco-friendly nature, and for being less susceptible to dendrite formation, enhancing their safety and longevity. Despite that, Fe-air batteries encounter challenges related to their low-rate capability, cycling life and side chemical reactions resulting in battery deterioration. In this work, density functional theory (DFT) study is employed to investigate the structural, mechanical and electronic properties of potential MnxOy bulk catalysts. The calculated lattice parameters and elastic constants compared well with those obtained experimentally, with the percentage difference of 2%. The total density of states (TDOS) indicate the MnO2 system as the most stable as compared to Mn2O3 and Mn3O4.These findings give insight in improving the life cycle and over-potential of the battery.

Apply for student award at which level::

Honours

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics for Development, Education and Outreach / 30

Assessment of Undergraduate Physics Students'Misconception about Heat and Temperature and Implications for Instruction

Author: Enock Jonathan[None]

Corresponding Author: enock10jonathan@gmail.com

Heat and temperature are fundamental concepts introduced in undergraduate physics thermodynamics with application in mechanics, energy, technology as well as in allied scientific disciplines such as materials science and chemistry. Towards promoting greater understanding of these concepts among students, it is important to identify student misconceptions. In this study, undergraduate physics students'conception of heat and temperature were assessed using the Heat and Temperature Concept Evaluation (HTCE) test instrument developed by Thornton and Sokoloff. The study covered 8 conceptual areas as follows: heat and temperature, rate of cooling, calorimetry, rate of heat transfer, perception of hotness, specific heat capacity, change of phase and thermal conductivity. Study results revealed student difficulties in the conceptual areas of heat and temperature, rate of cooling, rate of heat transfer and specific heat capacity. Interventions to improve student understanding to include experimentation are discussed.

Apply for student award at which level::

None

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Yes, I ACCEPT

Applied Physics / 31

Design and Experimental Evaluation of an Archimedes Screw Hydro Turbine (ASHT) for Rural Sustainable Energy Application

Authors: Enock Jonathan[None]; Kabelo Moketo[1]

[1] *National University of Lesotho*

Corresponding Author: enock10jonathan@gmail.com

A significant portion rural Africa still lack access to affordable, sustainable and modern energy, causing a knock-on effect on the development of education, agriculture, healthcare, business and transportation, ultimately lowering the rural quality of life. Towards a sustainable solution in meeting the rural Southern Africa energy demand, there is a need for indigenous development and implementation of suitable technologies. In this context, we present on the design and experimental evaluation of an Archimedes Screw Hydro Turbine (ASHT) prototype fabricated using recycled plastic for rural sustainable energy application. Being a device, that works mechanically to produce electrical energy from the flow of water with low head and flow rates, ASHT is suitable for use in water bodies such as running streams and rivers common in rural Africa as well as with irrigation channels, all representing a renewable energy source. Design consideration for optimised turbine performance included among other variables, the pitch of the screw, inner diameter of the screw, number of screw blades, angle of the screw, rotational speed, water flow rate and head. ASHT offer several advantages to include low maintenance, simple installation and maintenance, and operation at low head and flow rate. We envisage ASHT application in hybrid configuration in combination with solar technologies.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 32

Technology Innovation Platform at NRF-iThemba LABS

Author: Edward Nkadimeng[1]

[1] *NRF-iThemba LABS*

Corresponding Author: edward.khomotso.nkadimeng@cern.ch

The Technology Innovation Platform (TIP) at iThemba LABS, South Africa's national facility for accelerator-based sciences, aims to transform our nuclear and particle physics research into practical applications. We've set up TIP around several key technology projects in detector systems, data acquisition, specialised fabrication, and control interfaces. The work will include thick GEM detectors for the K600 spectrometer, systems based on XIA digitizers, electron beam welding techniques for niobium components, and EtherCAT solutions for our beam diagnostics. One of our main challenges is navigating the gap between the typically low Technology Readiness Levels of physics research and the requirements for commercial adoption. Despite these challenges, we believe TIP creates valuable pathways for physics innovation within South Africa's scientific landscape while supporting our core mission in nuclear physics research at iThemba LABS.

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None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Applied Physics / 33

Proactive Equipment Monitoring Using Vanilla LSTM for Predictive Maintenance at iThemba LABS

Author: Edward Nkadimeng[1]

[1] *NRF-iThemba LABS*

Corresponding Author: edward.khomotso.nkadimeng@cern.ch

iThemba LABS operates complex scientific equipment including particle accelerators where unexpected failures can disrupt critical experiments for extended periods. We present a predictive maintenance framework based on Vanilla LSTM networks that analyzes multivariate time-series sensor data to anticipate equipment failures. The model was trained on operational data from 2021-2024, monitoring key parameters like voltage, vibration, and pressure across various systems. Our approach demonstrates significant improvements over traditional methods, achieving a 75% F1-score in failure prediction with up to 72 hours warning time. The framework includes an interpretable failure scoring system that helps technicians prioritize maintenance interventions. Practical implementation challenges at iThemba LABS, such as handling noisy sensor data in high-vibration environments, were addressed through careful feature engineering and model optimization. The methods developed are particularly relevant for physics laboratories and other facilities operating sensitive, high-value equipment.

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None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics of Condensed Matter and Materials / 34

Quantum mechanical local energy density applied to many-electron systems

Author: Saga Abdalla[1]

[1] *University of Witwatersrand*

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The concept of a local energy density in a many-electron system has been a topic of discussion and debate for over 30 years. Chetty and Martin conducted the initial research in this field in the early 1990s, expanding upon the quantum mechanical stress theorem that Nielsen and Martin had derived in 1985. In the research that they conducted in 1992, Chetty and Martin introduced the idea of local energy density by utilizing the Kohn-Sham formalism within the framework of Density Functional Theory (DFT). They proposed that the kinetic energy density was non-unique, expressible either through the asymmetric operator, $-\frac{1}{2}\psi(\mathbf{r})\nabla^2\psi(\mathbf{r})$, or the symmetric operator, $+\frac{1}{2}|\nabla\psi(\mathbf{r})|^2$. Likewise, they also stated that the Hartree energy density can be represented in two distinct forms: one that incorporates the Coulomb potential, $\frac{1}{2}n(\mathbf{r})V(\mathbf{r})$, and another that involves the square of the electric field, $\frac{1}{8\pi}|\mathbf{E}(\mathbf{r})|^2$.

Subsequent research largely focused on working within a specific choice of energy density formulation and ensuring internal consistency within that gauge to obtain meaningful computational results. It has been demonstrated that local perturbative changes in a real physical system lead to corresponding local variations in the energy density. This establishes a correlation between modifications in the electronic band structure typically described in reciprocal space and variations in the energy density, which is a real-space quantity.

The recent study by Martin, Chetty, and Trinkle (2025) posits that the energy density in a many-electron system may be uniquely characterized. The primary objective of this thesis is to place this assertion on a solid mathematical and physical foundation. By starting from the many-body formulation of the electron problem, we demonstrate that the kinetic energy density is uniquely determined by the asymmetric operator that appears in the Hamiltonian. The Coulomb potential energy density is shown to be uniquely defined within this many-electron framework. It is only when the mean-field Hartree term is separated from the term involving the pair correlation function that one can argue the Hartree energy density is non-unique being expressible either in terms of the Coulomb potential or the square of the electric field. However, we argue that this separation is merely an artefact rather than a fundamental property of the system. Since the many-body formulation fully defines the problem, it naturally leads to a unique local energy density expressed through all the operators present in the Hamiltonian.

From this, we conclude that the local energy density of a many-electron system is uniquely defined and, crucially, experimentally measurable. This implies that the quantum mechanical energy density distribution of a many-electron system is not just a theoretical construct or a computational tool for deriving the total energy uniquely determined within Density Functional Theory via the electron density but rather an intrinsic and physically meaningful attribute of the system.

Apply for student award at which level::

PhD

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Yes, I ACCEPT

Poster Session / 35

Fuzzy-based criterion for groundwater quality classification in some rural parts of North-West Province, South Africa

Author: Oluwakayode Oyedokun[1]

Co-author: Bola Wojuola [1]

[1] *North-West University*

Corresponding Author: 50153463@mynwu.ac.za

This paper develops a decision-making algorithm using the fuzzy set theory in assessing the physico-chemical properties and microbial contaminants of boreholes located in villages around the North-West Province, where Magalies Water, a water board in the Republic of South Africa centrally operates.
Application of fuzzy rule-based optimization technique will be illustrated with 42 groundwater samples collected in the northern part of the province, an area with a sparse population trend, representing the rural and peri-urban communities in the province.
These samples were analysed for 13 different physico-chemical water quality properties and three biological contaminants namely Escherichia coli, total coliform and total plate count.
The South African National Standard (SANS) 241-2:2015 for drinking water (SABS, 2015) will be used to evaluate the borehole's quality. The water quality will be classified into 'excellent', 'good' , 'acceptable', and 'unacceptable'as proposed by Enitan-Folami et al, (2019) bearing in mind the current situation of rural communities in the country.
Fuzzy-based set theory methodology provides a non-probabilistic value in expressing the quality of water in the prescribed limits of various regulatory bodies'quality class and experts'perceptions from the field of drinking water quality.
This approach will proffer an intelligent-based classification model that will help assess the water quality and identify the nature of pollution, thereby informing the immediate communities and water industry about the borehole's condition and water treatment approach deemed necessary to prevent continuous deterioration.

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None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 36

Systematics study of ground-state bands in rotating even-even nuclei to reveal triaxial deformation at ground state

Author: Nkonzo Xulu[1]

Co-authors: Elena Atanassova Lawrie [2]; Sifiso Senzo Ntshangase

[1] *University of Zululand*

[2] *iThemba LABS*

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The question of whether atomic nuclei can have triaxial shapes at their ground states is still an ongoing subject of debate. In this study, we systematically analyze the ground-state bands of rotating even-even nuclei to identify the presence of triaxiality across the nuclear chart using experimental data. We apply the newly proposed Coriolis analysis method, which involves plotting $E_\gamma = E(I) - E(I-2)$ as a function of spin I. Of particular interest is the value I_c at which the curve crosses the x-axis. Using this method, we analyzed over 600 deformed even-even rotating nuclei and obtained results for 268 of them. The results show that these nuclei exhibit three distinct shapes: axially symmetric, stable triaxial, and γ-unstable shapes. A comparison of these theoretical and our experimental results, predicted by different models like the FRLDM calculations, shows that several hundred nuclei are affected by triaxiality [1]. A good agreement was found between the theoretical and experimental results, providing further evidence that the proposed approach is reliable. The analysis provides detailed information about the nuclear shapes associated with the nuclear ground-state band, helping determine whether the shape is axially symmetric or triaxial. The results of this work will be discussed at the South African Institute of Physics conference.

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MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 37

Stopping Force Measurements of 12C, 28Si, and 59Co Ions in Platinum Foils using Time-of-Flight Spectrometry

Author: Mamogo Masenya[1]

Co-authors: Abderraouf Belalia [2]; M Msimanga [3]

[1] *iThemba LABS*

[2] *University of Blida, LPTHIRM Lab.*

[3] *TUT/iThemba LABS*

Corresponding Author: mamogo@tlabs.ac.za

The time-of-flight elastic recoil detection analysis (TOF-ERDA) method is an ion beam analysis technique that can analyse light elements in a sample with high depth resolution. This method uses simultaneous measurements of recoil ion energy and time of flight to determine ion mass. TOF is used to compute the energy of recoil ions, resulting in higher energy resolution than standard Silicon semiconductor detectors. In this paper, we provide a straightforward experimental approach for generating stopping force data of carbon, silicon, and cobalt ions through 78Pt throughout a continuous energy range of 0.05 MeV/u to 0.5 MeV/u. The measurement was performed utilizing a Time of Flight - Elastic Recoil Detection Analysis (ToF-ERDA) configuration. A 40 MeV 197Au9+ beam was used to recoil 12C, 28Si, and 59Co ions from thick carbon, silicon dioxide, and cobalt targets, respectively, into a platinum stopper foil. The energy loss of the incident recoils through the stopper foil was estimated using the measured ToF across a defined route length, both with and without the stopper foil, and the stopping force was computed using the measured foil thickness. The results were compared with semi-empirical. The findings were compared to semi-empirical calculations utilizing Ziegler's Stopping and Range of Ions in Matter (SRIM) and Sigmaud and Schinner's theoretical code, the PASS code. Our data in the energy range under consideration is in good agreement with SRIM-2013 and Arstila's work, within 0.1 - 0.38 MeV/u in 28Si-Mo ion-target, but DPASS reveals considerable variations.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 38

The impact of geomagnetic storms and solar proton events in May and October 2024 on South Africa's upper atmosphere, compared to the historical event of October 2003

Author: Joseph Omojola[1]

Co-authors: N.E Engelbrecht [1]; R.D Strauss [1]

[1] *North-West University*

Corresponding Author: 55648029@mynwu.ac.za

This study investigated the impact of solar proton events (SPE) on the upper atmosphere over South Africa during intense geomagnetic storms in May (Dst = -412 nT) and October 2024 (Dst = -333 nT). Utilizing the NRLMSISE-2.0 atmospheric model and SOHO data, we characterized storm-time atmospheric composition and energetic particle fluxes. Significant fluctuations in atmospheric constituents were observed, with molecular nitrogen (N₂) increasing by 3.61×10⁶ cm⁻³ day⁻¹ during the May sudden storm commencement (SSC) and by 1.40×10⁶ cm⁻³ day⁻¹ and 2.26×10⁶ cm⁻³ day⁻¹ during the two-step SSC of October. A decrease in atomic hydrogen (H) of about 3.0×10⁴ cm⁻³ day⁻¹ occurred in May, while the largest decrease of approximately 8.60×10³ cm⁻³ day⁻¹ was noted during the October storm. These changes, driven by particle precipitation that enhances nuclear and molecular interactions at GNSS altitudes (400 –450 km), affect the total electron content (TEC) and may compromise GNSS signal accuracy. The results are compared with the historical event of solar cycle 23 in October 2003 (Dst = -353nT). This research enhances our understanding of space weather's impact on the upper atmosphere and related technologies.

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None

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Yes, I ACCEPT

Physics of Condensed Matter and Materials / 39

Influence of pressure and defects on CNT interlinking

Authors: Chani van Niekerk[1]; Robert Warmbier[1]

[1] *University of the Witwatersrand*

Corresponding Author: chani.vanniekerk@wits.ac.za

Carbon nanotubes (CNT's) have a variety of different uses, in nanoscience and nanotechnology, such as energy storage, device modelling, automotive parts, thin-film electronics etc. Due to the large range of applications understanding the characteristics and typical behaviour of these materials becomes important. In realistic systems, CNT's will contain defects such as adatoms and vacancies and be exposed to pressure changes.

It has been shown both theoretically and experimentally that when sufficient pressure is applied to an isolated, pristine CNT it can result in a structural deformation and can provide a means to change sp_2 to sp_3 bonds which at times leads to interlinking/bonding between CNTs in the material. [1] The applied pressure resulted in stronger harder materials with pressure tuneable band gaps. [2]

Experimentally, interlinking between tubes has been observed when defects are introduced into systems. Similarly to pressure, the cross-linking effect caused can be used to modify the material properties. [3, 4, 5]

The modification of the different electronic, optical, and mechanical changes accompanying these behaviours highlight the impact of understanding the effect of pressure and defects on CNT's. In this work we theoretically study the effects of pressure combined with different defects for various sizes and chiralities of CNT. We further use this to predict when the bond type will change and when interlinking is most likely to occur in a CNT system.

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Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 40

Interactions of s-triazine, xanthate and dithiocarbamate collectors on platarsite (100) surface at different pH conditions: A DFT-D3 study

Author: Bradley Nemutudi[1]

Co-authors: Phuti Ngoepe [1]; Peace Mkhonto [1]

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The study on performance of the novel 2,6-dithio-4-butylamino-1,3,5-triazine (DTBAT), normal butyl xanthate (NBX) and normal butyl dithiocarbamate (NBDTC) collector on platarsite serve as a foundation for understanding the flotation reactivity, which may be applicable in a wide range of sulphide and arsenide platinum group minerals (PGMs). This study adopted computational density functional theory (DFT) to perform the adsorption of NBX, NBDTC and DTBAT on platarsite (100) surface under neutral, alkaline and acidic conditions. It was observed that the collectors preferred monodentate adsorption mode between S atom on Pt atoms. Furthermore, it was found that the adsorption energies followed the decreasing order as: DTBAT > NBDTC > NBX, under both neutral and acidic conditions, while under alkaline conditions, the order followed as: NBX > NBDTC > DTBAT. These suggested that the DTBAT exhibited the strongest exothermic adsorption under both neutral and acidic conditions, while the NBX had strong exothermic adsorption under alkaline conditions. It was noted that the NBX collector had the strongest most exothermic adsorption energy (−413.17 kJ.mol^{−1}) which was under alkaline conditions. Therefore, these results identifies the NBX collector as a predicted well performing collector to improve the recovery of platarsite. Moreover, the alkaline conditions, is recommended for flotation recovery of platarsite mineral.

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PhD

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Yes, I ACCEPT

Poster Session / 42

Investigate the bulk and surfaces properties of PtAs2, PtSb2 and PtBi2 PGMs using the Ab-Initio Molecular Dynamics (AIMD) with Machine Learned Force Fields (MLFF) technique

Author: Ivyn Ndhlovu[1]

Co-authors: Peace Mkhonto [1]; Phuti Ngoepe [1]; Seshupo Mangwejane [1]

[1] *University of Limpopo*

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Abstract
The currently available machine learned force-field (MLFF) within ab-initio molecular dynamics (AIMD) embedded with the Vienna ab-initio simulation package (VASP), allows for generation of force field to handle large systems. The AIMD-MLFF methods were employed in the current study to investigate the bulk and surface properties of sperrylite (PtAs2), geversite (PtSb2) and insizwaite (PtBi2) platinum group minerals (PGMs) at 300 K. After training the lattice parameters were obtained as: PtAs2 (5.977 Å), PtSb2 (6.457 Å) and PtBi2 (6.721 Å). The trained force fields were then applied on 4x4x4 supercell produced lattice parameters of: PtAs2 (5.991 Å), PtSb2 (5.445 Å) and PtBi2 (6.723 Å). These were found to be in good agreement with the experimental values of 5.970 Å, 6.440 Å and 6.702 Å for PtAs2, PtSb2 and PtBi2, respectively. From ab-initio the (100) surfaces was determined as the most stable surface for all three minerals with PtAs2 having the surface of (1.00 J/m2), PtSb2 (0.42 J/m2) and PtBi2 (0.15 J/m2). The trained (100) surfaces for all minerals gave surface energies of: PtAs2 (1.76 J/m2), PtSb2 (1.32 J/m2) and PtBi2 (0.97 J/m2). Again, trained force fields applied to supercell (100) surfaces yielded surface energies of PtAs2 (1.67 J/m2), PtSb2 (1.27 J/m2), and PtBi2 (1.93 J/m2). These demonstrated that the viability of the AIMD-MLFF method at 300 K, produces results that correlate with experiment and ab-initio results. This cleared the path for the potential application of such a machine learning technique to surface adsorption.

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MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Astrophysics & Space Science / 43

Exploring ULXs as Short GRB Precursors

Author: Lutendo Nyadzani[1]

Co-authors: Justin Finke [2]; Soebur Razzaque [1]

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The joint detection of gravitational waves (GW170817) by LIGO and Virgo, together with the short gamma-ray burst (sGRBs) GRB 170817A observed by Fermi and INTEGRAL, has confirmed that at least some sGRBs originate
from the merger of two neutron stars (NS-NS). Despite this breakthrough, the evolutionary pathways that lead to such
mergers remain uncertain.

In this project, we study the likelihood that a binary system which undergoes a ULX phase will ultimately produce an sGRB. To do this, we use the rapid population synthesis code COSMIC to simulate large ensembles of massive binary systems across a range of metallicities and generate our ULX population. We use a detailed binary evolution code POSYDON to complement these statistical results to model selected ULX systems with more realistic mass transfer physics and common-envelope evolution. Our study aims to quantify the fraction of ULX systems that lead to sGRB-producing compact mergers and to characterize their delay time distributions and likely host galaxy properties.

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None

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Yes, I ACCEPT

Poster Session / 44

Application of Crystal Field Theory in Understanding Magnetic Transitions: Correlating Structural, Chemical, and Magnetic Properties in $Sm_2MnB'O_6$ (B'= Mn, Ce and Ru)

Author: Sibusiso Nqayi[1]

Co-author: Buyisiwe. M Sondezi [1]

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Crystal Field Theory (CFT) provides a fundamental framework for understanding magnetic transitions by elucidating the interactions between transition metal ions and their surrounding ligand fields. In complex oxides such as $Sm_2MnB'O_6$ (B'=Mn, Ce and Ru), CFT plays a crucial role in correlating structural distortions, chemical bonding, and magnetic ordering. This work demonstrates how variations in metal-ligand coordination environments influence spin states, exchange interactions, and overall magnetic behaviour. The interplay of Mn and B'in different polyhedra coordination leads to significant modifications in crystal field splitting, affecting charge distribution and magnetic coupling mechanisms. Additionally, structural distortions, including Jahn-Teller effects and bond angle variations, mediate the observed magnetic transitions from paramagnetic to ordered states. This work underscores the importance of CFT in predicting and tuning magnetic properties in perovskite-like oxides, offering insights into potential applications in spintronics and multifunctional materials.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Photonics / 45

Photonic-biosensing towards drug-resistant Tuberculosis diagnosis

Author: Sipho Chauke[1]

Co-authors: Charles Maphanga [2]; Felix Sizwe Dube [3]; Mabotse Tjale [4]; Patience Mthunzi-Kufa [5]; Saturnin Ombinda-Lemboumba [6]; Sinegugu Nzuza [7]

[1] *Council for scientific and Industrial research (CSIR) and University of Cape Town(UCT)*

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[3] *University of Cape Town, Cape Town*

[4] *Council for Scientific and Industrial Research(CSIR)*

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Early detection and treatment of TB remain key strategies to reduce transmission and disease progression. However, this is hampered by time-consuming, insensitive diagnostic methods, particularly for the detection of drug-resistant forms and in patients with human immunodeficiency virus infection (HIV). Several genes, such as RNA polymerase β subunit (rpoB) and enoyl reductase (InhA) genes, contain mutations that are responsible for drug resistance. One objective of this study is to use a surface plasmon resonance (SPR)-based biosensor platform to detect rpoB and inhA genes. Deoxyribonucleic acid (DNA) probes, specific for rpoB and inhA, were used as biorecognition elements to capture rpoB and inhA target DNA. The rpoB and inhA gene-specific thiolated DNA probes were immobilized on a gold-coated glass substrate before the target DNA was introduced for detection. As a negative control, mis-matched DNA, unspecific to both genes were used for confirmation of binding of the target DNA in the SPR exper-imental setup. The SPR optical setup was used for the analysis of the binding interactions occurring on the coated glass substrate. The total reflected intensity indicated the kinetics associated with DNA hybridization occurring between the target DNA and the capture probe. This is the initial step towards potentially detecting drug-resistant mutations using SPR-based biosensors for a point-of-care setting.

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PhD

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Yes, I ACCEPT

Poster Session / 46

A comparison of two biosensing recognition elements using SPR for the detection of drug-resistant genes

Author: sipho Chauke[1]

Co-authors: Charles Maphanga [2]; Felix Sizwe Dube [3]; Mabotse Tjale [2]; Patience Mthunzi-Kufa [4]; Saturnin Ombinda-Lemboumba [2]; Sinegugu Nzuza [5]

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The burden of tuberculosis (TB) infections is disproportionately high in low-income and resource-limited settings. This disparity exacerbates the emergence of multidrug-resistant (MDR) and extensively drug-resistant (XDR) My-cobacterium tuberculosis (Mtb), the bacterium that causes TB. Early detection and treatment of TB remain key strategies to reduce the spread and disease progression, particularly for the detection of drug-resistant forms. There-fore, optical-based diagnostic devices could solve this problem. Surface plasmon resonance (SPR) biosensors offer various advantages including rapid analysis, high specificity, and sensitivity as well as requiring small amounts of samples for analysis. For this study, two multidrug-resistant genes, namely, catalase-peroxidase (KatG) and enoyl reductase (InhA) were detected using a custom-built surface plasmon resonance (SPR) setup. Biotinylated and thio-lated deoxyribonucleic acid (DNA) probes, specific for the two genes (KatG and InhA), were used as biorecognition elements to capture KatG and InhA target DNA. The SPR setup was used for the analysis of the binding interactions occurring on the gold-coated slides. The SPR biosensor setup indicated binding interactions through the changes in reflected intensities. The reflected intensities indicated the differences in the resonance angle between each ex-perimental test. This is the initial step to identifying the best characterization of DNA as biorecognition elements for detecting drug-resistant mutations using an SPR-based setup.

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PhD

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Yes, I ACCEPT

Poster Session / 47

Developing a critical component of a fiber cable for the Affordable Multiple Aperture Spectroscopy Explorer Prototype (AMASE-P)

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The Affordable Multiple-Aperture Spectroscopy Explorer Prototype (AMASE-P) is an innovative project aimed at improving high-resolution integral field spectroscopy for investigating ionised gas in the Milky Way and nearby galaxies. A critical component of AMASE-P is the fibre instrument cable (FIC), designed to efficiently transmit light from the telescope to the spectrographs. Compact fibre bundles are essential for observing distributed sources in the sky, requiring precise positioning of individual fibres with a tolerance of better than a few microns. AMASE-P will be the first use of octagonal core 80 micron multimode fibres, the smallest of their kind in astronomy.

This study focusses on the careful placement and alignment of optical fibres in a hexagonal aperture and the development of a computational imaging algorithm to evaluate fibre positioning accuracy. The manufacturing process involves positioning 547 fibres in a 1.858 mm hexagonal hole, achieving a fibre fill factor greater than 90% to maximise photon collection. The fibres are terminated with surface roughness of 0.3 microns, matching the optical wavelength. Deviations exceeding $\pm 3\mu$m can lead to a loss of more than 10% in observing efficiency. Furthermore, stress-free mounting of the fibres is essential to avoid deterioration of the focal ratio at the output.

To address these challenges, we have developed a fibre assembly technology that combines high-accuracy fibre positioning with a metrology system. This system achieves a positioning precision of $\pm 3\mu$m. The high-precision algorithm images the fibre bundles and translates the pixel data into micrometre-scale measurements, accounting for detector resolution, pixel dimension, and magnification. This approach automates fibre alignment verification, reduces manual effort, and improves overall assembly efficiency.

Our method for developing and characterising fibre bundles for AMASE-P ensures minimal light loss, uniform signal capture, compact design, and high fill fraction, establishing a new benchmark for precision assembly in fibre-fed spectrographs for large-scale astrophysical studies.

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MSc

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Yes, I ACCEPT

Astrophysics & Space Science / 48

An investigative numerical modelling study of galactic deuterons in the heliosphere

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The observation of galactic cosmic ray (GCR) deuteron at the Earth has been done precisely with the PAMELA and AMS02 space detectors and reported from July 2006 to September 2014 and from May 2011 to April 2021, respectively. These observations span time frames that include solar maximum and both minimum modulation conditions in the $A > 0$ and $A < 0$ magnetic field cycles at rigidities between ~ 0.75 GV and ~ 19.5 GV. A surprise from AMS02 observation was that current available GALPROP calculated deuteron local interstellar spectra (LIS) are unable to reproduce the deuteron observations at rigidities above ~5 GV, and thus challenging the status quo regarding their origin in the galaxy. In this study a comprehensive 3D numerical model and a set of diffusion and drift coefficients, previously applied to a number of cosmic ray nuclei, together with a newly estimated LIS for deuterons, are used to simulate the modulation of deuterons from July 2006 to April 2021. The modelling results will be compared to observations made by PAMELA and AMS-02 detectors. This study will illustrate and discuss the effects due to different LISs and those caused by the main modulation mechanisms on deuteron modulation at the Earth. Furthermore, differences between the modulation of protons and deuterons at the Earth will be uncovered and highlighted.

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Astrophysics & Space Science / 49

Simultaneous multiple conjugate nighttime MSTIDs observations: 4 October 2018

Author: Zama Katamzi-Joseph[None]

Co-authors: Alicreance Hiyadutuje [1]; John Bosco Habarulema [1]

[1] *SANSA*

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This study reports on nighttime medium-scale traveling ionospheric disturbances (MSTIDs) observed by conjugate midlatitude all-sky imagers in Sutherland (32.4◦S, 20.8◦E; magnetic latitude: ~-40.9◦) and Asiago (45.87◦N, 11.53◦E; magnetic latitude: ~40.3◦) on the 4th of October 2018. These MSTIDs had fronts elongated along the northeast-southwest (NE-SW) and northwest-southeast (NW-SE) directions in the Southern and Northern Hemispheres. The NE-SW aligned MSTIDs propagated in the NW (SE) direction in the Southern (Northern) Hemisphere, while the NW-SE aligned MSTIDs propagated in the NE (SW) direction in the Southern (Northern) Hemisphere. This study reports the first optical observations of conjugate NE-SW/NW-SE aligned and equator-eastward propagating MSTIDs. These MSTIDs are possibly linked to gravity wave-induced polarization electric field in the Northern Hemisphere, as significant gravity wave activity in the mesosphere was detected from the OH and OI greenline observations by the Asiago imager, and mapped to the Southern Hemisphere. Their equator-eastward propagation direction was favoured by background winds at the hemisphere of origin, which were determined from a global model and observations. The NE-SW/NW-SE aligned and equator-westward propagating MSTIDs were likely generated through the coupled Perkins and sporadic E instabilities, since they were observed in the presence of sporadic E layers and with reasonable Perkins instability growth rates. Polarization electric fields induced by the observed gravity waves and sporadic E layers resulted in two pairs of conjugate MSTIDs.

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Consent on use of personal information: Abstract Submission:

Astrophysics & Space Science / 50

Characteristics of Nighttime Medium-scale Traveling Ionospheric Disturbances: Longitudinal Comparison of their Seasonal and Local Time Variations

Author: Zama Katamzi-Joseph[None]

Co-authors: Amore Nel [1]; John Bosco Habarulema [1]; Tshimangadzo Matamba [1]

[1] *SANSA*

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This study presents a statistical analysis of the occurrence rate of midlatitude nighttime medium scale traveling ionospheric disturbances (MSTIDs) that were detected in Swarm plasma density measurements from 2014 to 2023. Monthly and local time variations of MSTID occurrence rates are compared in four longitude sectors: America, Africa, Asia, and Pacific. The spatial distribution showed a longitudinal variation as the MSTIDs were abundant in the Pacific region and scarce in the African sector. While the MSTIDs had occurrence peaks during both solstices, the winter solstice peak dominated in all longitude sectors, representing a seasonal asymmetry. The local time variation of the MSTIDs revealed they occur predominantly during the postmidnight hours in all longitude sectors. However, post-sunset MSTIDs observations were enhanced over the Asian and Pacific sectors during the solstices. The longitudinal variation in the occurrence of MSTIDs is probably linked to the E–F coupling as it matched that of the nighttime sporadic E variation obtained from ionosonde measurements. While the semiannual seasonal variation may be explained by interhemispheric E–F coupling, the winter dominance of MSTIDs matches that of gravity wave activity. This indicates that gravity waves probably play a major role in seeding the MSTIDs observed in this study. Theoretical assessments of the longitudinal variations of MSTID driving mechanisms are needed to better understand the seasonal asymmetry and how it is affected by solar activity.

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Theoretical and Computational Physics / 51

Adiabatic elimination approach to the completely positive master equation for open quantum Brownian motion

Author: Ayanda Zungu[1]

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Recently, Bauer *et al.* [1,2] introduced *open quantum Brownian motion* (OQBM) as a scaling limit of discrete-time open quantum walks [3,4], providing a new mathematical framework for quantum Brownian motion. In this setting, the dynamics of the Brownian particle are governed by dissipative interactions with a thermal bath and depend on the state of internal degrees of freedom. A microscopic derivation of OQBM for a free Brownian particle subject to decoherent interaction with a thermal environment was subsequently proposed [5,6]. In our recent work [7], we extended this framework by deriving OQBM in a generic dissipative scenario using the method of adiabatic elimination of fast variables. However, this approach led to a master equation that is not completely positive, consistent with the limitations of the standard Caldeira-Leggett model [8,9]. To resolve the issue of positivity, we now apply the rotating wave approximation (RWA) to the system-bath interaction Hamiltonian. This leads to a completely positive master equation for OQBM in the case of a weakly driven open Brownian particle confined within a quadratic potential and dissipatively coupled to a thermal bath. From the resulting dynamics, we derive equations for the first, second, and third cumulants of the position distribution of the OQBM walker.

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Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 52

Systematics study of octupole bands in rotating even-even nuclei to reveal rigid or soft octupole shape

Author: Muzomuhle Muzomuhle[None]

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The systematic study of octupole bands in rotating even-even nuclei has gained interest in understanding features of the octupole deformation, including octupole rigidity and softness. Furthermore, one could study how nuclear rotation influences this rigidity or softness and how experimental data from gamma-ray spectroscopy aligns with theoretical predictions for octupole deformation. Nuclear with octupole shape resembles the shape of a pear. They show pairs of alternating parity bands, providing evidence of octupole correlation that influences macroscopic and collective features of nuclear matter and fundamental nuclear properties. Rotation is a distinct motion in both classical and quantum mechanics. Assuming a constant moment of inertia, the excitation energy is proportional to the square of the angular momentum operator, and the gamma-ray energies are directly proportional to the angular momentum, I, and inversely proportional to the moment of inertia, J. Moreover, nuclei can show both quadrupole and octupole deformations, a property often seen in heavy nuclei within the A ≈ 240 mass region. The presence of ground-state bands and their associated 3-octupole bands indicates the existence of octupole correlations. At present, researchers often apply the alignments analysis to identify whether a nucleus maintains a rigid octupole shape or displays octupole softness, (octupole vibration). This alignment analysis relies on input dependent parameters like Harris parameters, which introduces limitations in understanding nuclear shapes clearly. To overcome this, a new Coriolis technique is introduced, offering a parameter-free approach to analyze experimental data obtained from the National Nuclear Data Center (NNDC). This analysis represents a technique to study octupole deformations across different isotopes and compare results with existing techniques. Such Coriolis analysis is used to identify whether a nucleus has a rigid octupole shape or a soft octupole shape (vibration).

keywords: Octupole deformation, Gamma-ray, Coriolis technique, Rigid octupole & Soft octupole

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MSc

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Poster Session / 53

Effects of Tin (Sn) doping on the layered LiMnO2 cathode material for Lithium-ion batteries

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Co-authors: Kemeridge Malatji [1]; Noko Ngoepe [1]; Phuti Ngoepe [1]

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Abstract
Lithium transition-metal oxides, such as LiM_2O_2 and $LiMO_2$ (where M = Ni, Mn, Co, etc.), are commonly used as cathode materials in lithium-ion batteries. These materials offer good capacity, low cost, high thermal stability, and energy density. However, they suffer from Jahn-Teller distortion, which leads to structural instability and decreased performance. One way to improve these materials is through cation doping, which has been shown to improve electrochemical performance, enhance electrical conductivity, and stabilize the crystal structure. This study focuses on the effects of doping with tin (Sn) in layered $LiMnO_2$ (R-3m) and examines the changes using first-principles calculations combined with the cluster expansion technique. The cluster expansion approach generated several new Sn-doped phases of $LiMnO_2$, resulting in 29 different phases, three of which were identified as stable and favourable. These stable phases $Li_4MnSn_3O_8$, $Li_4Mn_2Sn_2O_8$, and $Li_4Mn_3SnO_8$ all exhibited negative heats of formation, indicating that they are thermodynamically stable. Among these, $Li_4Mn_2Sn_2O_8$ was found to be the most stable phase, as it has the lowest heat of formation and lies at x = 0.5 in the binary phase diagram, with equal proportions of Sn and Mn. According to the heats of formation, $Li_4Mn_3SnO_8$ was predicted to be the most thermodynamically stable of the phases, furthermore $Li_4Mn_3SnO_8$ was also found to have no band gap, which leads to improved electron conductivity. All the generated structures are mechanically stable and are likely to with stand large amounts of plastic deformation before failure.

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Honours

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Nuclear, Particle and Radiation Physics-1 / 54

RADIOLOGICAL RISKS ASSESSMENT OF MINING VICINITIES USING RESRAD COMPUTER CODE

Author: Peter Oluwadamilare Olagbaju[1]

Co-authors: Olanrewaju Bola WOJUOLA [1]; Samuel Che NDE [2]; Lobina Gertrude PALAMULENI [2]

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Environmental radioactivity monitoring and protection often require measurement and modelling of natural radionuclides in environmental media and exposure pathways. In this study, the activity concentration of natural radionuclides determined using Broad energy germanium detector, was used to model the radiological risks for a hypothetical resident using Residual Radioactivity (RESRAD) computer code. The activity concentration of K-40, Th-232 and U-238 of soil sampled in Rustenburg mining vicinities was found to be less than global average values of 400 Bq/kg, 35 Bq/kg and 30 Bq/kg reported by the United Nations Scientific Committee on the Effects of Atomic Radiation respectively. The maximum total effective dose and excess life cancer risk estimated using RESRAD-offsite code in investigated area are 0.5190 mSv/yr at year 16.92 and 8.58 at year 0, respectively. Total excess life cancer risk is observed to be below 2.90 × 10-4, along with the total effective dose which is also lower than 1 mSv/yr reported by UNSCEAR (2000). Thus, the study reveals insignificant radiological hazards in investigated mining vicinities. However, regular environmental measurement and monitoring is recommended to ensure resident exposure is as low as reasonably achievable.

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None

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Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 55

Statistical Discrimination of Uranium Ore Concentrate Using Trace Element Signatures: Developing nuclear forensic fingerprints

Author: Liteboho Ntsohi[1]

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Similar to ordinary forensics, nuclear forensic science uses data and modelling to infer historical information such as origin and production processes. To do this, unique characteristics of different nuclear material that make up nuclear fingerprint must be identified. To date, very few characteristics have been identified as signatures for uranium ore and uranium ore concentrate(UOC) including the REE pattern and trace elements (geological indicators of deposit type). In this study, the concentrations of trace elements: Ti, V, Cr, Co, Ni, Cu, Zn, Ga, Rb, Sr, Y, Zr, Sn, Cs, Ba, W, Pb in 9 different UOC surrogate samples collected from Botswana and Nigeria were determined using Inductively Coupled Plasma Mass Spectrometry. The compositional trace element data were subjected to an arsenal of univariate and multivariate statistical analysis techniques such as correlation analysis, one-way Analysis of Variance, Principal Component Analysis, and Hierarchical Cluster analysis to quantify the statistical significance of the differences observed and to test the potential discriminative power of individual trace elements between ores from the same region. ANOVA revealed significant differences ($p<0.5$) in Ti, Zn and Pb only while no significant differences ($p>0.05$) were observed in V, Cr, Co, Ni, Cu, Ga, Rb, Sr, Y, Zr, Sn, Cs, Ba, W. The study further found three principal components that explained 91% of the variance in the UOC samples. PC1 (V, Ti, Pb, Sn), PC2 (Cr, Cu, Zr) and PC3 (Cs, Rb, Zn), respectively. This study highlighted the potential trace elements signatures to distinguish between uranium ore from different locations.

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PhD

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Poster Session / 56

Up-conversion and thermometric performance of CaF2:Tb3+, Yb3+ material

Author: Mubarak Yagoub[1]

Co-author: Buyisiwe. M Sondezi [1]

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Temperature is an essential parameter in our lives. This spans from low-temperature environments of natural processes, such as biological systems, to high-temperature environments of manufacturing devices. Thermographic luminescence materials are an essential medium for remote temperature measurements. Luminescence materials thermometry utilizes temperature-sensitive powders, usually of host materials doped with small amounts of activator ions like rare-earth and/or transition metal ions. Thermographic phosphors exhibit a change in the luminescence emission intensity, a shift in the emission spectrum, or a decrease in the lifetime with temperature, from which the temperature can be obtained after calibration. The temperature quenching range, sensitivity, and precision of measurement are determined by the intrinsic characteristics of the phosphor materials, and they help discover and engineer new materials with enhanced temperature-dependent luminescence properties.
This work investigated the up-conversion and thermometric performance of CaF2:Tb3+, Yb3+ up-conversion material. The structural analysis was done using X-ray diffraction. X-ray photoelectron spectroscopy was used to identify the elemental composition of the material. The up-conversion of CaF2:Tb3+, Yb3+ material exhibited emission from both 5D4-7Fj and 5D4-7Fj bands. The luminescence intensity ratio (LIR) technique was employed, using 5D4-7Fj and 5D4-7Fj bands of CaF2:Tb3+, Yb3+ up-conversion for potential thermometric application. The temperature-dependent luminescence properties suggest that the material has the potential for thermometric applications.

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None

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Yes, I ACCEPT

Physics for Development, Education and Outreach / 57

Effects of Learning Environments as Basis for Cognitive Achievements on the Understanding of Basic Physics Concepts

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Friendly learning environments have been studied to investigate their effectiveness as the basis of cognitive achievements in the understanding of basic Physics concepts. This is very important when it comes to this notorious subject in terms of difficulty. Students generally believe Physics is a difficult subject, where the challenge is particularly prominent in the first few years of their university experience. This is the stage where students deal with misconceptions about the concepts they need to understand for their success. In an endeavour to deal with this challenge, some lecturers seek ways and strategies for effective methods that could be used to make the delivery of this course easy and manageable for students. A friendly enabling environment was under investigation as one of the methods that was explored in teaching a specific module to a group of first-year students, to enhance their involvement, understanding and ownership of their learning of Physics concepts. This study reports on the findings of this method.

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None

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Yes, I ACCEPT

Poster Session / 58

Tunable Electronic Properties of Graphdiyne Under Tension and Compression: A DFT Study

Author: Neelam Saghir[1]

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Graphdiyne, a carbon allotrope characterized by its unique two-dimensional structure, semiconducting behavior, and rich sp-hybridized carbon content, shows great promise for practical applications in fields such as energy storage, catalysis, and gas separation. Understanding the electronic properties of graphdiyne under tensile and compressive deformation is essential for its integration into flexible and stretchable electronic devices. Mechanical strain can significantly alter its band structure, offering a viable route to tune its conductivity and semiconducting behavior. Exploring these strain-induced effects enables the design of graphdiyne-based components with adjustable electronic performance, which is crucial for applications in nanoelectronics, strain sensors, and adaptive optoelectronic systems.
Using first-principles calculations based on density functional theory, this study systematically explores the effects of tensile and compressive deformation on the electronic properties of graphdiyne. The results indicate that graphdiyne possesses a direct and tunable band gap that responds to mechanical strain. Under uniaxial deformation, the band gap generally decreases as strain increases. In contrast, biaxial deformation leads to a band gap that increases with tensile strain and decreases with compressive strain. Band gap values obtained using the HSE06 functional are higher than those calculated with the GGA method, though both approaches yield similar band structure profiles and consistent trends in the band gap variation with strain. As deformation intensifies, charge transfer between carbon atoms in graphdiyne becomes more significant. Compressive strain enhances the structural stability of graphdiyne, while tensile strain reduces it. Compared to uniaxial strain, biaxial deformation exerts a stronger influence on the band gap and overall stability, but has a comparatively weaker effect on charge transfer.

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None

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Applied Physics / 59

What are the most suitable basic solar irradiance models for Southern Africa?

Author: Sindiswa M. Figlan[1]

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Solar irradiance modelling is critical for determining local solar energy potential. Several past studies have analysed the more easily attainable Global Horizontal Irradiance (GHI) within Southern Africa. However, less research has been carried out on the physically more useful Direct Normal Irradiance (DNI) and Diffuse Horizontal Irradiance (DHI). This study aims to alleviate this by investigating for these local sites simple clear sky models which are solely dependent on the solar zenith angle and identifying the appropriate scaling parameters for DNI and DHI. The accuracy of the Meinel model for DNI and a Logarithmic model for DHI are evaluated and compared to the Power Law model more commonly used in solar irradiance modelling. The model evaluations were conducted using 1-minute resolution data taken from 5 stations within the SAURAN network: Vanrhynsdorp, Richtersveld, Graaff-Reinet (all located in South Africa), Gaborone (Botswana) and Windhoek (Namibia) over the period 2014-2021, with a minimum of 13 clear sky days selected per station covering all seasons.

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MSc

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Physics of Condensed Matter and Materials / 60

Quantum materials in 2D flatland

Author: Biplab Sanyal[1]

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Two dimensional (2D) materials have gained a very dominating position in the world of quantum materials due to their high potential for advanced applications in flexible electronics, optoelectronics, energy storage, catalysis, spintronics etc. An enormous playground exists in developing 2D van der Waals heterostructure by combining a variety of 2D materials for realising extraordinary properties. In this talk, I will present some interesting properties of 2D materials regarding their peculiar electronic and magnetic properties revealed by sophisticated quantum mechanical simulations. Effects of doping and defects will be presented. Proximity induced modifications of electronic and magnetic properties of 2D heterostructure will be demonstrated too.

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None

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Yes, I ACCEPT

Photonics / 61

Enhancing the Efficacy of Photodynamic Therapy: The Role of Hypocrellin B, Quercetin, and their combinations in Human Breast Cancer Cell Line

Author: Sheeja S Rajan[1]

Co-author: Heidi Abrahamse [2]

[1] *University of Johannesburg*

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Photodynamic therapy (PDT) is an emerging treatment modality that utilizes photosensitizers and light to induce cytotoxic effects in cancer cells. This study investigates the combined therapeutic potential of hypocrellin B (HB) and quercetin (Quer) in PDT against human breast cancer cell lines. The primary objective was to evaluate the effects of PDT with HB, Quer, and their combination on cell viability, oxidative stress, mitochondrial integrity, and apoptosis in vitro. We utilized the MTT assay to assess cell viability post-PDT treatment, followed by the LDH assay to measure cellular membrane integrity. The ATP assay was employed to evaluate the energy status of cells after PDT, while reactive oxygen species (ROS) production was measured using a ROS assay to assess oxidative stress. Mitochondrial membrane potential was monitored to determine the effects on mitochondrial health. Finally, apoptosis was assessed using annexin V/PI staining and flow cytometry, which allowed for the detection of early and late apoptotic cells. The results revealed that combination therapy with HB and Quer significantly enhanced cytotoxicity compared to individual treatments, as evidenced by a marked decrease in cell viability, elevated ROS production, and loss of mitochondrial membrane potential. Furthermore, combined treatment induced a higher percentage of apoptosis, suggesting a synergistic effect between HB and Quer in enhancing PDT efficacy. These findings highlight the potential of HB and Quer as effective PDT agents for breast cancer therapy, supporting further exploration of their combination in clinical applications.

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None

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Theoretical and Computational Physics / 62

A farewell to waves

Author: Geoff Beck[1]

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The wave nature of particles is a notoriously unintuitive feature of quantum theories. However, it is often deemed essential, due to material particles exhibiting diffraction and interference. Troublingly, Lande and Levy-Leblond have shown that de Broglie wavelengths are not relativistically covariant, making any such wave properties physically inconsistent. In this work we explore whether modern experiments vindicate
an alternative view: that apparent waviness in diffraction and interference scenarios emerges as a consequence of quantised interactions between particles. Such a view has historically received very little attention, despite being the exact modern explanation of both the Kapitza-Dirac effect and ultrafast electron diffraction. We study a photon orbital angular momentum realisation of the double slit to prove this explanation capable of unifying quantum interference phenomena.

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Yes, I ACCEPT

Astrophysics & Space Science / 63

Probing the pi-axiverse with astrophysics

Author: Geoff Beck[1]

Co-authors: Santiago Loane [2]; Stephon Alexander [3]; Tucker Manton [4]

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[3] *Brown University*

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With the WIMP parameter space slowly being ruled out by experiments on all fronts, axions have become a highly studied alternative dark matter candidate. In this talk we present a particle physics model where the pion states of a dark copy of QCD have both axion and dilaton phenomenologies. This model allows for the formation of dilute axion stars over a far larger parameter space than allowed in typical axion models. We explore whether such a model could be detected via FRB-like emissions associated with stable axion star mergers, these have unique broad spectra (rather than axion lines). We demonstrate that strong detection prospects exist for these events with both MeerKAT and upcoming experiments like the SKA and ngVLA.

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Yes, I ACCEPT

Photonics / 64

Evaluation of Pheophorbide a Phototoxicity in Melanoma Cells Grown as Three-Dimensional Multicellular Tumour Spheroids

Author: Nkune Nkune[1]

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Melanoma is the deadliest form of skin cancer, with a rapidly increasing incidence and a poor prognosis for patients diagnosed at advanced stages. Despite several available treatments, including surgical excision, chemotherapy, radiation therapy, and immunotherapy, resistance to these therapies remains a significant challenge, particularly when the tumour has metastasised. Photodynamic therapy (PDT) is a promising modality for the treatment of cancer because it is non-invasive and selectively damages the cancerous tissue, minimizing damage to adjacent healthy tissues. Currently, most PDT experiments are still conducted on two-dimensional (2-D) monocultures, which fail to accurately mimic native three-dimensional (3-D) tissue architecture. Therefore, 3-D cell cultures serve as excellent models to resemble tumour tissue in terms of structural and functional properties. Commercially purchased A375 melanoma cells used in this study were cultured as 3-D tumour spheroids and treated with pheophorbide-a at varying doses (1-40 ⊠M) and irradiated at a fluency of 10 J/cm2 with a 660 nm diode laser. Post-irradiation cellular changes were observed using microscopy, adenosine 5′-triphosphate (ATP), and lactate dehydrogenase (LDH) assays. Photoactivated pheophorbide a led to a significant dose-dependent response to PDT, demonstrating notable morphologic changes, increased cytotoxicity, and reduced cell viability. The study indicated that PDT with pheophorbide-a is an effective treatment method for eradicating melanoma cancer cells in vitro.

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Theoretical and Computational Physics / 65

Laplacian eigenmodes in twisted periodic topologies for new physics models

Author: Anele Ncube[1]

Co-authors: Alan Cornell [1]; Aldo Deandrea [2]; Rhameez Herbst [1]

[1] *University of Johannesburg*

[2] *Université Claude Bernard Lyon 1*

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Laplacian eigenmodes in non-trivial topologies (e.g. having twisted periodicity) are important in constructing a complete picture of the physics at play within models that incorporate compact extradimensional spaces. Determining them analytically is generally unwieldy, and the existing standard numerical methods have limited ability as spatial dimensions increase and when computing higher-index eigenmodes is required. To determine the feasibility of using physics-informed neural networks to compute Laplacian eigenmodes, we apply them to three primitive test cases: the Möbius strip, the real projective plane ($\mathbb{R}P^2$) and the 3-torus (T^3) in Cartesian coordinates. The neural networks approach's potential performance beyond solving the simpler cases is estimated in terms of the approximation errors obtained by comparing with known analytical solutions.

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PhD

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Yes, I ACCEPT

Poster Session / 66

Ab initio study of Structural, energetic, electronic, and mechanical properties of Pmmn-V2O5 and Pnma-V2O5 polymorphs through Density Functional Theory Analysis

Author: Azile Same[1]

Co-author: Ndanduleni Lethole [1]

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Research has increasingly shifted towards alternative battery chemistries due to the high costs, Lithium depletion and safety concerns of Li-ion batteries. Mg-ion battery chemistry has gained attention as a promising alternative in rechargeable battery technology due to the bivalency of Mg2+ ions. In this chemistry, Vanadium Pentoxide (V2O5) is projected to a suitable cathode material for rechargeable Mg-ion batteries due to its structural coordination, which ensures fast 3-D Mg2+ ion diffusion paths and prospects of being reversible intercalating cathodes. This study employed ab initio computational simulations to examine the structural, energetic, electronic, and mechanical properties of the Pmmn-V2O5 and Pnma-V2O5 polymorphs. These properties were thoroughly analyzed using first-principles methods based on Density Functional Theory (DFT). All calculations were performed using the CASTEP simulation code integrated within the Materials Studio 2020 software, utilizing the Generalized Gradient Approximation (GGA) of Perdew-Burke-Ernzerhof (PBE) functional. Geometry optimization was carried out to determine the structural properties, which were found to be more than 95 % in agreement with the experimental data. The electronic band structures along high-symmetry directions in the Brillouin zone for both spin-up and spin-down configurations revealed energy band gaps of 2.535 eV and 2.011 eV, respectively, around the Fermi level, indicating semiconductor behavior for both polymorphs. Furthermore, the elastic constants of the monocrystalline structure of Pnma-V2O5 satisfied Born Stability conditions, suggesting mechanical stability, while Pmmn-V2O5 polymorph exhibits instability. These findings provide a comprehensive understanding of the structural, electronic, and mechanical properties of the Pmmn-V2O5 and Pnma-V2O5 polymorphs.

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MSc

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Yes, I ACCEPT

Astrophysics & Space Science / 68

Modelling Earth's magnetic field over the South Atlantic Anomaly region using Swarm satellite and ground-based data

Author: Sanele Lionel Khanyile[1]

Co-authors: Emmanuel Nahayo [2]; John Bosco Habarulema [1]

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The Earth's magnetic field plays a critical role in shielding our planet from solar and cosmic radiation, yet the South Atlantic Anomaly (SAA) region represents a significant weakening of this protective shield. This research aims to model the temporal and spatial evolution of the SAA region using the Revised Spherical Cap Harmonic Analysis (R-SCHA) technique, providing improved regional characterization and predictive capabilities. Utilizing satellite data from Swarm, alongside ground-based observatory records, we aim to refine regional predictions of the SAA's extent and intensity. The R-SCHA technique offers an enhanced resolution of localized magnetic variations, crucial for understanding the anomaly's underlying geodynamo processes and space weather impacts. Preliminary results will be presented, showcasing advanced data selection and processing techniques, which are essential in core field modelling as external field contributions must be minimized. Additionally, an analysis of all ground-based magnetic station records within the SAA region will be discussed, to further improve modelling accuracy. These findings are evaluated through a comparative analysis with the CHAOS-7 global magnetic field model to assess their accuracy and reliability.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics of Condensed Matter and Materials / 69

Investigation of Titanium, Zirconium, Vanadium, and Palladium Multilayer Systems for Advanced Hydrogen Storage Applications

Author: Christopher Mtshali[1]

Co-authors: Magubane Siphesihle [1]; Mojesi Rampai [1]; Mongwaketsi Nametso [1]; Nemukula Enos [1]; Zakhelumuzi Khumalo [1]

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Interest in utilizing solid materials for hydrogen storage has grown in recent years due to the necessity of reducing greenhouse gas emissions by harnessing hydrogen as an energy source. While this approach is generally regarded as safe, significant challenges remain in developing materials that are effective, easily synthesized, cost-efficient, highly stable, and exhibit rapid sorption kinetics. Moreover, the presence of oxides can considerably diminish the efficiency of potential solid materials designated for this purpose. In this study, we examined multi-layered systems comprised of thin films of titanium (Ti), zirconium (Zr), vanadium (V), and palladium (Pd) for hydrogen storage applications. Through the elastic recoil detection analysis (ERDA) technique, we found that the hydrogen content decreased as the oxygen concentration in the layers increased, underscoring the detrimental impact of oxygen on the system. Specifically, samples with a titanium oxide (TiO) ratio of 1:1 and vanadium oxide (VO) ratio of 1:1 exhibited a total hydrogen content of 99.122 atomic percent (at.%) at 200 ℃, whereas those with titanium trioxide (Ti2O3) at a 2:3 ratio and vanadium trioxide (V2O3) at a 2:3 ratio displayed a reduced hydrogen content of 60.016 at.% at 300 ℃, indicating a substantial change. The optimal temperature range for achieving the highest hydrogen content was determined to be between 200 ℃ and 300 ℃. To address the adverse effects of oxides, we propose employing an ion implantation mechanism in conjunction with in-situ thermal annealing to create oxygen-free samples for testing in hydrogen storage applications. The outcomes of this investigation, along with the proposed mechanisms, are presented and discussed.

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Poster Session / 70

MHD simulations of Lambda Cephei like astrospheres

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In this work simulations of the interaction of a stellar wind with the interstellar medium, which forms an astrospheric cavity, are presented. Results are shown where the astrosphere of Lambda Cephei is simulated for three different scenarios, corresponding to three different ISM speeds. The results can be visualized as density contour plots as well as radial profiles for different simulation periods. From these results, as the ISM speed increases, the astrospheres become more compressed and more bullet-shaped due to the increasing ISM ram pressure which reduces the bow shock and termination shock distances. Also shown are the importance of radiative cooling on astrospheric evolution. The inclusion of this process in magneto-hydrodynamic simulations result in a thinner outer astrospheric shell due to a decrease in thermal pressure.

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Honours

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Yes, I ACCEPT

Poster Session / 71

Enhancing Gamma-Ray Spectrometry Through Convolutional Neural Networks and Kolmogorov–Arnold Networks

Author: Vuako Maluleke[1]

Co-authors: Edward Nkadimeng [2]; Fhulufhelo Nemangwele [3]; Ntombizikhona Beaulah Ndabeni [4]

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Gamma-ray spectrometry remains a cornerstone technique in nuclear science and environmental radioactivity assessment, offering precise identification and quantification of radionuclides. Despite its efficacy, conventional analytical methods often rely on manual processing, which can introduce subjectivity, reduce throughput, and hinder real-time analysis. In this study, an automated framework is proposed for gamma-ray spectrometry by employing two advanced deep learning architectures: Convolutional Neural Networks (CNN) and Kolmogorov–Arnold Networks (KAN). The models are trained and evaluated using high-resolution spectral datasets acquired from high-purity germanium (HPGe) detectors. Input features include energy, channel, peak area, and centroid, extracted through digital signal processing techniques. Model performance is assessed based on standard classification metrics such as accuracy, precision, recall, and F1-score, allowing for a comparative evaluation of the CNN and KAN methodologies in terms of classification robustness and generalization capability. This work aims to demonstrate the potential of deep learning for automating gamma-ray spectrum interpretation, thereby enhancing the efficiency, reproducibility, and scalability of nuclear measurement systems. Detailed performance comparisons and implications for real-world deployment will be discussed during the presentation.

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MSc

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Yes, I ACCEPT

Physics for Development, Education and Outreach / 72

Practical teaching methods for enhanced interest in teaching and learning Physics for undergraduate university students

Author: Buyisiwe Sondezi[1]

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Challenges in the teaching and learning of physics existed as far as education existed worldwide. Lecturers and facilitators continually seek various approaches that could yield desirable results. However, the learning gains have mostly been disappointing, and physics is labelled as a difficult subject for the chosen few. That idea encouraged instructors to accept physics failure rates as normal. Whilst other efforts and approaches, which include extra classes and winter schools, are continually used, departing from the belief that physics is for the chosen has proven to be a challenge. In this work, we explore how teaching and learning can be enhanced using some 'easy-to-adopt approaches'that can potentially give desired results. The concept identification of prior learning of learners'understanding of the concepts, how to use social constructivism teaching strategies, and evaluating the effectiveness of these teaching and learning strategies will be presented.

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None

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Yes, I ACCEPT

Poster Session / 73

Nitrogen Flushing Efficiency in the ITk Outer Pixels of the Upgraded ATLAS Detector: A Steady-State Computational Fluid Dynamics Study

Author: Emmanuel Igumbor[None]

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The ATLAS inner tracker (ITK) proposed for the upgrade is divided into the strips, outer pixels and inner pixels, each with its own complexities and inbuilt systems. The outer pixel is sandwiched between the strips and the inner pixel. It is flushed with N_2 from the inlet to the outlet to maintain the dryness of the outer pixels. However, specific temperature, humidity and dew point temperature distributions must be maintained to keep the outer pixels always dry. Computational Fluid Dynamics (CFD) has been used to provide engineering insights into upgrading the ITK. For the efficient performance of the ITK, specific positions where sensors must be placed should be carefully considered. These positions should remain dry, maintaining an average dew point distribution of -60 ℃. Therefore, to provide insight into the environmental conditions of the outer pixels, a CFD model has been developed. The CFD method was employed alongside the equations for the conservation of mass, momentum, energy and species. Due to the high flow rates, turbulent flow was assumed for all simulations. The Reynolds-averaged Navier-Stokes (RANS) equations were utilized and discretized using the finite volume method. For turbulence modelling in the enclosed domain, the standard ⊠-ϵ model with standard wall functions was applied. The temperature distribution, humidity and dew point temperature distribution of N_2 flushing in the outer pixels were predicted. The results showed that the temperature distribution ranges from 25 ℃ in regions with temperature boundary conditions to -20 ℃ in the inner structure of the outer pixel. The humidity in the outer pixels was 2.3 %, while the dew point had a maximum of -60 ℃ and a minimum of -80℃, except in areas with room temperature (25 ℃) boundary conditions. The results indicate that at the obtained dew point value, condensation in the outer pixel will not occur. Hence, the outer pixel will remain dry, validating the experimentally required specifications

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Yes, I ACCEPT

Physics of Condensed Matter and Materials 2 / 74

Exploring the structural, magnetic, and elastic properties of Mn50Al50-xSnx alloys: A DFT study

Author: Thabang Mokwena[1]

Co-authors: Hasani Richard Chauke [1]; Phuti Esrom Ngoepe [2]; Ramogohlo Diale [3]

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Permanent magnets have the unique property of maintaining a high magnetic flux density when there is no external magnetic field. The ferromagnetic τ-phase MnAl intermetallic compound stands out as a promising candidate for rare earth-free magnets, attributed to its good machinability, low cost, and low density. However, the material was reported to be brittle and thermodynamically unstable. To mitigate this problem, the density functional theory is employed to investigate the structural, thermodynamic, magnetic, and elastic properties of Mn50Al50-xSnx alloys in the range (0≤x≤25). The lattice parameters of the binary MnAl were found to be in good agreement with previous theoretical and experimental data within 5%. Heats of formation results showed that substituting Al with Sn slightly decreases the thermodynamic stability of Mn50Al50-xSnx alloys. It was found that Mn50Al50-xSnx, in the range (0 ≤ x ≤ 25), shows ferromagnetic behavior due to non-zero net spin magnetic moments. Doping with Sn was found to enhance the magnetic strength of the system. The brittleness of the system reduces with increasing Sn concentration; however, complete ductility is not yet attained. The findings will provide valuable insights into the development of advanced permanent magnets.

Keywords: Mn50Al50-xSnx alloys, Density Functional Theory (DFT), Magnetic properties, Ductility

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MSc

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Yes, I ACCEPT

Astrophysics & Space Science / 75

Compton-induced cascade γ-rays in the radio galaxy NGC 1275

Author: Ntshatsha Mfuphi[None]

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Among the active galactic nuclei (AGNi), blazars are the brightest emitters of high- (HE, $E \geq 100\,\mathrm{MeV}$) to very-high-energy (VHE, $E \geq 100\,\mathrm{GeV}$) γ-rays from their jets. Radio galaxies, being the misaligned parent population of the blazar class, were historically not observed at these frequencies. However, there is a growing number of radio galaxies detected in HE–VHE γ-rays in recent years. In this work, we leverage and refine a Monte-Carlo photon and electron-positron ($e^{\pm}$) tracking code in the AGN environment of the radio galaxy NGC 1275. In the code, we consider the isotropic broad emission line and Shakura-Sunyaev (SS) accretion disk radiation fields, with mild magnetic fields in the AGN environment. We find that cascade γ-rays from the inverse-Compton scattering by relativistic $e^{\pm}$ pairs of these external radiation fields can explain the \emph{Fermi} Large Area Telescope' s (LAT) observation of the radio galaxy NGC 1275. We present a set of parameters obtained from the code and fit the source's spectral energy distribution during the flaring events recorded in December 2022 and January 2023.

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None

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Yes, I ACCEPT

Applied Physics / 76

POWER LAW MODEL (PLM) APPROACHES TO PREDICT THE PERFORMANCE OF A SMALL-SCALE PV SYSTEM

Author: Abraham Dimitri Kapim Kenfack[1]

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This paper proposes a mathematical approach to predict the real-time performance of the small-scale photovoltaic (PV) system mounted at the Arcadia based on the power law model (PLM), commonly used to predict the I-V curves of solar cells in standard test conditions (STC). The shape parameters involved in the PLM known as m and μ in this study were determined using experimental data collected under normal weather conditions (irradiation and temperature) based on the Newton-Raphson algorithm iterative method. From the investigations performed on the MATLAB platform, the obtained results reveal that the shape parameters do not strongly depend on temperature and irradiation as shown by the low correlation of 0.296 and -0.110 respectively for μ and -0.201 and -0.188 respectively for m . We also notice that the shape parameters are strongly correlated to the output electrical parameters: μ is strongly correlated to the fill factor with a correlation factor of 0.958 while m strongly depends on voltage with a correlation factor of 0.784. Additionally, this approach predicts with high accuracy in real-time, the output electrical parameters of the PV system with the mean value of R2, RMSE, and correlation r of about 0.99, 3.07 %, and 0.99 respectively. Furthermore, we noticed that the parameter μ varies between 0.8 and 1 during winter and from 0.5 to 0.8 in summertime, while m fluctuates between 10 and 20 during winter and from 10 to 25 during summertime. This approach offers high accuracy because the shape parameters take into account the dynamical behavior of the losses (internal and external), such as recombination effect, series and shunt resistance in each PV module, which varies under different weather conditions. The limitation of this model is that we do not have enough information that links the shape parameters to the electrical parameters such as ideal factor, saturation current, shunt, and series resistance to perform the qualitative investigation based on the shape parameters. Additionally, we do not have a mathematical formula that can facilitate the determination of the shape parameters to predict the performance of the PV system.

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None

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Yes, I ACCEPT

Poster Session / 77

Adsorption behavior of ternary Fe1-XYXAl alloy with H2O and O2

Author: Christy Graced[None]

Co-authors: Hasani Richard Chauke [1]; Ndanduleni Lethole [2]; Phuti Esrom Ngoepe [3]

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Iron aluminide is a metal alloy with unique properties, including high strength and temperature resistance, making it suitable for applications in aerospace and energy sectors. FeAl alloy has a good specific modulus, strength-to-weight ratio, and corrosion resistance to oxidation, sulfidation, and other forms of corrosion. These iron-aluminides showed a major embrittlement mechanism at room temperature, resulting in a loss of cohesive strength at their interfaces. Hence, the concept of surface is used to form a boundary as a protective layer on the outermost layer of a material through surface doping. This phenomenon influences factors such as adsorption and the formation of surface states. For high-temperature structural applications, such as high melting and disordering temperatures, high stiffness, low diffusivity, etc., also makes these alloys a challenge to process into useful developed materials. Hence, the need to improve the surface properties to enhance strength, adhesion, and durability through the development of new materials. The increasing availability of computational software programs with advantageous and improved methodologies, such as Metadise and VASP codes were was employed to evaluate surface properties. The alumina layer (Al2O3) formed on the metal's surface acts as a good barrier against oxygen penetration, delaying the production of other faster-growing oxides, which deteriorate the surface stability. The Eads/H2O showed higher surface energies compared to those of O2, which implies that Eads/O2 is more stable with the lowest surface energies compared to those of H2O. This is confirmed by literature that a protective Al2O3 oxide layer forms on the surface of the material, thus minimizing oxidation behaviour.

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PhD

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Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 78

Nature of the low-spin states in the moderately-deformed triaxial ¹⁹³Au nucleus

Author: Sinegugu Mthembu[1]

Co-authors: Beatrice Similindi [2]; Deon Steyn [3]; Elena Atanassova Lawrie [3]; Ignasio Wakudyanaye [4]; Jacobus Lawrie [5]; Linda Mdletshe [6]; Lucky Makhathini [5]; Makuhane Sithole [7]; Nico Orce [5]; Nkonzo Xulu [8]; Robert Bark [3]; Sikhanyiso Shabane [2]; Siyabonga Majola [9]; Thifhelimbilu Bucher [10]

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Unlike axially symmetric nuclei, triaxial nuclei give rise to exotic collective phenomena, such as nuclear wobbling and chirality—topics that have garnered significant attention in recent years. These phenomena not only challenge our understanding of nuclear deformation, but also enrich the landscape of gamma spectroscopy with distinctive signatures that demand both experimental and theoretical exploration. It has been recently proposed that odd-mass triaxial nuclei can exhibit wobbling motion even at low spins [1]. Excited bands interpreted as wobbling modes have been reported in several nuclei, including the gold isotopes ¹⁸³Au and ¹⁸⁷Au, which are excellent candidates for studying such phenomena due to the presence of triaxial shapes in this mass region [2,3].
In ¹⁸³Au, an excited band built on the h_{9/2} configuration was associated with transverse wobbling, where the odd proton aligns along the short nuclear axis [4]. In contrast, ¹⁸⁷Au showed evidence for longitudinal wobbling, with the odd proton aligned along the intermediate axis [5]. This difference in the angular momentum alignment of the valence proton in these two isotopes is particularly intriguing, as their proton Fermi levels are expected to be similar. The strongest experimental evidence supporting the wobbling interpretation was based on the evaluated large mixing ratios of the transitions linking the excited and yrast h_{9/2} bands. However, a recent remeasurement of these mixing ratios in ¹⁸⁷Au revealed a dominant M1 component [6], which rules out the earlier proposed wobbling interpretation. These contrasting findings highlight the challenges of such measurements and underline the need for further investigations—particularly in the gold isotopes.
In the present study, low- to medium-spin excited states of ¹⁹³Au were investigated using the tape station setup at iThemba LABS. These states were populated via β-decay following the ¹⁹⁷Au(p,5n)¹⁹³Hg reaction at E_p = 50 MeV. The resulting gamma rays were detected with three Compton-suppressed clover detectors and one Compton-suppressed segmented clover detector. In addition, a Si(Li) detector was used to measure internal conversion electrons. These measurements allowed us to explore the interplay between single-particle and collective excitations in bands based on the h_{9/2} and h_{11/2} configurations at low to medium spin. Various techniques were employed to extract multipole mixing ratios and assign spins and parities to the observed states. Furthermore, Quasiparticle plus Triaxial Rotor (QTR) calculations were performed to characterize the nature of the excited states.
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[6] S. Guo, et al., Phys. Lett. B, 828, 137010 (2022).

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PhD

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Physics of Condensed Matter and Materials 2 / 79

A DFT novel study on acidic and neutral arsenate and enoic/enoate collectors adsorption on spodumene and feldspar mineral surfaces

Author: Lesetja Matlabjane[1]

Co-authors: Peace Mkhonto [1]; Phuti Ngoepe [1]

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Spodumene ($LiAlSi_2O_6$) is a significant source of lithium that is widely used for commercial purposes such as in batteries, particularly for electric vehicles. In natural ore deposits, spodumene is commonly found alongside feldspar as the common gangue mineral. Density functional theory computational method was used in this study to investigate the interaction of arsenate and enoate/enoic collectors on both minerals at acidic and neutral simulated conditions. The minerals most stable surface had surface energies of 0.71 J/m². for Spodumene (110) surface, while the feldspar (001) surface had 0.831 J/m². The collectors, hydrogen butyl arsenate, sodium butyl arsenate, (E)-4-octenoic acid and sodium (E)-4-octenoate were adsorbed on the (110) surface of spodumene and (001) surface of feldspar. The butyl sodium arsenate molecule preferred to bind with the Al atoms on the spodumene surface and gave the most exothermic adsorption energy of -630,38 kJ/mol. For feldspar, the butyl hydrogen arsenate gave the adsorption energy of -335,41 kJ/mol. This showed that the arsenate collectors bind stronger than the enoate and enoic acids which are similar to oleic acids. Moreover, the arsenate prefers to bind strong with spodumene than feldspar, which suggest that the collector is feasible to separation of these minerals. Furthermore, spodumene prefers to bind strong with arsenate under neutral condition, while the feldspar bond strong at acidic. Therefore, the separation of spodumene from feldspar may be achieved using arsenate collector under neutral conditions.

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MSc

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Yes, I ACCEPT

Photonics / 80

Evaluation of the Phototoxic effect of Chemically Synthesized Silver Nanoparticles on Breast Cancer Cells

Author: Isaac Baidoo[1]

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Silver nanoparticles (AgNPs) have attracted considerable interest in cancer therapy, whereby their cytotoxicity is largely associated with the production of reactive oxygen species (ROS), as well as interfering with cancer cell energy metabolism and multidrug resistance. Other than their inherent cytotoxic potential, AgNPs have advanced significantly as carriers for drug delivery, improving the stability and targeting efficiency and cancer diagnosis. Further, the ability of AgNPs to convert absorbed light into heat, thus effectively inducing localized hyperthermia to selectively target and destroy cancer cells attributed to their photothermal efficacy. This study investigates the cytotoxic and phototoxic efficacy of chemically synthesized AgNPs in the MCF-7 breast cancer cell line. The AgNPs were synthesized via chemical reduction and characterized using ultraviolet-visible spectroscopy, Zetasizer, and dynamic light scattering. MTT assay was conducted to evaluate the cell viability percentage with or without light irradiation at 5 J/cm2 with 405 nm blue light Diode Laser. Furthermore, the AgNPs-induced cell death was visualized with Bright Field Microscopy. The photothermal induced temperature increase of AgNP solution was measured with a Thermal Camera.
The UV-Vis spectra confirmed the formation of AgNPs with a characteristic surface plasmon resonance (SPR) band between 300 nm and 600 nm, with a maximum absorption peak observed at 402 nm. Further physicochemical analysis revealed an average hydrodynamic diameter of 119.3 dnm, a zeta potential of −30.8 mV, and a polydispersity index (PDI) of 0.269 at pH 7.65, indicating suitable size distribution, surface charge, and colloidal stability under physiological conditions. A dose-dependent cytotoxic response was observed across treated groups. At 5 µg/mL, MCF-7 cells exhibited 64.4% viability in the absence of irradiation, while exposure to 405 nm laser resulted in a reduced viability of 50.1%, demonstrating enhanced cytotoxicity following photoactivation. Without AgNP treatment, laser exposure alone produced a negligible ~1℃ temperature increase. In contrast, AgNP-treated samples displayed a 3℃ increase over 120 seconds of irradiation, confirming the nanoparticles'photothermal conversion capability. The observed enhancement in cytotoxicity upon irradiation suggests a localized hyperthermic effect accompanied by plasmon-mediated generation of ROS. These findings support the contribution of both photothermal and photodynamic processes to the overall phototoxic efficacy of the AgNPs.
These results collectively demonstrate that AgNPs facilitate enhanced cancer cell death through the integration of photothermal and photodynamic mechanisms, supporting their potential application as photo-responsive agents in targeted cancer therapy.

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MSc

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Yes, I ACCEPT

Photonics / 81

Rate equations for the control of Yb-171 ions

Author: Abigail Iyer[1]

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Trapped ions are promising candidates to use as qubits in quantum computers, offering long coherence times, scalability, and precise control of the states of each ion individually by means of lasers. The long-term goal of this quantum control project is to achieve unsharp measurements with two isotopes of ytterbium, Yb-171 and Yb-174, in a linear Paul trap. To predict and interpret experimental results for one of the species, Yb-171, we numerically model the atom-radiation interactions using rate equations. Rate equations are a set of coupled, first-order differential equations describing the time-dependent evolution of the ion's hyperfine state populations due to transitions between levels. We semi-classically model the interaction between the ion valence structure and lasers, which includes electric dipole and electric quadrupole transitions. Using the model, we analyse hyperfine state population dynamics to gain insights on how to increase the efficiency of and estimate timescales for various quantum control processes used experimentally. These processes include doppler cooling, state preparation , electron shelving and state detection. Ions are doppler cooled to reduce their kinetic energy so that they remain trapped, enabling precise control and manipulation. Doppler cooling is estimated in the simulation as an accumulation of spontaneous emission due to driving a transition. State preparation initialises the ion into the qubit ground state. We model electron shelving by populating and depopulating a long-lived metastable state by pumping an electric quadrupole transition. State detection is performed by pumping a closed loop transition that produces measurable fluorescence. To recover efficiency of these processes, several additional lasers are used to depopulate dark states.
Understanding how these processes influence the ion's state is crucial for optimizing them, ultimately improving future experimental control and efficiency in the laboratory.

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MSc

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Physics of Condensed Matter and Materials / 82

Physiochemical, optical and magnetic properties of nickel-magnesium ferrite nanoparticles for various applications

Author: Sifiso Nxumalo[1]

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The current work focuses on the properties of MgFe2O4, Ni0.5Mg0.5Fe2O4, and NiFe2O4 nanoparticles synthesized via the glycothermal reaction method. The product compounds were characterized for structural, morphology, optical, and magnetic properties using X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FT-IR), Transmission electron microscopy (TEM), Scanning electronic microscope (SEM), and Energy dispersive X-ray spectroscopy (EDX). Their magnetic properties were evaluated using Electron paramagnetic resonance (EPR) and Mössbauer spectroscopy (MS) techniques. XRD data for all materials revealed single-phase formation with no impurities detected. Using the Debye-Scherrer equation calculated from the highest peak (311) plane, the crystal sizes for MgFe2O4, Ni0.5Mg0.5Fe2O4, and NiFe2O4 were determined to be 11.4 ± 0.2 nm, 9.1 ± 0.2 nm, and 8.6 ± 0.2 nm, respectively. XRD data was also used to determine the values of the lattice parameters, which were 8.380 nm, 8.350 nm, and 8.330 nm for MgFe2O4, Ni0.5Mg0.5Fe2O4, and NiFe2O4, respectively. The reduction in these values was attributed to smaller ionic radii of Ni+2 (0.069 nm) substituting larger ions of Mg+2 (0.072 nm). A single spinel structure of the ferrites was also confirmed by FT-IR data where two bands near 400 cm-1 and 600 cm-1 were observed, which are the features of the single spinel structure. Hence, the XRD and FT-IR results correlated well. TEM images reveal spherical-shaped particles for all materials with average particle size distribution for MgFe2O4, Ni0.5Mg0.5Fe2O4, and NiFe2O4 nanoparticles as 18.62 ± 3.42 nm, 17.46 ± 2.59 nm, and 16.11 ± 2.93 nm, respectively. The morphology of the nanoparticles observed from SEM photograms shows clustering and fewer clustered particles as the substitution of the magnesium ions increases. The elements in each compound were verified using energy-dispersive EDX and confirmed to be true as the desired compounds. No contamination was observed. The optical properties were investigated using UV-visible spectroscopy. The energy values for the band gap derived from the Tauc plot were obtained for MgFe2O4, Ni0.5Mg0.5Fe2O4, and NiFe2O4 nanoparticles were 2.07 eV, 1.92 eV, and 1.88 eV, respectively. The magnetic nature of the prepared samples was established through EPR and MS. The EPR study confirmed the paramagnetic behaviour of the materials. MS results revealed ferrimagnetic and paramagnetic Fe ions in materials. MS spectra were fitted with two sextets (ferrimagnetism) and one doublet (paramagnetism). These results suggest that these materials can be suitable for various applications, such as in medical and electrical.

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Physics of Condensed Matter and Materials 2 / 83

Structural, stability, and magnetic studies of polymer-coated magnesium-zinc ferrite nanoparticles synthesized via glycol-thermal route

Author: Sakhile Sduduzo Mthimkhulu[1]

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Magnesium-zinc ferrite (Mg1-xZnxFe2O4, for $0 \leq x \leq 1$ Nanoparticles (NPs) were successfully synthesized using the glycol-thermal reaction method. The NPs were then coated with a biocompatible polymer (chitosan). The naked and coated materials were characterized for structural properties using an X-ray diffractometer (XRD), where crystallite sizes increased from an average of 12.79 nm to 14.98 nm, while the average lattice parameter reduced from 8.38 to 7.94 Å upon coating. The surface morphology of the material was evaluated using Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM). TEM images reveal spherical shape particles for all NPs with an enhancement after coating, while SEM photograms reveal less agglomeration after coating. The stability of the NPs in an aqueous environment was evaluated using an Antoni par reactor (littersizer DLS 500), where the chitosan-coated NPs exhibited zeta-potential above +30 mV, which is attributed to stable particles compared to the naked particles. 57Fe Mössbauer spectroscopy, Vibrating Sample Magnetometer (VSM), and Electron Spin Resonance (ESP) techniques were used to study the magnetic properties of the as-prepared and coated NPs. Mössbauer spectra show ferrimagnetism for $x \leq 0.5$ and paramagnetism for $x > 0.5$ at room temperature. The magnetization hysteresis loops obtained by the VSM exhibited the presence of superparamagnetic NPs in both as-prepared and coated NPs. More significant saturation magnetization and coercive field were observed in the concentration of $x = 0$ compared to $x = 0.5$ and 1.0 NPs. This was attributed to the Mg+2 magnetic ions substituting the non-magnetic Zn+2 ions. Including the chitosan on the surface of Mg-Zn ferrite NPs shows good stability, suggesting moderate results. The polymer coating shielded the magnetizations of the as-prepared NPs, which enhanced the decrease in the saturation magnetization values. Furthermore, this reduction in the saturation suggested the superparamagnetism behavior of the coated NPs, and this property is one of the essential features in the application of magnetic NPs as drug-delivery agents. Conclusively, these polymer-coated ferrites present feasible nanocarriers in magneto-targeted drug delivery.

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MSc

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Poster Session / 84

Long-term Be disc structural study of Be X-ray binaries using MeerLICHT

Authors: ITUMELENG MONAGENG[1]; Muano Mbedzi[2]; Nnditshedzeni Eric Maluta[3]; Tshifhiwa Steven Ranwaha[3]

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Be X-ray binaries (BeXBs) are a subclass of high-mass X-ray binaries consisting of a Be star and a compact object, typically a neutron star. The Be star features a Keplerian disc, known as a "decretion" disc, in its equatorial regions. This disc is thought to form due to the star's rapid rotation. The interaction between the decretion disc and the neutron star leads to the accretion of matter, which results in increased X-ray emissions.

Variability in the decretion disc of BeXBs spans a wide range and is primarily observable at optical wavelengths. Key observational characteristics of Be discs include emission lines in optical spectra, photometric variability, and infrared excess. Understanding long-term variations within the decretion disc is essential, as it is this matter that ultimately contributes to the multiwavelength emission observed in these systems.

In this study, we use long-term multi-band photometric data from the MeerLICHT wide-field optical telescope to examine changes in various properties of the discs over different timescales. The optical data includes ugriz+q photometry, and we systematically analyse changes in brightness and color from a sample of BeXBs located in the Small Magellanic Cloud, each with distinct orbital parameters.

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Honours

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Poster Session / 85

IoT-Based SCADA for remote monitoring and controlling PV Water Pumping Systems

Authors: Annita Jokazi[1]; Eric Maluta[2]; LIVHUWANI MASEVHE[3]; Tshifhiwa Ranwaha[1]

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Over the past decade, photovoltaic water pumping system (PVWPS) concept failed to perform optimally due to its complexity of multiple systems that run together. Lack of access to real-time data caused poor system's performance and ultimately ceased to supply the solar energy to pump the water. Therefore, a system to integrate and manage the multi-systems nexus of PV solar power output, water pumping, automated irrigation, and water leakage signature is necessary. The aim of the current study is to present the implementation of Supervisory Control and Data Acquisition (SCADA) system for real-time remote monitoring and control of the PVWPS to control the remote terminal units (RTUs) and programmable logic controllers (PLCs) microcomputers that are deployed across the sites. The proposed SCADA system communicates with site equipment such as sensors and actuators for pumps and valves, solar panels and inverters, motors and variable speed drives, sensors and HMI. It involved the reflection of data on a Human Machine Interface (HMI) from different sensors, which are deployed on different locations and data was stored in a cloud system upon which it was able to be visualized and interpreted. The architecture of IoT-based SCADA leveraged on the ThingSpeak IoT platform with built-in MATLAB for advanced analytics. The results show an IoT cloud application, a very user-friendly open source webapp with its built-in intuitive functionalities, for processing, logging and visualising data remotely. It is essentially capable of exploring, visualising: solar PV generation, site-consumption (water and power), water level, meteorological parameters and ON/OFF button to run or stop the pump remotely. The PVWPS dashboard also shows key reports such as the aggregated historic data in daily, weekly, monthly, quarterly and annual totals. This approach of integrating IoT and SCADA technologies to optimize water-energy management in PVWPS offers a reliable and sustainable solution that reduces consumption and enhances productivity.

Keywords: Supervisor Control and Data Acquisition, Photovoltaic water pumping systems, Remote Terminal Unit, Internet of Things, ThingSpeak

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MSc

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Poster Session / 86

First-Principles Investigation of the Structural, Electronic, and Optical Properties of $CsPbI_3$ Perovskite for Solar Cell Applications

Authors: Mkhatshwa Xolile[1]; Tshifhiwa Ranwaha[1]; ELKANA RUGUT[2]; Eric Maluta[3]

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The growing global energy crisis necessitates the search for sustainable and environmentally friendly alternatives to fossil fuels. In this study, first-principles Density Functional Theory (DFT) calculations were employed to investigate the structural, electronic, optical, and mechanical properties of the all-inorganic perovskite compound $CsPbI_3$, a promising material for clean energy applications. Using the generalised gradient approximation (GGA-PBE functional) within Materials Studio, the crystal structure was optimized, and the electronic band structure, density of states (DOS), and optical absorption spectrum were analyzed. The results revealed that $CsPbI_3$ exhibits a suitable bandgap and strong optical absorption, making it a potential candidate for efficient solar cell applications. Mechanical property calculations, including elastic constants, bulk modulus, shear modulus, Young's modulus, and Poisson's ratio, confirmed the material's mechanical stability, satisfying the stability criteria for cubic systems. The material resisted shear deformation and ductile behaviour, as indicated by a bulk-to-shear modulus ratio (B/G) of 2.01 and supportive Pugh's and Poisson's ratios. Furthermore, low reflectance and high optical conductivity suggest excellent optoelectronic performance, while thermodynamic analysis confirmed its stability under operating conditions. Overall, the study provides valuable theoretical insights into the suitability of $CsPbI_3$ perovskite for solar energy harvesting and other energy-related applications, contributing to the advancement of clean and sustainable energy technologies.

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Physics of Condensed Matter and Materials / 87

Synthesis, Structural, and Gas Sensing Properties of Rare Earth-Substituted Zinc and Cobalt Ferrites: A Comparative Study

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This study presents a comprehensive comparative analysis of pure and rare earth (RE)-substituted spinel ferrites, including $ZnFe_2O_4$, $CoFe_2O_4$, $Zn_{0.05}Co_{0.05}Fe_2O_4$, and their Gd^{3+}- and Nd^{3+}-substituted counterparts, synthesized via the glycothermal method. The substitution of RE ions at Fe^{3+} octahedral sites was employed to investigate their impact on the structural, physicochemical, and gas sensing properties of the materials. XRD confirmed the formation of single-phase cubic spinel structures across all samples. A distinct shift in diffraction peaks toward lower angles upon RE substitution indicated lattice expansion, attributable to the larger ionic radii of Gd^{3+} and Nd^{3+}. The average crystallite sizes, calculated using the Debye-Scherrer equation, were approximately 11.3 nm for $ZnFe_2O_4$, 8.2 nm for $CoFe_2O_4$, and 22.3 nm for $Zn_{0.05}Co_{0.05}Fe_2O_4$, with slight variations following rare earth doping. FTIR spectroscopy exhibited characteristic metal–oxygen stretching bands near 540 cm^{-1} and 410 cm^{-1}, corresponding to tetrahedral and octahedral sites, respectively. Shifts and broadening of these peaks in RE-doped samples confirmed modifications in the local bonding environment and cation distribution. HRTEM images revealed partly spherical nanoparticles with uniform size distribution and clearly resolved lattice fringes. Interplanar spacing in RE-substituted samples ($x = 0.10$) was ~0.292 nm for the (220) planes, except for $ZnGd_{0.10}Fe_{1.90}O_4$, which exhibited 0.486 nm spacing in the (111) plane. These values aligned well with XRD data and reflected enhanced surface roughness and boundary strain favourable traits for surface active applications. EPR spectra at room temperature revealed g-values ranging from 2.10 to 2.32. Broader resonance linewidths observed in RE-substituted samples indicated increased magnetic anisotropy and dipolar interactions. Gas sensing tests conducted for NO_2, H_2S, and CH_4 across a temperature range of (100 −300) ℃ showed promising results. Gd^{3+}-substituted $CoFe_2O_4$ demonstrated the highest sensitivity toward NO_2 (~82% at 200 ℃), attributed to enhanced surface reactivity and elevated oxygen vacancy concentrations. In contrast, Nd^{3+}-substituted $ZnFe_2O_4$ exhibited high selectivity for H_2S (~75% response at 150 ℃), along with rapid response and recovery times, likely due to improved charge carrier mobility and defect-assisted adsorption mechanisms. The co-doped $Zn_{0.05}Co_{0.05}Fe_2O_4$ displayed a balanced sensing performance across all tested gases, suggesting compositional tunability through dual substitution. This study highlights the significant role of rare earth doping in tuning the structure–property–performance relationship in spinel ferrites. Gas sensing analyses establish a strong foundation for the development of RE-doped ferrites as multifunctional materials suitable for both biomedical and gas sensing applications. Magnetic property measurements are currently underway to further understand the role of RE ions in influencing magnetic ordering and spin dynamics.

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PhD

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Poster Session / 88

The use of computer-based experiments in physics education

Authors: Lydia Mavuru[None]; Mohapi Thebe[None]; Sam Ramaila[None]

Corresponding Author: mohapit@vut.ac.za

The integration of computer-based experiments (CBEs) in physics education has transformed traditional teaching methodologies by providing interactive, data-driven, and real-time analysis capabilities. This paper examines the role of CBEs in enhancing conceptual understanding, fostering inquiry-based learning, and improving student engagement. By utilizing digital simulations, virtual laboratories, and sensor-based data collection tools, CBEs offer a flexible and cost-effective alternative to conventional experiments, addressing resource limitations in many educational settings. The study explores the pedagogical advantages of CBEs, particularly their impact on students'problem-solving skills, scientific reasoning, and ability to visualize abstract physics concepts. Additionally, challenges associated with the adoption of CBEs, including accessibility constraints and technological infrastructure requirements, are critically analyzed. The findings emphasize the necessity of robust instructional strategies to optimize the benefits of CBEs in physics education. The paper concludes with recommendations for effectively integrating CBEs into curriculum design, bridging the gap between theoretical knowledge and practical application to enhance learning outcomes in physics education.

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None

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Physics of Condensed Matter and Materials / 89

The effect of molybdenum carbide additive on the magnetic and physical properties of Fe based NbC cermets

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Cermets are composite materials that exhibit a unique combination of mechanical and physical properties that favour their application as cutting and wear resistant tools. The tuning of properties for performance is dependent on the interactions between the refractory metal and the magnetic binder. In this work, magnetic, electrical and thermal properties of Fe-based Niobium Carbide cermets were investigated using Mössbauer spectroscopy and Physical Property Measurement System. Niobium carbide cermets containing 12 wt% Fe and 12 wt% FeNi were vacuum sintered at 1390℃ with Mo₂C additives. The room temperature Mössbauer spectrum for the Fe based NbC milled powders is primarily ferromagnetic with a magnetic field of 32 T consistent with α-Fe. The spectrum also exhibits a small paramagnetic doublet with an isomer shift of 0.188 mm/s and a quadrupole splitting of 0.816 mm/s which can be assigned to amorphous Fe₂O₃. The Mössbauer spectrum for the sintered NbC-12Fe grade show three ferromagnetic phases in the binder with magnetic fields ranging from 29 T to 33 T. A small paramagnetic phase is observed which increases with the addition of Mo₂C. The NbC-12FeNi spectrum is primarily paramagnetic, ɣ-FeNi with a minor ferromagnetic component. The addition of molybdenum carbide to NbC-FeNi resulted in a paramagnetic structure as compared to NbC-Fe where the spectrum is characterised by ferromagnetic behaviour. The VSM measurements at 2 K reveal several competing strong ferromagnetic fields present in the NbC-Fe and NbC-FeNi cermets. At room temperature (300 K), however, the NbC-Fe has a weak ferromagnetic structure, whilst strong paramagnetic phases were observed in the FeNi binder systems. The addition of Mo₂C in the NbC-Fe cermet results in a strong paramagnetic phase with a weak coercive field. The NbC cermets have significantly lower thermal conductivity values compared to WC hardmetals. The addition of Mo₂C does not appear to have a significant effect on the thermal conductivity of the Fe based NbC cermets. The data will be presented and discussed in the presentation.

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PhD

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Nuclear, Particle and Radiation Physics-1 / 90

X-ray production cross section measurements for the analysis of metal halide perovskite thin films using heavy ion PIXE spectroscopy

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X-ray production cross section measurements for the analysis of metal halide perovskite thin films using heavy ion PIXE spectroscopy

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Abstract.

The use of perovskites for the development of solar cell devices continues to gain traction due to their high light absorption efficiency and tuneable bandgap. Unfortunately, well studied high efficiency organic perovskites contain lead halide compounds in their composition, such that wide-scale commercialisation may not be feasible due to environmental risks and the associated resource access limits. The alternative and more environmentally friendly inorganic metal halide perovskites however have a lower band gap and similarly low light absorption efficiencies compared to their organic counterparts, which negatively affects their performance. Current efforts aimed at achieving higher absorption efficiencies requires better understanding of their structural complexity, including quantitation of both light and heavy elemental impurities within the perovskite matrix. The concurrent use of Ion Beam Analysis (IBA) techniques such as Heavy Ion Particle Induced X-ray Emission (HI-PIXE) spectroscopy together with Time of Flight- Elastic Recoil Detection Analysis (ToF-ERDA) may be an effective method for studying these properties. For instance, PIXE can be used to provide information on the relative concentration of heavy elements, while ToF-ERDA can provide information on the relative concentration of light elements (from H up to O), along with elemental depth profiles of a material (as well as its thickness).

However, unlike with protons, using heavy ion probes like presents a challenge for PIXE due to the unavailability of X-ray production cross section data needed for atomic quantitation. This also extends to the analysis of heavy element targets such as Sn and Cs, which are typically found in metal halide perovskites like . Large discrepancies between theoretical predictions and experimental X-ray production cross section data exacerbate this limitation, requiring additional and substantial experimental measurements. This study therefore presents measurements of X-ray production cross sections of Sn and Cs induced by ⁶³Cu^{q+} ion beams within the (20 –34) MeV ion energy range.

The measurements were carried out using CsBr and thin films prepared using spin coating on Fluorine doped Tin Oxide (FTO) substrates. The cross section data is compared to conventional theoretical models such as the ECPSSR, developed from the binary encounter approximation, and is discussed in terms of the prominent ionisation mechanisms.

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Nuclear, Particle and Radiation Physics-1 / 91

Nuclear structure investigations via the (p,d) neutron removal reaction

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Nuclear structure studies are essential for unraveling the complex interactions between the nucleus and nuclear forces, as well as understanding how shell effects emerge throughout the nuclear chart. High-precision measurements of nuclear properties—including energy levels, spins, parities, and spectroscopic factors—offer valuable insights into the nucleus's internal structure and play a key role in testing and improving nuclear models. In this presentation a detailed investigation of the 36S(p,d)35S neutron-removal reaction using a 66 MeV proton beam will be presented, probing nuclear structure and the Fermi surface of sd nuclei. A strong j-dependence for l = 2 states will be revealed, providing refined insights into spin-orbit splitting and shell rigidity. The findings, including spectroscopic factors of states which includes isobaric analog state contributions, advance our understanding and offer benchmark data for theoretical models.

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None

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Nuclear, Particle and Radiation Physics-1 / 93

Linear polarization measurement on gamma rays from non-oriented nuclear states

Author: Beatrice Similindi[1]

Co-authors: Elena Atanassova Lawrie [1]; Jacobus Lawrie [2]; Sinegugu Mthembu [3]; Siyabonga Majola [4]

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Co-author : Dr E.A Lawrie
Dr S.N.T Majola

Gamma ray spectroscopy is a powerful tool in nuclear structure, but the interpretation of the intrinsic properties of the nucleus becomes complex if the parity of the emitted radiation is not known. This study aimed at developing a technique to measure linear polarization of γ rays emitted from non-oriented nuclear states for the clover detectors of the iThemba LABS AFRODITE and GAMKA arrays. Orientation was created by gating on a γ ray detected in one clover detector while observing another γ ray detected in coincidence in another detector. Having being well known for their high efficiency in detecting γ rays, the clover detectors used in this study comprise 4 Ge crystals which were used as Compton polarimeter, which allows us to measure linear polarization. A focus was made on studying the Compton scattering of γ rays across the 4 Ge crystals in which the Klein-Nishina equation was utilised for the two experimental set-ups to measure the polarization anisotropy. Theoretical curves for all observed rays emitted from the beta-decay of 152 Eu were derived and compared with the measured polarization anisotropy, Ap to deduce the polarization sensitivity, Q(γ). Furthermore, the degree of linear polarization was determined experimentally for the γ rays observed in 196Hg following the beta-decay of 196Tl using the deduced polarization sensitivity for the AFRODITE array. The technique has also been applied for the upgraded GAMKA array. The polarization sensitivity for the GAMKA array was determined using experimental data with Eu source by measuring the linear polarization anisotropy and comparing it with the theoretical curves for linear polarization for the well-known pure transitions.
The derived linear polarization sensitivity Q was then used to determine mixing ratios of observed mixed transitions. In addition, the angular correlation coefficients for both pure and mixed transition have been measured and compared with the theoretical coefficients. Lastly, final values for the mixing ratios for M1+E2 and E0+M1+E2 transitions have been determined by combining angular correlation and linear polarization results for all observed γ ray cascades detected with the GAMKA array and with Eu source. The deduced polarization sensitivity can be used in future experiments that intend to measure γ rays whose parities as well as mixing ratios are not known.

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Poster Session / 94

First Principles Study of the Properties of K2SbAu Ternary Compound for Energy Harvesting Applications

Author: Ibrahim Musanyi[1]

Co-authors: Francis Nyongesa [1]; John Kachira [1]; Martin Nyamunga [1]; Mwende Mbilo [1]; Robinson Musembi [1]; Samuel Wafula [1]

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We are inspired to study the K₂SbAu ternary compound using first-principles methods based on density functional theory (DFT) to advance the optoelectronic technology. This comprehensive study predicts structural, electronic, elastic, mechanical, and optical properties. The lattice parameters of the K₂SbAu ternary compound were in agreement with the experimentally observed values. We observed the structural stability of the K₂SbAu ternary compound using the enthalpy of formation, which was found to be negative, confirming the thermodynamic stability and the possibility of experimental synthesis. The electronic properties suggest narrow indirect band gaps of 0.78 to 1.84 eV using various approximations. The K₂SbAu compound was mechanically stable based on an elastic investigation. Furthermore, we discovered that the compound was ductile, ionic, and anisotropic. The K₂SbAu ternary compound exhibited high optical absorption in the ultraviolet-visible range, suggesting its suitability as a photo absorber in photovoltaic devices. Thus, our findings provide insights for further experimental investigation.

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Physics for Development, Education and Outreach / 95

A review of upgrades to First-Year Physics Experiments to integrate digital control and utilization of more modern technology.

Author: Hendrik Jacobus van Heerden[1]

Co-authors: Koos Terblans [1]; Richard Harris [1]; Shaun Cronje [1]

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Hands-on laboratory work is essential in first-year physics education, yet traditional setups can lack precision and adaptability. In this study, we present upgrades to key first-year experiments (air-track, the simple pendulum, and optics-based experiments), to enhance accuracy, interactivity, longevity and student engagement.

For the air-track and pendulum experiments, we developed a custom Windows-based C# software interfaced with Arduino microcontrollers to automate control and data acquisition. This upgrade improves measurement capabilities and allows for greater experimental flexibility as well as longevity and compatibility. In optics, we replaced filament-based light sources with LEDs, providing more stable and energy-efficient illumination. The spectral characteristics of the different light sources and their implications for experimental results will be presented.

These enhancements offer a more modernized learning experience, fostering deeper conceptual understanding through improved experimental interaction. We will discuss the advantages and challenges of these upgrades, including reliability, ease of use, and student feedback. By integrating modern technology into classical experiments, we aim to bridge the gap between traditional physics education and contemporary scientific methodologies.

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Photonics / 96

In vitro evaluation of hypocrellin B based-photodynamic therapy on human oesophageal cancer HKESC-1 cells

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Background: Oesophageal cancer is a malignant disease that accounts for the seventh major cause of cancer-associated death worldwide. Hypocrellin B, a natural photosensitizer, has been employed for photodynamic therapy for various neoplastic diseases. However, studies that utilize hypocrellin B-based- photodynamic therapy on oesophageal cancer are limited. This current study examined the in vitro effects of hypocrellin B-based-photodynamic therapy on human oesophageal cancer cells.
Materials and methods: Human oesophageal cancer HKESC-1 cells were grouped into non-photodynamic and photodynamic therapy groups. Both groups were treated with varying concentrations of hypocrellin B. After four hours, the photodynamic therapy category was irradiated at a fluency of 5 J/cm2 and a wavelength of 470nm. Twenty-four-hour post-irradiation cell viability, lactate dehydrogenase (LDH) release and damage to the mitochondrial and nuclear morphological assessments were performed.
Results: Treatment with hypocrellin B-mediated photodynamic therapy significantly reduced the amount of ATP/viability of HKESC-1 cells, and the amount of LDH released was notably higher in the photodynamic therapy group. Mitochondrial membrane potential was impaired, and nuclear condensation was markedly observed in the hypocrellin B-mediated photodynamic therapy.
Conclusion: Hypocrellin-B mediated photodynamic therapy demonstrated remarkable anticancer activities in oesophageal cancer HKESC-1 cells.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 97

Investigation of the (Pt,Pd)BiTe and (Pt,Pd)Te2 bulk and surface stability at 300K using AIMD-MLFF

Author: TSHEPO RONALDO MAAKA[1]

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This study adopted the ab-initio molecular dynamics (AIMD) modelling technique imbed-ded within the Vienna ab-initio simulation package (VASP). The machine learned force field (MLFF) was utilized for robustness of the AIMD simulations. These methods were adopted unravel the bulk and surface stability of the platinum group minerals (PGMs) such as moncheite (PtTe2), merenskyte (PdTe2), michenerite (PdBiTe) and maslovite (PtBiTe) minerals at room temperature (300 K). The AIMD-MLFF trained bulk models produced lattice parameters of: a = b = 4.026 Å, c = 5.221 Å for PtTe2, a = b = 4.040 Å, c = 5.133 Å for PdTe2, a = b = c = 6.746 Å for PtBiTe, a = b = c = 6.749 Å for PdBiTe. The generated force field applied on the 4x4x4 supercells. The 4x4x4 supercells produced lattice parameters of: a = b = 4.079 Å, c = 5.283 Å for PtTe2, a = b = 3.982 Å, c = 5.130 Å for PdTe2, a = b = c = 6.716 Å for PtBiTe, a = b = c = 6.719 Å for PdBiTe These were in agreement with the experimental lattice parameter a = b = 4.049 Å, c = 5.288 Å for PtTe2, a = b = 3.978 Å, c = 5.125 Å for PdTe2, a = b = c = 6.689 Å for PtBiTe, a = b = c = 6.646 Å for PdBiTe.
The (001) surface for (Pt,Pd)Te2 and (100) surface for (Pt,Pd)BiTe were determined to be the most stable surfaces from computed X-ray diffraction (XRD). The ab-initio surface energies were calculated as 0.42 J/m2 for PtTe2 and 0.31 J/m2 for PdTe2. For (Pt,Pd)BiTe the surface energies were 0.75 J/m2 for PtBiTe and 0.78 J/m2 for PdBiTe. The AIMD-MLFF surface ener-gies correlated with those from ab-initio simulation where by the surface energies of 0.73 J/m2, 0.80 J/m2, 0.44 J/m2 and 0.33 J/m2 were obtained for PtBiTe, PdBiTe, PtTe2 and PdTe2, respec-tively. These showed that the (Pt,Pd)Te2 minerals have lower surface energies than the (Pt,Pd)BiTe minerals, suggesting that the former cleaves easily compared to the latter. These showed that the AIMD-MLFF method is a feasible method for simulation of minerals.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Astrophysics & Space Science / 98

Characterisation and Calibration of the Kepler KL4040 sCMOS camera for Optical Observations at the UFS/Boyden Observatory

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Co-authors: Brian van Soelen [1]; Wian Smit [1]

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The Kepler KL4040 sCMOS camera by Finger Lakes Instruments was evaluated for its suitability as an affordable alternative to older CCD sensors for optical photometry at the Boyden Observatory. Due to the sensor architecture where each pixel has its own electron to voltage converter, a thorough characterisation and calibration study was conducted to identify key performance factors and necessary considerations for operational implementation. The KL4040 achieves a high dynamic range by merging two 12-bit images into a single 16-bit image, with binning performed via software.
Laboratory tests examined bias stability, dark current, and photo-response characteristics. Bias frames exhibited a 7.5% increase in mean counts as temperature rose from -15℃ to 10℃, with dark current showing a linear temperature dependence. A small offset between the merged images for the 12bit to 16bit conversion was identified but was correctable through adjustments to the gain transition parameter that determines the offset value between high and low gain. Photo-response curves for the B, V, R, and I bands confirmed linearity across all bands. Fixed pattern noise (FPN), a known issue in sCMOS sensors, was effectively mitigated through bias, dark, and flat-field corrections.
On-sky tests included standard field photometry of the AAVSO SA107 field. Transformation coefficients enabled photometric corrections to within 2% of known values. Additionally, high cadence photometry of the pulsating white dwarf binary system AR Sco was performed to test fast photometry throughput. A full orbital period of AR Sco was captured at a 6 s cadence, revealing the 118.2 s beat period via Lomb-Scargle analysis. The folded light curve displayed clear periodic variations.
These results confirm the KL4040 as a viable, cost-effective alternative to CCDs for photometry at the Boyden Observatory. While it lacks single-photon sensitivity, its quantum efficiency, fast readout, and large sensor size make it a strong contender for astronomical imaging on a budget. In addition, because of image manipulation such as binning and sub-frame selection happening post image readout and is not hardware based, image quality, size and throughput can be optimized through software development and is not limited to hardware capabilities.

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Nuclear, Particle and Radiation Physics-2 / 99

Analysis of Long-Term Stability Uncertainty in Luminosity Measurements Using the Tile Calorimeter of the ATLAS Detector for Run 3 Proton-Proton Collisions at $\sqrt{s} = 13.6$ TeV in 2023

Authors: Bruce Mellado[1]; Phuti Rapheeha[1]

[1] *University of the Witwatersrand*

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Precision luminosity measurements are crucial for determining the fundamental properties of physics processes at the Large Hadron Collider (LHC). In the ATLAS experiment, luminosity uncertainties often represent one of the leading sources of systematic uncertainty in cross-section measurements, directly impacting sensitivity to new physics searches and background estimations.

Since the calibration of the primary luminometer of ATLAS, LUCID, is performed only once per data-taking year, studying the long-term stability of LUCID luminosity measurements is crucial, as it significantly contributes to the total uncertainty in the ATLAS luminosity measurement. In this study, the Tile Calorimeter is used to evaluate and monitor the long-term stability of the luminosity measurements. Results are presented for the ATLAS detector during proton-proton (pp) collisions at $\sqrt{s} = 13.6$ TeV in 2023. A long-term stability uncertainty of $\delta L/L = 0.1\%$ is obtained for the 27.58 fb^{-1} of data delivered to ATLAS.

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Poster Session / 100

Co3O4 SURFACE STUDIES AND ADSORPTION OF Li2O2 NANOCLUSTER

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ABSTRACT
Lithium-air batteries represent one of the most promising technologies for energy storage, characterized by their high energy density (1086 Wh/kg) and substantial specific capacity (3842 mAh/g). However, they experience a practical drawback that involves the production of unstable discharge products (LiO2, Li2O and LiO) resulting in battery degradation. Cobalt oxide (Co3O4) is considered an effective electrocatalyst for Li-air batteries because of its mixed Co2+ and Co3+ oxidation states which reduce over-potential and significantly improve the cyclic performance of a Li–O2 battery. Despite that, there is a limited understanding of the adsorption of stable discharge products (Li2O2) on major Co3O4 surfaces. In this work, we use the density functional theory (DFT) method to investigate the surface properties and the adsorptions of Li2O2 nanocluster to mimic the growth of the discharge product on the major surfaces. Thus, the (001) surface was found as the most stable among the three low Miller indexes (i.e., (001), (011) and (111)) surfaces. The constructed Wulff Morphology was compatible with the previous studies, with a dominance of the (001) plane. The discharge Li2O2 nanocluster were then adsorbed on the (001) surface and the results shows that the nanocluster favors to bridge across the Co2+ and Co3+ with the adsorption energy of Eads = -4.147 eV. The findings for this research will help us better understand the production of Li2O2 and its interactions with the Co3O4 electrocatalyst.

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Honours

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Nuclear, Particle and Radiation Physics-2 / 102

The W boson as a probe for the initial state of hadron collisions at the LHC

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The charged vector boson ($W^{\pm}$) is produced in the hard partonic scattering of relativistic hadronic collisions, where its production cross-section can be calculated theoretically from perturbation theory and the relevant hadronic parton distribution functions (PDFs). Since it does not interact strongly and decays leptonically, the W boson serves as an ideal probe of the initial state of the collision - such as the contributing quark PDFs. In this presentation, the focus will be on the production of $W^{\pm}$ in the forward rapidity region of simulated relativistic proton-proton collisions, where the POWHEG and Pythia event generators are used to simulate the events of interest. The $W^{\pm}$ production is studied via the muonic decay channel as $W^{+} \rightarrow \mu^{+}\nu_{\mu}$ and $W^{-} \rightarrow \mu^{-}\bar{\nu}_{\mu}$, where the muon can be measured with the ALICE Muon Spectrometer in the forward rapidity region of $2.5 < y < 4.0$. The primary charged-particle multiplicity is introduced as an additional observable of interest to study the initial state - where the self-normalised $W \rightarrow \mu$ production as a function of the self-normalised multiplicity is defined and studied specifically. It is demonstrated that the study in proton-proton collisions can serve as a meaningful baseline measurement for other hadronic collision systems, where an outlook is presented to do the same study in proton-lead and lead-lead collisions with Run 3 data from ALICE.

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MSc

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Yes, I ACCEPT

Astrophysics & Space Science / 103

Modelling the antiproton modulation related to AMS-02 observations between 2011 and 2021

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Co-authors: Mabedle Ngobeni [2]; Dzivhuluwani Ndiitwani [3]

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In this study, the previously established set of modulation parameters used to reproduce PAMELA and AMS-02 proton observations between 2006 and 2022 is applied in the 3D steady-state drift numerical model to simulate antiproton spectra observed by AMS-02 detector between 2011 and 2021. In this way, the only differences between galactic protons and antiprotons simulations in the model remain their local interstellar spectra (LIS) and the sign of their charges. This is a better approach to antiproton modelling, especially when novel insights into potentially new physics are sought. Surprisingly, the simulated solar modulation effects on antiprotons were found to be much less pronounced than on protons at the same rigidity. For example, the computed intensity of antiprotons at ~ 1 GV was found to increased by ~13% between 2011 and 2019, whereas for protons at the same rigidity the intensity increased by ~ 86%. This result has now been confirmed by precise AMS-02 observations done at the same position around the Earth and over a long period. In this study it will be shown how the antiprotons LIS at lower rigidities intriguingly resembles the shape of the modulated spectra, and how this greatly influences the adiabatic energy losses these particles experience deep inside the heliosphere.

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PhD

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Physics of Condensed Matter and Materials / 105

Analysis of proton irradiation effects on fluorine-doped tin oxide thin films for optoelectronic applications in the LEO environment

Author: Bosco Oryema[1]

Co-authors: Edward Jurua [2]; Itani Given Madiba [3]; Malik Maaza [3]

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Fluorine-doped tin oxide (FTO) is an n-type semiconductor transparent conducting oxide (TCO) widely adopted for various applications, including gas sensors, digital displays, touch switches, optical windows, and electrochromic applications. To investigate its suitability for optoelectronic applications in the Low Earth Orbit (LEO) environment, FTO thin films were exposed to different fluences of 2 MeV protons at a ground-based particle accelerator facility. The induced changes in the properties of the proton-irradiated films were analyzed using atomic force microscopy (AFM), UV-vis-NIR spectrophotometry, and X-ray diffraction (XRD) techniques.

The results showed that the 2 MeV protons considerably reduced the optical transparency and decreased the optical bandgap of the films, indicating the existence of electronic defects and structural disorder. The XRD analysis revealed slight irradiation-induced enhancement in the percentage crystallinity and shifts in peak positions of the diffraction spectral lines. Also, surface modification of the films was also observed as a reduction in the surface roughness of the films with increasing proton fluence. Generally, this work highlights the distinct radiation tolerance and suitability of FTO for use in the space environment and contributes to the fundamental understanding of metal oxide thin films for space applications.

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Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 107

Electromagnetic and thermodynamic properties in the quasi-continuum of mid-mass nuclei through inverse and direct kinematics.

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[1] *University of Johannesburg*

Corresponding Author: mhlanganon@uj.ac.za

The electromagnetic properties of nuclei excited to the quasi-continuum region are best studied and explained using statistical decay observables, such as the nuclear level density (NLD) and γ-ray strength function (γSF). These quantities can be extracted from experimental particle-γ coincidence matrix using the Oslo method and Shape method, respectively. In this study, experiments were carried out at iThemba LABS using the AFRODITE array with ^{84}Kr beam on a deuterated polyethylene target, and proton beam on ^{64}Ni target to undergo (d, p) reactions, producing 85Kr and ^{63}Ni. The nuclear level density and strength function will be extracted from the coincidence events which were detected in the AFRODITE array. The NLD and γSF will be investigated to i) determine the existence of low-lying energy enhancement in ^{85}Kr, confirm the reported of low-lying energy enhancement in ^{63}Ni ii) perform a rigorous test of the Brink-Axel hypothesis in ^{85}Kr and ^{63}Ni, and iii) the first experimental determination of thermodynamic properties of ^{85}Kr and ^{63}Ni.

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PhD

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Poster Session / 108

Analysing Core-Shell Compatibility During the Cycling Process Using Molecular Dynamics Simulations

Author: Precious Makhubela[1]

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[1] *University of Limpopo*

Corresponding Author: 201649531@keyaka.ul.ac.za

The O3-type Li2MnO3 layered cathode material shows great potential for large-scale energy storage in electric grids and vehicles due to its high capacity and energy density. However, it tends to undergo structural changes from a layered to a spinel configuration during charge cycles. Recent advances in surface coating techniques have improved the electrochemical performance of these cathodes by enhancing conductivity, stabilizing structures, and preventing harmful reactions with the electrolyte. However, the core-shell configuration in surface-coated materials still suffer mechanical degradation caused by interfacial stress. The radial tensile stress at the core-shell interface can lead to delamination of the coating layer, weakening the structural integrity of the cathode and negatively impacting the long-term performance of lithium-ion batteries. In this study, Li2MnO3 is coated with Li0.69MnO2, a layered material known for its phase stability and high ionic conductivity. Molecular dynamics simulations, performed using the DL_POLY code, were utilized to analyse the cycling performance of the Li2MnO3-Li0.69MnO2 core-shell system and assess the potential risk of delamination under various temperature conditions. During the simulations, the core was delithiated from Li2MnO3 to LiMnO3. The Nose-Hoover thermostat under the NVT ensemble was used, with temperatures ranging from 300 K to 1500 K. Structural snapshots revealed fluctuations in system stability at different temperatures. At certain temperatures, the core-shell system experienced significant atomic loss from both the core and shell, whereas at other temperatures, it regained structural order with minimal atom loss. Lithium diffusion coefficients varied with lithium concentration, with Li1.3MnO3 and Li1.7MnO3 exhibiting higher diffusion at lower temperatures, while Li1.4MnO3 showed the highest diffusion rate of 1.25 m2/s at 1500 K. The maximum recorded diffusion occurred in Li1.7MnO3 at 1200 K, reaching 3.02 m2/s. Overall, higher atom loss corresponded to increased diffusion, though this trend was not consistent across all concentrations. These results highlight the balance between lithium diffusion and structural integrity, offering key insights for improving the durability of coated cathode materials in advanced lithium-ion batteries.

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PhD

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Photonics / 110

<i>In</i> <i>Vitro</i> Effects of Blue Laser Light as an Antimicrobial Agent on Microbial-Infected Fibroblast Cells

Author: Francis Obeng Brenya[1]

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Corresponding Author: 224192965@student.uj.ac.za

<i>In</i> <i>Vitro</i> Effects of Blue Laser Light as an Antimicrobial Agent on Microbial-Infected Fibroblast Cells

<u>Francis Obeng Brenya</sup>¹ and Nicolette Nadene Houreld¹

¹Laser Research Centre, Faculty of Health Science, University of Johannesburg, Johannesburg, South Africa

<i>Pseudomonas</i> <i>aeruginosa</i>, <i>Staphylococcus</i> <i>aureus</i>, and <i>Streptococcus</i> <i>pyogenes</i> are key pathogens that delay healing and pose challenges due to their antibiotic resistance. Antimicrobial photobiomodulation (aPBM) using blue light (400-470 nm) has been shown to have antibacterial properties; however, its effects on mammalian cells are not well understood. We investigated the effect of blue laser light (470 nm, 82.7 mW/cm², 10 J/cm², 2 min) on bacteria-infected BJ-5ta fibroblast cells. BJ-5ta cells were co-cultured for 24 h with each of the three bacterial strains (1.50 x 10³ CFU/mL) and then exposed to blue light. Fibroblast cell viability and bacterial colony counts were assessed 24 h post-aPBM. Control cells (0 J/cm²) infected with <i>S</i>. <i>aureus</i> exhibited 95% fibroblast cell viability and increased bacterial counts (1.80 x 10⁵ CFU/mL). Control cells (0 J/cm²) infected with <i>S</i>. <i>pyogenes</i> and <i>P</i>. <i>aeruginosa</i> showed 89.5% fibroblast cell viability, with bacterial counts increasing to 3.00 x 10⁵ and 2.36 x 10⁵ CFU/mL, respectively. In irradiated (10 J/cm²) BJ-5ta cells infected with <i>S</i>. <i>aureus</i>, <i>P</i>. <i>aeruginosa</i>, and <i>S</i>. <i>pyogenes</i>, fibroblast cell viability was 89.2%, 94.6%, and 77.6%, respectively. As compared to the controls, bacterial counts decreased to 1.30 x 10⁵ CFU/mL, 1.35 x 10⁵ CFU/mL, and 1.20 x 10⁵ CFU/mL, respectively. Blue light (470 nm, 82.7 mW/cm², 10 J/cm²) induced bacterial death while preserving fibroblast cell viability after a single exposure. aPBM has the potential to address the medical challenges associated with infected wounds and open new avenues for future research.

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PhD

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Astrophysics & Space Science / 112

Response of Ionospheric Topside Electron Density during Solar Flares

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Co-authors: John Habarulema [2]; Dzivhuluwani Ndiitwani [1]

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The topside ionosphere is highly sensitive to solar flare activity, which leads to sudden enhancements in solar X-ray and EUV flux. These enhancements can significantly alter electron density profiles, impacting satellite communication and navigation systems. This study examines the response of topside electron density (Ne) to solar flares using in-situ data from the Swarm satellites. Electron density measurements during selected solar flare events are compared against X-ray flux data obtained from the GOES satellite to quantify the degree of ionospheric response. Additionally, background Ne values from the International Reference Ionosphere (IRI) model are employed to distinguish flare-induced perturbations from normal diurnal and latitudinal variations. A global analysis is carried out to investigate the topside ionospheric electron density response across different latitude regions. Preliminary findings reveal a consistent decrease in Ne during flare events, with the magnitude of the response varying by local time, latitude, and flare intensity. The study also explores how the ionospheric response aligns or diverges from IRI predictions during solar flares.

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MSc

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Applied Physics / 113

An empirical method to negate Bragg-peak shifts due to partial gauge volume illumination in neutron powder diffraction studies

Author: Deon Marais[1]

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Partially filled neutron gauge volumes in neutron powder diffraction experiments lead to anomalous shifts in diffraction peak positions. In stress analyses, these shifts create systematic errors in lattice parameter measurements, potentially leading to incorrect interpretations of strain if left uncorrected. This phenomenon is known as the pseudo-strain effect.

The instrumental gauge volume (IGV) refers to the region which is defined by the intersection of the incident and diffracted neutron beam paths. When this volume is fully embedded in a homogenous sample that does not exhibit large grains or preferred crystallographic orientation, the geometric centre of the IGV closely corresponds to the neutron-weighted centre of gravity (NCOG) of the crystallites being probed. The NCOG represents the effective spatial position within the sample from which the diffracted neutron intensity appears to originate and is influenced by the incident beam intensity distribution, sample geometry, relative sample position / orientation and attenuation cross-sections. In situations where the sample is smaller than the beam, or the beam is not fully embedded in the sample, offsets may exist between the IGV centroid and the NCOG.

To account for the effects of partial illumination, a method was devised to determine the NCOG offsets considering the factors mentioned based on previous investigations \1. In addition, an empirical model, shown in Figure 1, was devised to correct the peak shift due to the combined effect of NCOG offsets and the non-negligible wavelength distribution spread of the incident neutron beam.

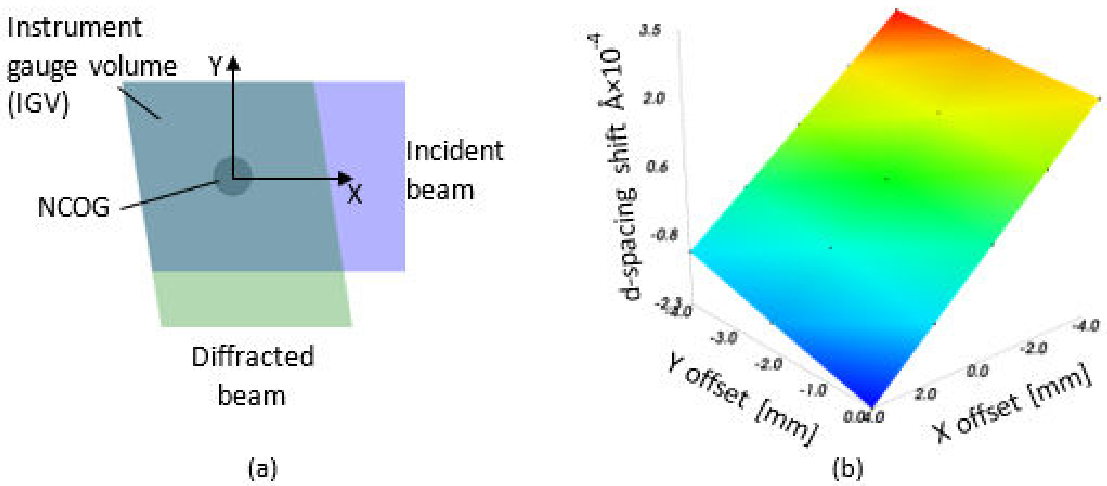

Figure 1: enter image description here

Figure 1. (a) Experimental setup and (b) d-spacing shift due to positional changes of the NCOG within the IGV

\1 D. Marais, Z.N. Sentsho, A.M. Venter. Numerical neutron attenuation correction for partially-illuminated powder samples. Materials Characterization. 153(2019)234-239 (https://doi.org/10.1016/j.matchar.2019.05.011.)

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Astrophysics & Space Science / 114

Simulating cosmic ray diffusion coefficients in synthetic compressive magnetic turbulence

Author: Jonathan Stephanus Troskie[1]

Co-author: Nicholas Eugene Engelbrecht [2]

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In order to reliably estimate cosmic ray (CR) transport effects due to turbulence in the heliospheric magnetic field (HMF), and to validate existing diffusion theories (see, e.g., Engelbrecht et al., 2022, for a review), direct simulations, which involve solving the Newton-Lorentz equation numerically, may be employed (e.g., Els and Engelbrecht, 2024). Prior work, guided by turbulence conditions observed in the inner heliosphere, has largely focused on CR transport due to turbulence transverse to the background magnetic field. However, CR transport in the outer heliosphere, including in the heliosheath (HS), where HMF turbulence has been observed to have a compressive component (e.g., Fraternale et al., 2019), has, to date, received comparatively little attention. In this work, an approach to modelling HMF turbulence with an arbitrary compressive component, based on the synthetic turbulence model of Tautz and Dosch (2013), is suggested. Furthermore, turbulence parameters which may be expected in the HS are inferred from available analyses (e.g., Fraternale et al., 2019; Zhao et al., 2024). These parameters are then used as inputs for the particle pusher code detailed by Els and Engelbrecht (2024), modified so as to account for the presence of compressive turbulence, from which estimates for CR transport coefficients due to HMF turbulence conditions in the HS are calculated.

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PhD

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Yes, I ACCEPT

Poster Session / 115

Structural and electronic properties of Copper sulphide (Cu2S) and copper selenide (Cu2Se) powders

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The structural and electronic properties of Cu2S and Cu2Se powder samples were investigated using X-Ray Powder Diffraction (XRD), UV-vis spectroscopy and Fourier transform infrared spectroscopy (FTIR) and Current-voltage (I-V) measurements. XRD was used to calculate the lattice constants and crystal size of both materials. The lattice parameters of Cu2S and Cu2Se were calculated were found to be a = b = c = 5.518 Å and a = b = c = 5.750 Å respectively, which shows the cubic structures for both materials. The outstanding peak 220, which was observed in both XRD illustration results represents the Cu ions. The calculated crystal size of Cu2S and Cu2Se samples were found to be 7.076 Å and 8.985 Å respectively. FTIR characterisation revealed defects in the form of similar functional groups, such as O-H stretching and N-H stretching vibrations for both materials. Through UV-vis characterisation both materials show good absorption in the visible and near-infrared light regions. The calculated Optical band gaps of Cu2S and Cu2Se is 4.35 and 4.50 eV respectively, which suggests semiconductor materials. The I-V measurement curve indicate semiconductor characteristics and some degree of diode characteristics behaviour.

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None

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Yes, I ACCEPT

Applied Physics / 116

Listening With Light

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Environmental vibrations can induce distortions in live fibre optic cables through the elasto-optic effect, leading to changes to both the light's state of polarisation (SOP) and phase. Coherent optical receivers, essential to modern telecommunications, offset these distortions by employing advanced digital signal processing (DSP) techniques to filter out the effects during high-speed data reception. This presents an interesting opportunity: Why not extract the channels' SOP and phase estimation data from the receiver for environmental sensing purposes? Although SOP and phase estimation data from coherent optical receivers have been used to detect sub-hertz frequency events like earthquakes and tsunamis, their application in acoustic sensing remains unexplored. This study investigates whether these SOP and phase changes, detectable over live data channels using coherent receivers, can be used to sense low-frequency acoustic signals in a controlled laboratory environment. Unlike traditional acoustic sensing techniques, such as Distributed Acoustic Sensing (DAS), which relies on dedicated sensing fibres, this method uses existing data channels and receivers, eliminating the need for additional infrastructure. If successful, this approach could extend existing fibre optic infrastructure capabilities for applications like subsea cable monitoring and urban infrastructure surveillance.

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MSc

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Photonics / 117

Optimizing Photobiomodulation Parameters for Tenogenic Differentiation

Authors: Brendon Roets[1]; Heidi Abrahamse[2]; Anine Crous[1]

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Tendons are frequently damaged by acute injuries, such as sports injuries or chronic overuse and age-related degeneration. Native tendon healing is lengthy and ineffective due to the tissue's inherently low cellularity, limited vascularization, and low metabolic activity of resident tenocytes. Natural healing is often accompanied by fibrosis, adhesion formation and re-injury is common. Current treatment options focus on symptom management and gradually strengthening the tissue over time. Mesenchymal stem cell (MSC) therapy offers a promising alternative due to the ability of MSCs to proliferate, differentiate into tenocytes and produce ECM (extracellular matrix) components to facilitate tendon repair. Photobiomodulation (PBM), uses specific light wavelengths to stimulate intracellular chromophores and activate various cellular functions. PBM has demonstrated potential in enhancing stem cell viability and proliferation, as well as tenogenic differentiation and ECM production. Despite this, there is a lack of standardized PBM parameters (wavelength and fluency) for tenogenic differentiation, hindering reproducibility, cross-study comparisons and translation into clinical trials. This study aimed to evaluate the potential of PBM to enhance tenogenic differentiation and to determine the optimal PBM parameters. Adipose-derived mesenchymal stem cells (ADMSCs) were irradiated using 525 nm, 825 nm, and a combination of both wavelengths at fluences of 5 and 10 J/cm^2. Prior to PBM treatment, the stem cell nature of the ADMSCs was confirmed via immunofluorescent detection of CD44, CD90, and CD166. Post-differentiation assessments included morphological analysis (May-Grünwald-Giemsa staining), cytotoxicity, and proliferation assays. Tenogenic differentiation was evaluated via gene expression (Scleraxis, Tenomodulin, Collagen I, Tenascin-C, and Biglycan) and immunofluorescence staining (Scleraxis, Tenomodulin, and Collagen). The results confirmed the stemness of the ADMSCs and showed that tenogenic differentiation, particularly when combined with PBM, enhanced cell viability, proliferation, and expression of tenogenic markers, without significant morphological changes. These findings highlight PBM as a promising adjunct to improve tenogenic outcomes.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 118

The effect of Ce and Gd on the magnetic and mechanical properties of Nd2Fe14B permanent magnets

Author: Mphamela Enos Baloyi[1]

Co-authors: Hasani Richard Chauke [1]; Phuti Esrom Ngoepe [2]; Ramogohlo Diale [3]

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Neodymium-based permanent magnets (Nd2Fe14B) can be used in various applications, such as electric vehicles and wind power generators, due to their high magnetic field strength and demagnetisation resistance. However, they suffer from low operating temperatures below 585 K and poor mechanical properties. This study investigates the effect of rare earth elements such as Gd and Ce on the Nd2Fe14B magnets. Their structural, electronic, mechanical and magnetic properties were calculated using the ab initio density functional theory approach. Heats of formation were used to mimic the thermodynamic stability of the magnets and predicted that NdCeFe14B was the most stable. The partial substitution of Nd with Gd improves the ductility, mechanical stability, magnetic strength and operation temperature of Nd2Fe14B permanent magnets. These findings provide insight into the future development of permanent magnetic compounds with good mechanical properties and high operation temperatures.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Photonics / 119

Crafting Optical Neural Networks Using Multimode Fibre

Author: Christopher Rawlings[1]

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The utilisation of mode division multiplexing, where multiple spatial modes transmit data simultaneously, holds significant promise for enhancing bandwidth in free space optical communication systems. However, atmospheric turbulence can compromise the reliability of these systems. To address this longstanding problem, traditional neural networks have been employed to classify modes in turbulence. However, these neural networks face challenges relating to energy efficiency, computational speed, and latency. In contrast, optical neural networks offer a potential solution by providing the computational capabilities of traditional networks while mitigating these limitations. In our approach, modal crosstalk within a multimode fibre acts analogously to the weighted sums performed by each layer in a traditional neural network. We demonstrate how an all optical neural network can be built using a multimode fibre and can be used to classify optical modes in turbulence.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Photonics / 120

Manipulating Modes in Mulitmode Fibres with Magnets

Authors: Mitchell Arij Cox[1]; Mohammed Raiyan Sharif[1]

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The Faraday Effect, a magneto-optic phenomenon, causes the rotation of linearly polarised light when subjected to a magnetic field along the direction of propagation. In magneto-optic materials like multimode fibres, where different spatial modes interfere to form complex speckle patterns, could these modes be influenced by applying an external transverse magnetic field to the multimode fibre? By utilising different fibre types, including single-mode and step-index multimode fibres, and employing a physics-informed neural network (PINN) to reconstruct the transmission matrix under a magnetic field, we experimentally demonstrate a mode-dependent Faraday Effect in multimode fibres, a new and unexpected result.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 121

Adaptive Multi-tier Neural Architecture for Optimized Environmental Parameter Management in High-Energy Physics Detector Systems

Author: Isaiah Chiraira[1]

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In large-scale particle physics experimentation, maintaining precise control of diverse environmental parameters across complex detector subsystems constitutes a fundamental operational requirement, directly impacting data acquisition integrity, component longevity, and systemic stability. Contemporary slow control infrastructures predominantly employ static threshold parameters, deterministic rule-based decision matrices, and uniform sensor interrogation protocols—methodological constraints that engender suboptimal energy utilization, latent anomaly identification, and restricted deployment scalability. This research introduces a computationally adaptive control framework configured to address the distinctive environmental monitoring and regulation challenges inherent in high-precision detector environments.

The proposed implementation architecture comprises three integrated analytical tiers: (1) spatiotemporal clustering algorithms that establish statistically significant correlations between interdependent environmental sensors based on physical proximity coefficients and temporal behavioral patterns; (2) Graph Neural Network (GNN) predictive modeling that leverages topological relationships to forecast localized and system-wide environmental dynamics under conditions of incomplete or asynchronous sensor data acquisition; and (3) hierarchical reinforcement learning (HRL) optimization that simultaneously develops control policies at discrete component and integrated subsystem levels. Through algorithmic modulation of sensor sampling frequencies and dynamic recalibration of actuator response functions, the system promises to reduce operational redundancy, adapt to environmental perturbations, and implement preemptive intervention strategies for anomaly mitigation across multiple environmental variables within experimental detector systems. The methodological framework and resulting algorithmic implementations are designed for deployment within CERN's experimental infrastructure, with particular emphasis on integration with existing detector control systems while facilitating enhanced operational efficiency and environmental parameter stability.

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MSc

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Yes, I ACCEPT

Astrophysics & Space Science / 122

Statistical Interpretation of the Thermospheric Density Responding to Geomagnetic Disturbances.

Author: Sthandiwe Msomi[1]

Co-authors: Daniel Billett [2]; Judy Stephenson [1]

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Variations in thermospheric density play an essential role in satellite operations, particularly during geomagnetic disturbances, where fluctuations in atmospheric drag impact orbital stability. A significant incident on February 4, 2022, saw SpaceX lose 38 Starlink satellites due to unanticipated atmospheric drag following a geomagnetic storm. This study aims to identify high- risk periods in thermospheric density using observational data from ESA's Swarm Satellite C. By integrating key geomagnetic indices such as Kp, AE, and SYM-H, this research studies the geomagnetic activity with thermospheric density variations to assess space weather disturbances. The study uses statistical analysis to develop a predictive framework for identifying potentially hazardous periods, ensuring future satellite missions are better equipped to prevent similar risks. Data visualisation techniques, including plotted density fluctuations, provide deeper insights into the relationship between geomagnetic activity and atmospheric variability. The findings contribute to a broader understanding of thermospheric dynamics and their implications for satellite operations, mission planning, and the long-term sustainability of space activities.

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MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 123

Hydrothermal Synthesis of ZnO-TiO2: Yb3+/Ho3+ Phosphor Heterostructures for Up-conversion Luminescence Applications.

Author: MACHEBA MATAKGANE[1]

Co-authors: M.R. MHLONGO [1]; R.E. Kroon [2]; S.J. MOFOKENG [3]; T.P. MOKOENA [4]

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ZnO-TiO2:Yb3+/Ho3+ phosphor heterostructures were successfully synthesized by the hydrothermal process. The structure, morphology and upconversion (UC) luminescence properties of the prepared heterostructures were investigated. The mixed oxides of ZnO and TiO2 anatase and rutile were confirmed by X-ray diffraction (XRD). Scanning electron microscopy (SEM) revealed the agglomerated and spherical morphology of the prepared nanophosphor. Transmission electron microscopy (TEM) confirmed that the particles of the prepared heterostructures are in the nanoscale range. Diffuse reflectance spectra (DRS) exhibited several absorption bands at 453, 488, 540 and 647 nm associated with the transitions of Ho3+ ion: 5I8 ⟶ 5G6, 5I8 ⟶ 5F3, 5I8 ⟶ 5F4/ 5S2, and 5I8 ⟶ 5F5, respectively. Due to the doping concentration of Ho3+ and Yb3+ ions, the nanocomposite's estimated optical band gap energy increased. The UC emission spectra upon excitation wavelength of 980 nm revealed two emission peaks located at 545 and 661 nm from the doped nanocomposite. These emission peaks can be attributed to 5S2/5F4 ⟶ 4I8 and 5F5 ⟶ 5I8 transitions of Ho3+ ions, respectively. The Commission Internationale de I'Eclairage (CIE) analysis revealed that the emission colour is towards the greenish region. The sample with the best UC luminescence intensity was ZnO-TiO2:0.1mol%Ho3+/9mol%Yb3+, which showed good stability after an initial intensity decrease of ~15% during degradation assessment.

Apply for student award at which level::

PhD

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Yes, I ACCEPT

Physics of Condensed Matter and Materials / 124

Seebeck and SBS studies on buried amorphous carbon channels in Diamond

Author: Shunmugam Ramsamy Naidoo[1]

Co-authors: Arthur Every [1]; Christophe Adessi [2]; Jérémie Margueritat [2]; Nyiku Mahonisi [1]; Régis Debord [2]; Sana Salami [2]; Stéphane Pailhès [2]; Valentina M. Giordano [2]; Zuko Mthwesi [1]

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Recent studies has shown that buried amorphous carbon layers in diamond created by ion implantation have Seebeck behaviours that can be attributed to the graphitic assembly of the carbon bonds. The extent of the sp2 carbon network is clearly attributed to the fluence and annealing cycle used. In these buried layers we observe the shift of the minimum of the Seebeck voltage amplitude to higher temperatures compared to free standing graphite. The contribution to the Seebeck voltage due to the phonon-drag effect is well understood in graphite. In our system we have a buried graphitic channel surrounded by a diamond matrix. This unique system suggest that electron-phonon interactions at the boundaries of the buried interfaces have an influence on the Seebeck behaviour. We show in parallel unique signatures from the elastodynamic response of the system as measured by Surface Brillouin scattering for a hard-soft-hard system.

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None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 125

Characterization of instrumental background in a (p,γ) reaction, studied at the iThemba LABS Tandetron facility

Authors: Chamunorwa kureba[1]; Kgashane Malatji[2]; Lindsay Donaldson[3]; Retief Neveling[4]; Sandile Jongile[5]; Thuthukile Khumalo[6]; Tshegofatso Bokhutlo[7]

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Understanding background radiation is essential for precision studies in any facility. This work investigates background contributions observed during radiative capture measurements at the low-energy nuclear astrophysics beamline (H-line) of the iThemba LABS Tandetron facility. The H-line is dedicated to studying the statistical properties of proton-rich isotopes via proton or alpha induced reactions, providing key observables such as photon strength functions and level densities which are critical inputs for nucleosynthesis reaction calculations.

To achieve high-precision measurements, experiments utilize a high-resolution gamma-ray detection system comprising High-Purity Germanium (HPGe) and Cerium-doped Lanthanum Bromide ($LaBr_3$:Ce) detectors, along with the 3 MV Tandetron accelerator.A key challenge in these measurements is distinguishing true reaction signals from background contributions, which may arise from beam interactions with beam-line elements or contaminants on the target.

Findings indicate that suboptimal beam tuning can result in unintended interactions with beam-line components, while beam spreading after the target leads to further interactions. This comprehensive background characterization allows for refinements in experimental methodology, ensuring improved accuracy in PSF studies.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 126

INVESTIGATING THE PHOTON STRENGTH FUNCTION FOR 61Cu USING 60Ni (p, γ) REACTION AT iTHEMBA LABS

Authors: Adivhaho A Netshiya[1]; Armand Bahini[2]; Folurunso Ogundare[3]; Jacob Bekker[4]; Kgashane Leroy Malatji[5]; Lesedi Jafta[6]; Lindsay Michelle Donaldson[2]; Luna Pellegri[7]; Mathis Wiedeking[8]; Nyaladzi Palalani[3]; Pete Jones[9]; Philip Adsley[10]; Refilwe Emily Molaeng[11]; Retief Neveling[9]; Sandile Jongile[2]; Sebenzile P.E Magagula[12]; Shanyn Hart[13]; Sifundo D Binda[11]; Thuthukile Khumalo[14]; Tshegofatso Goitseone Modise[3]; Vincent. B Kheswa[15]

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[15] *IThemba LABS, Department of Applied Physics and Engineering Mathematics, University of Johannesburg, South Africa*

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INVESTIGATING THE PHOTON STRENGTH FUNCTION FOR ⁶¹Cu USING ⁶⁰Ni (p, γ) REACTION AT iTHEMBA LABS

The Brink-Axel hypothesis assumes that photo-de-excitation only depends on the emitted γ-ray energy Eγ and not the detailed structure of the initial and final states (spin and parity) involved in the transition as it is the case for photo-excitation process. While the hypothesis is widely used for all PSF energy regions such as the giant dipole resonance (GDR), it remains under investigation for the low energy region 1. In the present work, this hypothesis will be tested below the neutron separation energy, using for the first time radiative proton capture. An experiment to indirectly measure the photon strength function (PSF) took place at iThemba LABS's Tandetron facility, to populate excited states in ⁶¹Cu utilizing ⁶⁰Ni(p, γ)⁶¹Cu reaction. The model independent ratio method [2] and the shape method [3] will be used to investigate the statistical γ-ray decay to individual well established discrete states. With the neutron separation energy at 11.7 MeV, populated states with beam energies in the range 2.32-4.32 MeV will confine the study below the particle separation energy.

Data analysis is ongoing, and preliminary results will be presented.

References

1. S. Goriely et al., Eur. Phys. J. A 55, 172 (2019).
2. M. Wiedeking et al. Phys. Rev. Lett. 108, 162503 (2012).
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This research work is supported in part by the National Research Foundation (Grant No:118846, 92600, 90741, 92789 and REPSARC180529336567). It is also based upon work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics under Contract No. DE-AC02-05CH11231.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 127

Burn-in Testing for Transformer-Coupled Buck Converters in the ATLAS Tile Calorimeter's Low Voltage Power Supplies

Author: Thabo Pilusa[1]

Co-authors: Bruce Mellado [2]; Chuene Mosomane [3]; Roger Van Rensburg [1]; Ryan Mckenzie ; Vongani Chabalala [1]

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[3] *iThemba Labs*

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The High Luminosity Large Hadron Collider (HL-LHC) is scheduled to commence operations in 2030, targeting a luminosity five times than that of the current LHC run. This substantial increase in luminosity necessitates significant upgrades to the LHC detector systems. The Phase-II upgrades of the ATLAS detector involve a complete upgrade to the low voltage power supply (LVPS) system of its Tile Calorimeter (TileCal). The TileCal includes 256 LVPS boxes, each composed of eight transformer-coupled buck converter boards alongside auxiliary components. The Phase-II upgrade buck-converter boards are designed to step down the input voltage from 200 V DC to 10 V DC, which is required to power the front-end electronics of the ATLAS detector. Half of the required buck-converter boards are slated for production in South Africa in 2025, with 104 units already produced during the preparatory pre-production phase. The LVPS boxes are located on-detector, limiting access to the buck-converter boards during the operation of the ATLAS detector. If a failure occurs in the boards, the front-end electronics that they supply power to will remain inoperative until the year-end technical stop. To ensure long-term reliability of the boards within the TileCal and identify potential early- life failures, all boards undergo a rigorous burn-in testing process. This process subjects the boards to extreme operational conditions beyond their standard operating parameters within TileCal. Such testing is essential to ensure that there are no failures in the boards, guaranteeing uninterrupted data-taking during operation of the ATLAS detector.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Astrophysics & Space Science / 128

Multi-Wavelength Observations of AGN Activity in the Fornax Cluster

Author: Dejene Zewdie Woldeyes[1]

[1] *North-West University*

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Active Galactic Nuclei (AGN) play a critical role in regulating and shaping galaxy evolution through various influential processes or mechanisms that impact the surrounding interstellar and intergalactic medium. In dense environments such as galaxy clusters, this interplay becomes even more complex due to environmental effects like ram pressure stripping, tidal interactions, and strangulation. In this talk, I will discuss AGN-host galaxies in the Fornax Cluster using Multi-wavelength observations from MeerKAT (probing neutral hydrogen gas), MUSE/VLT (resolving ionised gas and stellar kinematics), and eROSITA (tracing hot X-ray emitting gas). With this multi-wavelength observations of galaxies across three key gas phases: cold (HI), warm (ionised), and hot (X-ray). We will uncover signatures of AGN feedback, gas accretion or stripping, and environmental suppression of star formation. With this ongoing project, we will constrain how AGN influences their host galaxies and how the cluster environment modulates gas content and AGN activity and to our broader understanding of galaxy transformation in clusters and the role of AGN in quenching or fuelling galaxies within such environments.

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Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 129

The low-lying electric dipole strength in nuclei: the role of deformation

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Co-authors: Harshna Jivan [2]; Peter von Neuman-Cosel [3]; Andy Krugmann [3]; Atsushi Tamii [4]

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The electric dipole response in nuclei is characterised at high energies by the isovector Giant Dipole Resonance (IVGDR) and, for neutron-rich nuclei, by the Pygmy Dipole Resonance (PDR) around the neutron separation energy. Even though these two excitation modes have been extensively studied, some of their characteristics are still not understood. This talk will concentrate on the discussion of the role of deformation in the excitation of the PDR. Two independent experiments were performed to study the electric dipole response of the quadrupole-deformed 154Sm nucleus. The inelastic scattering of 120-MeV alpha particles was studied at iThemba LABS while 295-MeV protons were used at RCNP. The first comparison of the isoscalar and isovector responses of the a the deformed nucleus will be presented.

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Consent on use of personal information: Abstract Submission:

Applied Physics / 130

Physics-based modelling and simulation of lithium-ion battery capacity fade and degradation

Authors: Eric Maluta[1]; Patel Sana[2]; Ratshilumela Steve Dima[3]; Tshifhiwa Ranwaha[2]; Regina Maphanga[4]

[1] *University of Venda*

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[3] *CSIR*

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Lithium-ion batteries (LIBs) have revolutionised the automotive industry (mainly electric vehicles)as a sustainable energy storage solution for electric vehicles due to their high-power and energy density. Their widespread adoption is crucial for achieving global decarbonization goals and reducing dependence on fossil fuels. However, the degradation of LIBs over time remains a challenge, leading to capacity fade and loss of battery performance, which ultimately affects the their lifespan and efficiency. Hence, it is essential to understand the aging processes in LIBs for improving battery design and optimising battery operation. This study employs physics-based electrochemical models that are implemented in an open-source battery simulation package –PyBaMM to understand the impact of high charging rates on capacity fade and degradation (solid electrolyte interphase growth and lithium-plating). The simulation was performed for 50, 100 and 200 cycles, using charging rates of 2 C, 8 C, 16 C, 20 C. Results indicate that higher charging rates exhibits faster aging of the battery. At moderate rates (2C, 8C), the SEI growth dominated during the initial cycleswhile at higher C-rates (16 C-20 C) lithium-plating became the primary contributor to capacity loss. Batteries charged at a higher current 20 C showed a 50% capacity loss within 100 cycles.
Keywords: Lithium-ion batteries, modelling, degradation, capacity loss, C-rate, solid electrolyte interphase.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Photonics / 131

Group delay dispersion measurements using the i2PIE pulse characterization technique

Author: Eugene Fouche[1]

Co-authors: Gurthwin Bosman [1]; Pieter Neethling [1]

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Group delay dispersion (GDD) plays an important role in the creation and control of ultrashort pulses. As ultrashort pulses travel through dispersive media, the different frequency components travel at different speeds, increasing the pulse duration due to broadening of the pulse temporal profile. To create transform limited pulses (pulses that are as short as allowed by the available bandwidth), there needs to be a flat phase profile across all the frequencies that are present in the pulse. It is therefore important to be able to characterize optical materials used in nonlinear optics experiments, since these materials influence the pulse length of ultrashort pulses and the outcome of the experiments.

We demonstrate the use of the i^2PIE pulse characterization technique to measure the GDD of various optical materials (e.g. quartz window, microscope slide). i^2PIE is used to measure the amplitude and phase of the pulse. The GDD is found by fitting a parabola to the measured phase profile of the broadband laser pulse after passing through the sample. The GDD of the samples can be determined with a resolution of ±5 fs^2, which is comparable with standard GDD measurements, and an order of magnitude better than GDD measurements using the MIIPS pulse characterization scheme. This highlights the versatility of the i^2PIE pulse measurement protocol and its superior performance when compared to other existing pulse characterization techniques.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Astrophysics & Space Science / 132

Constraints on Cosmological Parameters Using a Large Sample of Gamma-Ray Bursts with their redshift derived by Machine Learning

Author: Tamador Khalil Mansoor Aldowma[1]

Co-author: Soebur Razzaque [1]

[1] *University of Johannesburg*

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Various empirical correlations between observable and derived parameters have been proposed to use Gamma-Ray Bursts (GRBs) as standard candles similar to Type Ia supernovae (SNe Ia) for measuring cosmological distances. The Yonetoku relation, which connects the intrinsic peak energy to the isotropic peak luminosity, stands out as a promising tool. In this work, we present results from machine learning models applied to GRBs, from the Fermi-GBM and Kouns-Wind catalogs, to estimate their redshifts. These models, based on peak-flux intervals and parameter fittings from both datasets, allow us to explore the Yonetoku correlation using GRBs with pseudo-redshifts. We focus on estimating the distance modulus and constraining cosmological parameters using this relation. Our analysis includes 1576 GRBs with pseudo-redshifts (publicly available via Zenodo) and 116 GRBs with spectroscopic confirmed redshifts from the Fermi-GBM catalog. Additionally, we incorporate recent SNe Ia samples from SNe U2.1 and the Dark Energy Survey (DES-SNe). Unlike previous studies, we perform a simultaneous calibration of the Yonetoku relation and cosmological parameters using a Markov Chain Monte Carlo (MCMC) method, applied across both the full redshift range and within specific redshift bins, assuming a flat universe within the Lambda Cold Dark Matter (ΛCDM) model. This work aims to assess the potential of leveraging a large sample of GRBs with pseudo-redshifts from the Fermi-GBM and Kouns-Wind catalogs to provide meaningful constraints on cosmological models.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 133

Insights into the Structural, Thermodynamic, Electronic, and Mechanical Properties of CaMn2O4 Polymorphs via Density Functional Theory Analysis

Authors: Ndanduleni Lethole[1]; Oswald Roberts[None]

[1] *University of Fort Hare*

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Calcium, the fifth most abundant element in the Earth's crust, has emerged as a promising alternative to lithium for next-generation rechargeable ion batteries due to its natural abundance, low cost, and favourable redox potential. However, identifying a suitable cathode material capable of accommodating the reversible insertion and extraction of Ca^{2+} ions without undergoing significant structural or volume changes remains a major challenge. In this context, the density functional theory (DFT) serves as a powerful tool for the screening and evaluation of potential cathode materials. This study employs DFT calculations to investigate the structural, electronic, and mechanical properties of various polymorphs of CaMn2O4 as potential cathode materials for rechargeable Ca-ion battery chemistries. The simulations were performed using the CASTEP code within the Materials Studio 2020 environment, utilizing the Perdew–Burke–Ernzerhof (PBE) form of the generalized gradient approximation (GGA) for exchange-correlation interactions. The calculated structural parameters align well with existing experimental data, validating the computational methodology. Electronic density of states (DOS) analysis reveals that all CaMn2O4 polymorphs exhibit semiconducting behaviour. Mechanical property assessments, including elastic constants and moduli, indicate that the materials are mechanically stable. Further elasticity analysis suggests the onset of permanent deformation at strain levels above 0.6. This study provides valuable insights into the theoretical potential of CaMn2O4 as a cathode material for calcium-ion batteries.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 134

Prediction of Gas Sensing Materials Using Machine Learning Algorithms

Authors: Shandukani Kharavho[1]; Ratshilumela Steve Dima[2]; Tshifhiwa Ranwaha[1]; Eric Maluta[3]; Regina Maphanga[4]

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There is a growing need for safer homes, environments, and industries; this can be achieved by having gas sensors that are more efficient, cost-effective, and have low power consumption. However, currently used materials for gas sensing have limitations, calling for a need to search for materials with optimal and desired gas-sensing properties. Traditional methods, such as density functional theory, have been used extensively to explore and predict gas-sensing material properties such as adsorption energy, band gaps and response time. Traditional approaches often impede the search for materials' properties because they are time-consuming and computationally costly. This study uses the machine learning approach to predict the properties of gas-sensing materials. The performance of different machine learning algorithms, namely, support vector machine, random forest regressor, gradient boosting regressor, and extra gradient boosting regressor, is evaluated, our results shows that the extra gradient boosting regressor scored R2 of ~ 89%, followed by the gradient boosting regressor, recording a score of 85%; both algorithms had low root mean square errors of 0.70 and 0,95, respectively. This study demonstrates the robustness of ML algorithms to learn and study the pattern of gas-sensing materials for the adsorption of various toxic gases on different surface materials based on the DFT calculated and experimental results for selected descriptors for feature engineering.By training the ML models with the dataset, it can be concluded that prediction with ML is fast and cost-effective, with the ML models' accuracy evaluated using the metrics evaluation of root mean square error (RMSE) and coefficient of determination (R2).

Apply for student award at which level::

MSc

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Yes, I ACCEPT

Physics for Development, Education and Outreach / 135

Strengthening First-Year Physical Sciences Success: A Five-Year Analysis of Throughput with an Emphasis on AI-Driven Strategies

Author: Sewela Khunoana[None]

Co-authors: Sam Ramaila [1]; Vinny Motjoadi [2]

[1] *University of Johannesburg*

[2] *University Of Johannesburg*

Corresponding Author: sewelakhunoana4@gmail.com

In recent years, declining student success rates, particularly in first-year programs, have become a critical concern in higher education. This study examines throughput rates in first-year physics and chemistry courses over a five-year period, drawing on data from an extended curriculum program to identify and address key challenges. At the core of this study is the integration of Artificial Intelligence (AI) to enhance teaching and learning processes. Grounded in the Technological Pedagogical Content Knowledge (TPACK) framework, the study explores how AI can be embedded into the physical sciences curriculum to support student engagement and content mastery without disrupting existing pedagogical methods. By leveraging AI, the study aims to bridge the gap between theoretical knowledge and practical application, thereby improving throughput rates. Findings indicate that AI-driven strategies have significant potential to enhance student success in first-year physical sciences programs. AI-powered tools can facilitate personalized and adaptive learning experiences, leading to improved student engagement and retention. However, continuous assessment and refinement of these strategies are essential to ensure their effectiveness in meeting the evolving needs of students. By fostering AI-enhanced learning environments, institutions can reduce dropout rates, alleviate the demand on student support services, and implement more targeted interventions for at-risk students.

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None

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Yes, I ACCEPT

Poster Session / 136

Modeling Hybrid Energy Systems for Carbon Neutrality in South Africa.

Authors: Mabunda Hlayiseka[1]; Tshifhiwa Ranwaha[1]; Lufuno Takalani[2]; Eric Maluta[2]

[1] *University Of Venda*

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This study examines the contribution of hybrid energy systems to achieving carbon neutrality in South Africa's power sector by integrating solar, wind, and hydroelectric resources. Employing the IRENA FlexTool, the study examines various hybrid system configurations to evaluate their efficiency in reducing reliance on fossil fuels while ensuring grid stability. This study investigates the complex interactions among various renewable energy sources in the context of South Africa's significant dependence on coal, a key factor in national carbon emissions. The was aimed to identify the most effective energy combinations that improve generation efficiency, reliability, and cost-effectiveness. The model used consider seasonal variability, demand fluctuations, storage capacity, and transmission limitations to assess the practical implementation of hybrid systems. A specific emphasis is placed on evaluating the practicality of integrating pumped hydro storage to address the variability of renewable energy sources and maintain a reliable power supply. The results emphasize efficient hybrid system designs that can lower emissions and enhance long-term energy security. The analysis provides practical policy suggestions for enhancing hybrid renewable initiatives, fostering investment, upgrading infrastructure, and enacting regulatory changes. This study illustrates the technical and economic feasibility of hybrid renewable systems, thereby reinforcing South Africa's net-zero commitments and offering essential insights for policymakers, planners, and stakeholders focused on developing a resilient, cost-effective, and environmentally sustainable power sector.

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Honours

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Yes, I ACCEPT

Poster Session / 137

Structural and Magnetic Properties of $Ni_{0.5}M_{0.5}Al_{0.1}Fe_{1.9}O_4$ (M = Zn, Mn, Mg) Ferrites

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This study explores the structural and magnetic properties of $Ni_{0.5}M_{0.5}Al_{0.1}Fe_{1.9}O_4$ (M = Zn, Mn, Mg) spinel ferrites synthesized using a modified glycolothermal method tailored for enhanced control over particle sizes, crystallinity, and tuning of magnetic parameters. Additionally, the study aims to optimize magnetic hyperthermia parameters and leverage biodegradable elemental compositions. By systematically substituting Zn, Mg, and Mn, we tuned key magnetic parameters such as saturation magnetization, coercivity, and effective magnetic anisotropy through their distinct site preferences and spin interactions. Zn^{2+} was chosen to enhance magnetization for soft magnetic applications, Mg^{2+} to promote low-loss behaviour for power electronics, and Mn^{2+} to induce spin canting for tuneable responses; Al^{3+} was incorporated to reduce cell volume and drive Fe redistribution, thereby enhancing superexchange interactions.

Preliminary results from X-ray diffraction and Rietveld refinement confirmed phase purity and single-phase formation. Crystallite sizes from 9–11 nm were determined using the modified Scherrer method, while the lattice parameters followed Vegard's law, indicating the successful formation of a continuous solid solution. The unit cell volume reduced at each substitution level, resulting in a more stable structure. SEM-EDX analysis showed good agreement between experimental and theoretical compositions. Electron spin resonance (ESR) measurements were conducted. The Zn-substituted spinel ferrites exhibited the lowest resonance field at 2747.6 Oe, while the Mg-substituted samples showed the highest resonance field, with the Mn-substituted ferrite falling in between. These shifts in resonance fields are attributed to differences in magnetocrystalline anisotropy. The decrease in g-values from 2.5 to 2.3 indicates significant variation in the electronic structure and spin-orbital coupling due to cation distribution. An increased resonance field was associated with more significant magnetic anisotropy, lower g-values, and enhanced anisotropic behaviour. Vibrating sample magnetometer measurements showed saturation magnetizations ranging from approximately 23 to 55 emu/g and extremely low coercivitiy between 16 and 21 Oe, characteristic of superparamagnetic behaviour. The net magnetic moments deduced from the experimental data were in good agreement with theoretical estimates from cation distribution.

This work elucidates the fundamental structure-property relationships in spinel ferrites and opens avenues for the development of advanced materials synthesized by a modified glycol thermal method with potential applications in magnetic hyperthermia therapy whilst leveraging South Africa's abundant transitional metals. Further investigations include measuring the materials'magnetic properties at low temperatures and using Mössbauer spectroscopy to examine Fe^{3+} oxidation states, site occupancy, magnetic ordering of the materials, and measurement of magnetic hyperthermia measurements such as specific loss power (SLP).

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None

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Yes, I ACCEPT

Photonics / 138

Laser-synthesized Selenium nanoparticles for SARS-CoV-2 detection using LSPR

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Abstract: Accurate and timely diagnostics are essential for identifying infected individuals, enabling prompt treatment and control strategies to prevent further spread. The COVID-19 pandemic highlighted the critical role of diagnostic testing for disease preparedness and response. Conventional diagnostic techniques such as polymerase chain reaction (PCR) are effective at detecting viral pathogens, but they have shortcomings, such as long turnaround times. In this work,a photonic-based diagnostic tool, localized surface plasmon resonance (LSPR) integrated with selenium nanoparticles (SeNPs), is proposed. The laser ablation approach was used to synthesize SeNPs. Furthermore, an optical biosensing substrate coated with APTES was functionalized with SeNPs and Severe acute respiratory syndrome coronavirus 2 monoclonal antibodies (SARS-CoV-2 mAb). After characterization of the biosensing substrate, it was used for the detection of SARS-CoV-2 pseudovirus (analyte) using an in-house-built LSPR system. The presence of SARS-CoV-2 pseudovirus was successfully detected using LSPR integrated with SeNPs. In the presence of pseudovirus, a wavelength shift brought on by the SeNPs was observed, whereas the negative sample, which was pathogen-free, showed no shift. The LSPR technique can be translated into a rapid and accurate diagnostic tool for detecting infectious viral pathogens such as SARS-CoV-2, especially in point-of-care settings. Such photonics-based methods have the potential to contribute to addressing challenges with effective disease control and hence significantly reduce mortality rate due to the spread of infectious diseases.
Keywords: Selenium nanoparticles, SARS-CoV-2, Localized surface plasmon resonance, laser ablation

Apply for student award at which level::

PhD

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Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-2 / 139

Triboson Excesses in light of a Real Higgs Triplet Model

Author: Srimoy Bhattacharya[1]

Co-authors: Mukesh Kumar [1]; Siddharth P. Maharathy [1]; Andreas Crivellin [2]; Bruce Mellado [3]; Rachid Mazini [1]

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In recent years, the "multilepton anomalies" have emerged, consisting of several persistent tensions in channels with multiple electrons and/or muons in the final states, with missing transverse energy and (b-) jets. These anomalies have prompted growing interest in the possibility of a new scalar particle beyond the Standard Model (SM).
In this context, excesses have been observed in the diphoton, $Z\gamma$ and WW spectra, pointing toward the presence of a Higgs-like scalar S with mass $m_S \approx 152 \pm 1$ GeV.

While these excesses suggest the existence of a new resonance, the ZZ final state remains consistent with Standard Model predictions, showing no significant deviation. This consistency can be naturally explained if the scalar S belongs to a Real Higgs Triplet (RHT) with hypercharge $Y = 0$, which does not couple to a pair of Z bosons at tree level. In such a scenario, charged and neutral triplet scalars can be produced via Drell-Yan processes and decay into electroweak gauge bosons, leading to enhancements in triboson final states such as WWW, WWZ, and WZZ.

Recent ATLAS and CMS measurements of triboson processes report observed (expected) significances of $6.4\sigma(4.7\sigma)$ in the VVZ channel and $4.4\sigma(3.6\sigma)$ in WWZ. These can be interpreted as a possible link to the extended Higgs sector. In this study, we investigate whether the RHT Model with hypercharge $Y = 0$ can accommodate these triboson excesses through Drell-Yan production of triplet scalars, which subsequently decay into electroweak bosons, leading to an enhancement in triboson final states. We explore the parameter space where S is identified as a component of the extended Higgs sector, with a small but nonzero diphoton branching ratio. Using Monte Carlo simulations, we analyze the predicted cross-sections for WWZ, WZZ, and WWW production and compare them with current experimental data.

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None

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Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 140

Portable African Neutron-Gamma Laboratory for Innovative Nuclear Science

Authors: Christo van Tubbergh[1]; Ferdinand van Niekerk[2]; Glen Taylor[3]; Luna Pellegri[4]; Maahir Rahman[3]; Nieldane Stodart[1]; Pete Jones[1]; Shanyn Hart[5]; Stephan Woodborne[1]

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iThemba LABS has pioneered a mobile gamma-ray detection unit1 which allows a user to operate in the field and chart the location, strength and energy of gamma radiation. The system incorporates a sensitive scintillation detector[2] typically used for accelerator-based spectroscopy at the SSC laboratory and was integrated into a backpack incorporating a fast 125 MHz digitiser for readout and a GPS enabled Raspberry Pi microprocessor system, allowing in situ measurements of radiation around the Cape Town site, with collected data streamed to the cloud and analysed offline. After conducting a series of rollout radiation measurement tests at Faure site, iThemba LABS has successfully used the gamma-ray detection system in collaboration with local and regional institutions to take radiation monitoring measurements from calibrated sources in the field, including radiation measurements tests conducted at Kruger National Park and at mining areas both in South Africa and in Botswana. It has also been used in the commissioning of the SAIF facility monitoring the performance of the water-cooling circuits.

The Portable African Neutron-Gamma Laboratory for Innovative Nuclear Science (PANGoLINS) project aims to investigate measurements of both gamma rays and neutrons which forms an important component part on site or in transit and the detection of both fissile material for the use in decarbonised energy sources or disposal thereof. A core component of the project is be to miniaturize the weight of the gamma ray detection device and associated infrastructure so that it can be loaded on an unmanned aerial vehicle to enable access to, and enhance performance of radiation monitoring measurements at remote sites leading to autonomous operations.

PANGoLINS incorporates commercial detector assemblies of $LaBr_3(Ce)$, $SrI_2(Eu)$ and/or CLYC(Ce) for spectroscopy. In addition, the project encompasses the instrumentation of other scintillation detectors with silicon photomultiplier technologies. The coupling of these to readout devices such as high density ADC readout are planned for applications for nuclear science, medical imaging or astronomy.
An overview of the project, its progress and potential outcomes will be presented.

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** Supported 2023-24 by the Technology Innovation Agency under Grant number 14606/01
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None

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Yes, I ACCEPT

Poster Session / 141

Investigation of Poly(2,5)-benzimidazole (ABPBI)-Carbon Nanotube Composites for LEO Applications: An Integrated Computational and Experimental Study

Author: Luwy Swanepoel[None]

Co-authors: Christopher Arendse [1]; Kingsley Obodo [2]; Lionel Fourie [1]; Lynndle Square [3]

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This study explores the potential of an ABPBI–carbon nanotube composite as a candidate for space coating applications in Low Earth Orbit (LEO), using a combined computational and experimental approach. The goal is to assess how the composite's structural, electronic and optical properties respond to the demanding conditions of the space environment.

Density functional theory (DFT) as implemented in the CASTEP program was employed to construct and analyse a single-walled carbon nanotube (SWCNT) supercell with an adsorbed ABPBI monomer. Geometry optimisation, density of states (DOS), band structure (BS) and absorption spectrum analyses were conducted. Results showed significant π–π stacking interactions between the polymer and nanotube, charge redistribution and a notable decrease in the bandgap. These changes suggest improved electrical conductivity and enhanced absorption in the UV region.

Complementing the simulations, experimental studies were conducted on multi-walled carbon nanotube (MWCNT) reinforced ABPBI films. Optical characterisation using ultraviolet–visible (UV–Vis) spectroscopy and photoluminescence (PL) measurements revealed a consistent blue shift in the absorption peaks and noticeable changes in fluorescence intensity with increasing carbon nanotube (CNT) concentration. These effects indicate strong electronic interactions between ABPBI and the nanotubes. The widened Stokes shift observed in the PL results further supports improved charge separation and emission behaviour.

Overall, the experimental findings align well with the computational predictions, confirming that nanotube incorporation alters the electronic and optical response of ABPBI in a controlled and beneficial way. While the composite demonstrates properties—such as strong CNT–polymer coupling—further studies are recommended to evaluate its thermal performance and mechanical resilience under extended LEO exposure. The strong agreement between computational and experimental work in this study lays a foundation for further exploring the durability of ABPBI composites in the volatile environment found in LEO.

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Honours

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Yes, I ACCEPT

Photonics / 142

The Photo-Thermal Effect of Green-Synthesized Gold Nanoparticles on Human Breast Cancer Cells

Author: Mpho Mohlongo[1]

Co-authors: Blassan George [2]; Heidi Abrahamse [2]

[1] *University of Johannesburg*

[2] *Laser Research Centre, Faculty of Health Sciences, University of Johannesburg, Doornfontein, Johannesburg 2028, South Africa*

Corresponding Author: 217039520@student.uj.ac.za

Breast cancer continues to be one of the main causes of cancer-related deaths among women globally, highlighting the need for new, targeted, and less harmful treatment options. Gold nanoparticles (AuNPs) have been identified as potential tools in nanomedicine due to their compatibility with biological systems, customizable surface chemistry, and distinctive optical characteristics. Nevertheless, traditional synthesis methods often utilize toxic reducing agents, which limits their use in medicine. This study investigates an environmentally friendly method for synthesizing AuNPs using an extract from the Kniphofia porphyrantha plant and assesses their effectiveness in treating breast cancer. The AuNPs were synthesized through a green chemistry approach, utilizing aqueous plant extracts both as reducing and stabilizing agents. The spectrophotometric analysis was performed to confirm the optical properties of AuNPs. At the same time, the phototoxic effects of synthesized AuNPs on MCF-7 breast cancer cells were evaluated by assessing morphological changes, cellular viability, and cytotoxicity rates 24 hours post-irradiation using a 525 nm laser with a fluency of 10 J/cm². Results showed a dose-dependent response to the treatment, demonstrated by significant morphological changes, increased cytotoxicity, and decreased cell viability compared to untreated cells, indicating the anticancer properties of green AuNPs. This highlights the dual advantages of green AuNPs: sustainable production and potential use in cancer therapy. These results encourage further exploration of the optical properties and biological activity of plant-synthesized AuNPs as promising candidates for cancer nanomedicine.

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MSc

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Yes, I ACCEPT

Physics of Condensed Matter and Materials / 143

Effect of annealing conditions on the photocatalytic activity of anodic TiO2

Author: Assane Talla[1]

Co-authors: Sinoyolo Ngongo [1]; Ettienne Minnaar [1]; William Goossen [1]; Zelalem Urgessa [1]; Johannes Reinhardt Botha [1]

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Photocatalysis using titanium dioxide nanomaterial remains one of the most promising technologies for sustainable and environmental remediation. Because of their morphology (i.e. a high surface area), nanostructured TiO2 nanotubes have been actively studied due to their potential use in photocatalytic applications.
In this work, anodic TiO2 nanotubes are used as photocatalysts for the degradation of methylene blue dye. The TiO2 nanotubes were fabricated at ambient temperature in an ethylene glycol-based electrolyte under a constant voltage. The as-anodized tubes were annealed in an oxygen-rich atmosphere and in vacuum at different temperatures and then characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM) and transmission electron microscopy (TEM). The annealed samples were used as photocatalysts to degrade methylene blue dye under irradiation from a Xenon Lamp.
The XRD results show that heterophase anatase-rutile samples (with specific compositions) can be achieved by systematically varying the annealing temperature. SEM and TEM analysis reveal the formation of two distinct layers corresponding to the anatase and rutile TiO2 phases. The heterophase anatase-rutile samples exhibit the best performance, with near-complete degradation of the pollutant. It is shown the degradation efficiency increases with the rutile composition. The sample annealed at 700oC has a higher rutile composition and its degradation efficiency is 10% higher than that of the sample annealed at 600 oC. In comparison to the aspect ratio of the nanotubes, the results indicate that at higher annealing temperatures, the phase is likely the dominant factor contributing to the degradation efficiency of the organic pollutant.
The reaction rate in the presence of the heterophase TiO2 as well as the mechanisms of degradation are also presented and discussed.

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None

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Yes, I ACCEPT

Physics of Condensed Matter and Materials / 144

Structural and Optical Investigations of Tm3+/Yb3+ Doped Yttrium Pyrogermanate for Blue and NIR Upconversion

Author: VEERA NAVEEN KUMAR BASINA[1]

Co-author: R.E Kroon

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The rare-earth germanates has attracted significant attention due to their remarkable thermal stability, low phonon energy, and structural flexibility, making them promising hosts for rare-earth ion doping in photonic and optoelectronic applications. Yttrium pyrogermanate (Y₂Ge₂O<sub>
phosphors were synthesized via the solid-state reaction method and doped with Tm³⁺ and Yb³⁺ ions to investigate their structural and optical properties for potential upconversion (UC) applications. The focus was on evaluating how co-doping with Yb³⁺ enhances the blue/NIR emission of Tm³⁺ under near-infrared 980 nm excitation.
Powder X-ray diffraction confirmed the formation of the tetragonal P4₁2₁2 phase for both undoped and doped samples, with no secondary phases detected. Field emission scanning electron microscopy revealed irregularly shaped particles with average grain sizes of around 1 μm, forming agglomerated clusters typical of solid-state reaction prepared materials. The diffuse reflectance revealed absorption bands around 452 nm (¹H₆⟶¹G₄),
684 nm (³H₆⟶³F₃) and 797 nm (³H₆—
of Tm³⁺ ions, as well as and 980 nm (²F_{7/2} ⟶ ²F_{5/2})
of Yb³⁺ ions, confirming successful doping. A notable red-shift in the absorption edge was observed in the co-doped sample.
The photoluminescence measurements excited at 355 nm exhibited characteristic blue emission at ~453 nm (¹D₂ ⟶ ³F₄) and weaker red and NIR bands at 650 nm (¹G₄ ⟶ ³F₄) and 792 nm (³H₄ ⟶ ³H₆) of Tm³⁺ ions. Upconversion studies under 980 nm excitation showed weak blue emission at ~475 nm(¹G₄ ⟶³H₆) and a strong NIR emission at ~797 nm (³H₄ ⟶ ³H₆). Notably, co-doping with 2% Yb³⁺ enhanced the UC emission intensity considerably compared to the singly doped sample, confirming efficient energy transfer from Yb³⁺ to Tm³⁺ ions. This enhancement is attributed to two-photon and three-photon energy transfer upconversion (ETU) mechanisms responsible for NIR and blue emissions, respectively, with Yb³⁺ ions acting as effective sensitizer. These findings demonstrate the potential of rare-earth doped pyrogermanate phosphors as promising candidates for UC-based applications.

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PhD

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Yes, I ACCEPT

Poster Session / 145

Synthesis and characterization of Gd₂Co<i>T</i>O₆ (<i>T</i> = Mn, Fe)

Author: PANKAJ MOHANTY[1]

Co-authors: Bincy Susan Jacobs [1]; Mokgadi Ramavhuya [1]

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The occurrence of negative magnetization (NM) refers to a switch from positive magnetization to negative values with the application of a positive probing magnetic field below the temperature having a magnetically ordered phase, which can rarely be caused by diamagnetism 1. Such a novel phenomenon has created curiosity due to two states such as positive and negative magnetization as a function of applied magnetic field (<i>H</i>) and temperature (<i>T</i>) and also the property of the system [2]. Previous reports on La_{1.5}Sr_{0.5}Co_{1−<i>x</i>}Fe_{<i>x</i>}MnO< [3], Er₂CoMnO₆ [4] and Gd₂CoRuO₆ [5], quaternary double perovskites with the empirical formula R₂<i>T</i><i>T</i>'O₆ (R: rare-earth ions; <i>T</i> and <i>T</i>': transition metal ions) not only demonstrate features like NM but also concurrently show inverse exchange bias effect, arising be-cause of the complex interplay at the interface of ordered phase with disordered phase due to antisite formation, and neighboring magnetic clusters. Double perovskites (DPs) of the form R₂<i>T</i><i>T</i>' O₆ have opened up research avenues because of their significant physical properties such as magnetocaloric effect, metamagnetism, and exchange bias in addition to NM [6]. Intrinsic NM effect characterized by magnetization measured under field (<i>M</i>_{FC}) less than zero under positive cooling fields <i>H</i>_{cool} was observed in the Gd₂Co_{2−<i>x</i>}M compounds from <i>x</i> = 1.1 to 1.5. The results conclude that the inverse nature of exchange bias has the same cause as NM, which is ascribed to the opposite alignment of the resultant ferromagnetic moments to the applied cooling field below the magnetic compensation point. The present work presents a simple sol-gel method to synthesize Gd₂CoTO₆ (<i>T</i>= Mn, Fe) samples together with characterization of the compounds through different measurement techniques in order to compare the physical properties with those reported in literature.

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[6] Li et al, Phys. Rev. B 107, 214445 (2023)

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Yes, I ACCEPT

Poster Session / 146

Equilibrium and elastic properties of hexagonal molybdenum disulphide

Authors: Mokete Abram Mahladisa[1]; Tshepho Mcdonald[None]

Co-authors: Bulelwa Ntsendwana [2]; Lucky Sikhwivhulu [2]; Malil Matshaba [1]; Thuto Mosuang [3]

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Equilibrium and elastic properties of hexagonal molybdenum disulphide (MoS2) are investigated using the full-potential all electrons linearised augmented plane wave method. Generalized gradient approximation of Perdew-Burke-Ernzerhof for solids (GGA_PBE_Sol) was chosen to calculate equilibrium electronic structure and elastic properties. Electronic band structure and density of states results suggest a semiconductor material with an indirect narrow energy band gap. Elastic constants C11, C12, C13, C33, and C44, bulk modulus (Bo), shear modulus (G), Young's modulus (Y), and Bo/G ratio in the same symmetry were also calculated at 0 GPa. All acquired results were compared with related experimental and theoretical data.

Keywords: Molybdenum disulphide, band gap, equilibrium structure, electronic band structure, density of states, elastic properties.

Apply for student award at which level::

PhD

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Yes, I ACCEPT

Poster Session / 147

Artificial Intelligence (AI) a Modern Tool to Learn Physics

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The present time includes all tools that can assist the human race to make things faster reducing effective time. In the era of Artificial Intelligence (AI) it is very important to find its applicability in the field of teaching particularly Physics. The present work aims at the discussion of all type of AI-based tools that can be useful for teachers and learners keeping in mind the the exploitations of it. Also the shortcomings and limitations will be discussed precisely. The work will give an overall idea about the implications of AI in "Physics Education".

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Yes, I ACCEPT

Poster Session / 148

First-Principles Study of Nb/Mn Doping on $LiNiO_2$ (101) Surface And It's Interaction With Ethylene Carbonate

Author: Khomotso Maenetja[1]

Co-authors: MMESHI JASSICON HIINE ; Phuti Esrom Ngoepe [2]

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Nickel-rich layered materials such as $LiNiO_2$ offer high energy density, making them strong candidates for next-generation lithium-ion battery cathodes. However, their structural instability remains a critical challenge. In this study, spin-polarized density functional theory calculations [DFT + U-D3 (BJ)] were employed to investigate the effects of Nb and Mn doping on the first and second layers of the $LiNiO_2$ (101) surface. Surface free energy calculations reveal that doping lowers surface energy compared to the pristine surface, indicating enhanced surface stability. Furthermore, Nb doping in the second layer provides greater stabilization than in the first layer, while Mn doping is more effective in the first layer. Bader charge and work function analyses suggest that surfaces with second-layer doping exhibit higher reactivity at the topmost layer. Ethylene carbonate (EC) adsorption on both pristine and doped surfaces yielded negative adsorption energies, confirming thermodynamic stability. Among the investigated sites, adsorption at the Ni_{23} site showed the strongest interaction, with the most negative adsorption energy. These findings provide insight into the role of Nb and Mn dopants in tuning surface stability and reactivity of $LiNiO_2$ cathodes, with implications for improved electrolyte interaction and battery performance

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Theoretical and Computational Physics / 149

Eigenvalue determination for a Toy and Woods-Saxon Potentials using unsupervised PINN

Author: Tshegofatso Tshipi[None]

Co-author: Alan Cornell [1]

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Traditional numerical methods have been widely used to determine eigenvalues in quantum few-body problems. But little effort has gone towards exploring novel approaches like Physics-Informed Neural Networks (PINNs) as an alternative. In this work we shall explore the application of PINNs to determine the low-lying bound state for a toy molecular potential and the Woods-Saxon potential. The former is mainly used as a test bed for testing the accuracy of new theoretical models. The latter is a more realistic potential used to model the inter-action between nucleons inside the nucleus. Utilizing the unsupervised PINN framework to determine the eigenvalues for the radial Schrödinger equation, this framework approximates the eigenfunction by a trial solution that automatically satisfies the bound state boundary conditions. Preliminary results demonstrate that the PINN model has the potential to
predict the bound states'eigenvalues for the molecular potential, thus indicating the viability of PINNs as a powerful alternative for solving eigenvalue problems in quantum-few body problems.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics of Condensed Matter and Materials / 150

Cage motion of Iron (Fe) in Silicon (Si)

Author: Lehlohonolo Lisema[1]

Co-authors: D Naidoo [1]; H.P Gunnlaungsson [2]; J. Schell [3]; K Bharuth-Ram [4]; K. Johnson [5]

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Due to its negative impact on semiconductor devices, iron (Fe) is one of the most thoroughly investigated impurities in silicon. It is a usual unintended impurity in silicon manufacturing, functioning as a fast diffuser and severely lowering carrier lifetimes, especially harmful for solar cells applications. It is still unclear how defects or other impurities interact with substitutional and interstitial Fe under implantation conditions. Obtaining an understanding of the behaviour of metal impurities, such as Fe, in silicon can result in methods for improving gettering procedures, which transfer metallic impurities to less hazardous areas of devices. This motivates investigation of the fundamental properties and behaviour of Fe in silicon at the atomic scale. Techniques such as emission Mössbauer spectroscopy and emission channelling provide valuable insights into the behaviour of dilute probe atoms in these contexts. We demonstrate, using iron-57 Mössbauer spectroscopy following implantation of manganese-57 (T½ = 1.5) min. that substitutional Fe in silicon is not located on the ideal substitutional site, but exhibits cage motion or jumps via saddle sites, located 0.17(3) Å from the ideal substitutional site. In the temperature range from 300 K to 500 K, the jump rates follow an Arrhenius behaviour, with rates in the vicinity of 10^7-10^8 Hz and an activation energy of 0.18(3) eV. Our data also suggest compressive strain on substitutional sites and relaxing strain on interstitial sites when the implantation is below ~450 K. These findings provide new insights into the atomic-scale behaviour of Fe in silicon, which is essential for improving material processing and device performance.

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None

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Yes, I ACCEPT

Poster Session / 151

Theoretical Insights into Mooihoekite: A DFT-D Investigation of the bulk properties.

Author: Kagiso Mashishi[1]

Co-authors: Mofuti Mehlape [1]; Peace Mkhonto [1]; Phuti Ngoepe [1]

[1] *University of Limpopo*

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Mooihoekite (Cu₉Fe₉S₁₆) is a copper-iron sulfide mineral belonging to the chalcopyrite derivative family, characterized by its metal-enriched composition. It crystallizes in the tetragonal system and is commonly found in association with minerals such as haycockite, magnetite, pentlandite, mackinawite, and sphalerite. Despite its structural similarity to the well-studied chalcopyrite, Mooihoekite remains relatively underexplored from both computational and experimental perspectives. To address this gap, this study employs density functional theory with dispersion corrections (DFT-D) to investigate the bulk properties of Mooihoekite. The Hubbard U parameter is incorporated to account for correlation effects arising from localized d-states on transition metal atoms. The calculated structural parameters and interatomic distances show excellent agreement with available experimental data. Electronic structure analysis reveals semiconducting behavior with a band gap of approximately 0.7 eV and antiferromagnetic ordering, evidenced by predominantly symmetric spin-up and spin-down density of states (DOS). Mechanical stability is confirmed through the calculated elastic constants, which satisfy all stability criteria, while the Pugh ratio (B/G) indicates ductile behavior. The ground-state magnetic moment is determined to be ~5 μB at 0 K, consistent with experimental observations of temperature-dependent magnetism. These findings provide a foundational understanding of Mooihoekite's structural, electronic, mechanical, and magnetic properties, paving the way for further exploration of its surface chemistry and potential applications.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Astrophysics & Space Science / 152

Exploring the properties of pulsars and their nebulae through observations and modelling

Author: Trevor Nyambe[1]

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Crab-like and Vela-like pulsars are young, rapidly rotating neutron stars with strong magnetic fields. They are noted for their strong pulsed radio and gamma-ray emission and association with pulsar wind nebulae (PWNe). While Crab-like pulsars are generally younger and exhibit bright, compact nebulae, Vela-like pulsars are slightly older and often linked to more diffuse PWNe with complex emission characteristics. We identify sources that exhibit characteristic features such as phase-aligned radio and gamma-ray light curves (in the Crab-like case) and non-phase-aligned radio and gamma-ray light curves (in the Vela-like case), along with sharp gamma-ray peaks and highly polarised radio emission: imprints that are typical of these pulsar classes. We then apply the Rotating Vector Model (RVM) to their radio polarisation data to extract key geometric parameters, such as magnetic inclination and viewing angle, which shape the observed polarisation profiles. Following the RVM analysis, we model the gamma-ray light curves using high-energy emission models, which offer complementary constraints on the pulsar geometry and help identify the likely regions of particle acceleration within the magnetosphere. Our initial results show a good agreement between the models and observations, highlighting the importance of viewing geometry in pulsar emission. Further spectral and spatial modelling of their associated nebulae will enhance our understanding of energy transfer and the structure of pulsar-PWN systems.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Astrophysics & Space Science / 153

Searching for persistent radio emission towards selected Fast Radio Burst positions

Author: Thulo Letsele[1]

Co-authors: Christo Venter [1]; Mechiel Christiaan Bezuidenhout [2]

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Fast Radio Bursts (FRBs) are millisecond-duration radio emissions originating from cosmological distances, as indicated by their large dispersion measures. While numerous FRBs have now been localised to their host galaxies, a distinct class of compact electromagnetic counterpart, the Persistent Radio Source (PRS), has also been identified in some cases. These PRSs, have so far only been found in association with a small number of actively repeating FRBs. Characterising these PRSs is crucial for providing insight into the progenitors, local environments, and evolution of FRBs. Currently, only four repeating FRBs (FRB 20121102A, FRB 20190520B, FRB 20201124A, and FRB 20240114A) have confirmed associations with a PRS. This work presents several potential candidates for PRSs associated with FRBs using data from the MeerKAT Radio Telescope. A comprehensive multi-wavelength approach is necessary to confirm whether these candidates genuinely qualify as PRSs, with the aim of increasing the currently limited sample of known FRB-PRS associations.

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MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 154

Annealing-Driven Structural and Optical Properties in $BaAl_2O_4/MgAl_2O_4:Tb^{3+}$ Mixed-Phase Nanophosphors Prepared by Citrate Sol-Gel Method

Author: Caroline Ratlhagane[None]

Co-authors: A. Bele [1]; G. G. Matlou [1]

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In this study the mixed phases BaAl2O4/MgAl2O4: 0.1 Tb3+ (BM:0.1% Tb3+) nanophosphors were prepared via the citrate sol-gel method. The structural and optical properties were investigated by varying the annealing period from 1 hour to 5 hours, while keeping the annealing temperature at 1000°c and the doping concentration of 0.1% Tb3+ constant. The phase quantification of the X-ray diffraction (XRD) indicated that the mixed phases are composed of the hexagonal BaAl2O4 and cubic MgAl2O4 crystal structures. The Scanning Electron Microscope (SEM) results showed that AP influenced the morphology of the prepared samples, and the Energy dispersive X-ray spectroscopy (EDS) confirmed the expected elemental composition of Ba, Mg, Al, O and Tb3+ . Transmission Electron Microscope (TEM) confirmed the particle size of the prepared sample is in nanoscale range. The effects of the annealing period were observed on Photoluminescence (PL) results showed multiple emission peaks which were attributed to BaAl2O4 and MgAl2O4 Tb3+ transitions.

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PhD

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Poster Session / 155

First-Principles Study of Mn-Doped $LiNiO_2$ (101) Surface and Its Interaction with Ethylene Carbonate Electrolyte

Author: MMESHI JASSICON HIINE[None]

Co-authors: Khomotso Maenetja [1]; Phuti Esrom Ngoepe [2]

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Nickel-rich layered metal oxides, such as $LiNiO_2$, are among the most promising cathode materials for next-generation lithium-ion batteries due to their high energy density. Doping is widely recognized as an effective strategy to enhance their structural stability and electrochemical performance. However, a detailed understanding of the role played by individual dopants is essential for rational material design. In this study, spin-polarized density functional theory calculations [DFT + U-D3 (BJ)] were conducted to examine the effect of Mn doping on the first and second layers of the $LiNiO_2$ (101) surface. The surface free energy is lower when Mn is incorporated into the first layer, implying that first-layer doping offers more effective surface stabilization than second-layer doping. Bader charge analysis shows a lower charge on Mn in the first layer, while a higher work function is observed, indicating that the surface doped in the second layer is more reactive at the outermost layer. Additionally, ethylene carbonate (EC) adsorption at various Ni sites on both pristine and doped surfaces yielded negative adsorption energies, confirming thermodynamic favorability. Among these, the Ni_{23} site exhibited the most negative adsorption energy, suggesting a stronger interaction between EC and the surface.

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MSc

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Astrophysics & Space Science / 156

Solar wind temperature anisotropy during the Ulysses Spacecraft first polar pass

Author: Ephrem Tesfaye Desta[1]

Co-authors: Du Toit Strauss [2]; Eugene Engelbrecht [1]

[1] *Centre for Space Research, North-West University*

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Corresponding Author: ephrem.tesfaye@aau.edu.et

Anisotropy is a property of turbulence in solar wind plasma in which velocity and magnetic fields fluctuate along and perpendicular to the ambient magnetic field. Recent in situ measurements confirmed that the solar wind in the inner heliosphere exhibits a temperature anisotropy. The presence of this anisotropy results in magnetohydrodynamic (MHD) waves and instabilities. In this report, we analyze the proton temperature anisotropy using data from the Ulysses spacecraft during its first latitude scan. Radial and latitudinal variations of temperature anisotropy for Fire-hose and Mirror instabilities are discussed.

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Yes, I ACCEPT

Astrophysics & Space Science / 157

A Temporal-spectral study of short gamma-ray transients: Identifying distinct signatures of gamma-ray bursts and magnetar giant flares

Author: Dimakatso Maheso[None]

Co-author: Soebur Razzaque [1]

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Short gamma-ray bursts (SGRBs) and magnetar giant flares (MGFs) are short gamma-ray transients (SGRTs) with similar temporal profiles but distinct progenitors—SGRBs arise from compact binary mergers, while MGFs originate from magnetars in nearby galaxies. When MGFs are observed at large distances, their characteristic fading pulses may be undetectable, making them difficult to distinguish from single-pulsed SGRBs, particularly in the absence of redshift information. This study analyses the temporal and spectral properties of redshift-known SGRBs detected by Fermi-GBM and two Fermi-detected MGFs, GRB200415A and GRB231115A. Pulse rise times, obtained via Norris function fits, reveal that MGFs exhibit significantly faster rise times than SGRBs. Spectral analysis over the 10 keV–40 MeV range using Comptonized and Band models shows that MGFs have much harder low-energy spectral indices. These differences support the interpretation that MGFs result from rapid energy release near a magnetar's surface, while SGRB emissions are likely driven by internal shocks at larger radii from the central engine.

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PhD

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Yes, I ACCEPT

Physics of Condensed Matter and Materials / 158

Investigation of Biomimetic Coatings on Glassy Carbon and Ti-6Al-4V Substrates: Impact of Varying Surface Preparation Methods

Author: Unaisa Dockrat[None]

Co-authors: Johan Malherbe [1]; Thabsile Theodora Thabethe [1]; Tshepo Paul Nstoane [2]

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Biomimetic coatings, an innovative advancement in biomedical engineering, replicate the complex mechanisms and properties observed in biological systems to enhance the performance, durability, reliability, and biocompatibility of biomedical implants [1-2]. These coatings aim to improve implant integration with the human body, addressing the challenges of traditional coatings like thermally sprayed hydroxyapatite (HAp), which can suffer from inherent residual stress, undesirable thermal products, poor biocompatibility, infection risk, and inadequate tissue integration [2]. By imitating natural biochemical processes, biomimetic coatings with better cellular adhesion, proliferation, and differentiation [3] can be produced. This study explores biomimetic deposition on Ti-6Al-4V (Ti64) and glassy carbon (GC) substrates, pretreated with sandblasting, plasma etching, and polishing, and then immersed in simulated bodily fluid (SBF) for 56 days. The resulting coatings were analysed using scanning electron microscopy (SEM) for surface morphology, energy-dispersive X-ray spectroscopy (EDS) for elemental analysis, atomic force microscopy (AFM), and X-ray diffraction (XRD) to evaluate their structural and compositional properties.
EDS analysis revealed higher Ca and P on coatings deposited on plasma-etched and polished GC substrates, while sandblasted Ti64 substrates showed higher O, Ca, and P. Plasma-etched GC and sandblasted Ti64 apatite coatings resembled thermally sprayed HAp layers on Ti64, indicating similar elemental compositions. Ti64 substrates subjected to polishing and plasma etching had lower element percentages due to pre-treatment. SEM images showed distinct surface morphologies: GC substrates had tightly packed spherical particles creating a rough texture, while sandblasted Ti64 substrates exhibited densely packed spherical clusters and plasma-etched Ti64 samples had small, uneven clusters forming a porous texture. XRD confirmed coatings on polished and plasma-etched GC and the sandblasted and plasma-etched Ti64 as hydroxyapatite with fine grain size. XRD analysis confirmed all patterns to display distinct peaks corresponding to apatite, confirming successful biomimetic apatite coating formation. The AFM measured the Young's modulus of the coatings and observed values within the range comparable to that of human cortical bone (17–25 GPa) [4]. These findings suggest that biomimetic coatings can successfully produce apatite coatings suitable for biomaterial implants, potentially improving implant integration.

Key words: Hydroxyapatite, Biomimetic mineralization, simulated body fluid (SBF), biocompatibility

1 Smith, A. M., & Callow, J. A. (2016). Biomimetic Coatings for Biomedical Applications: Advances in Synthesis and Applications. Journal of Biomedical Materials Research Part A, 104(6), 1457-1472. doi:10.1002/jbm.a.35781.
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Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 159

The PANDORA Project: Investigating Photonuclear Reactions in Light Nuclei.

Authors: Atsushi Tamii[1]; Jacob Bekker[2]; Luna Pellegri[3]; PA Söderström[4]; Retief Neveling[5]

Co-authors: Agnese Giaz [6]; Andreas Görgen [7]; Andreea Gavrilescu [4]; Armand Bahini [8]; Asli Kosuglu [4]; Bruny Baret [9]; C Wang [10]; D Balabanski [4]; Denis Allard [9]; Elise Martinsen [7]; F Furakawa [11]; H Shibakita [12]; H Shimojo [12]; Igor Jurosevic [13]; J Finsrud [7]; JK Dahl [7]; JW Brümmer [5]; Junki Tanaka [11]; K Sakanashi [12]; KCW Li [7]; Katje Zhou [10]; Max Spall [13]; Nobu Kobayashi [11]; Oliver Wieland [14]; Pete Jones [5]; Peter von Neuman-Cosel [13]; R Iwasaki [11]; Refilwe Emily Molaeng [15]; S Okamoto [16]; S Ota [16]; Sifundo D Binda [15]; Sunniva Siem [7]; T Okamura [16]; Takahiro Kawabata [12]; Tatsyuya Furuno [12]; Thuthukile Khumalo [17]; Vetle Ingeberg [7]; Wanja Paulsen [7]; Y Fujikawa [16]; Yohei Sasagawa [11]; Yuya Honda [7]; Zaihong Yang [10]

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The PANDORA (Photo-Absorption of Nuclei and Decay Observation for Reactions in Astrophysics) project explores photo-nuclear reactions in light nuclei (A $<$ 60) through both experimental and theoretical studies. This research is particularly relevant to ultra-high-energy cosmic rays (UHECRs), where energy and mass loss primarily occur via electromagnetic interactions between nuclei and the cosmic microwave background, driven by the isovector giant dipole resonance (IVGDR) and it also has profound significance for nuclear physics for reaction calculations, theoretical models and nuclear data benchmarks. A key limitation in current UHECR propagation models is the scarcity of reliable experimental data for critical nuclei. To address this, PANDORA will utilize virtual photon experiments at iThemba LABS and RCNP, as well as real photon experiments at ELI-NP, to extract essential nuclear parameters, including IVGDR cross-sections, E1 strength distributions, and branching ratios for particle decay. The project's first experiment was conducted at RCNP in late 2023, focusing on photo-absorption and charged particle decay in ^{12}C and ^{13}C. This study utilized the Grand Raiden spectrometer, SAKRA (a backward-angle silicon detector array), and SCYLLA (a LaBr$_3$ detector array). This presentation will discuss the analysis of these measurements and their implications for UHECR propagation, particularly in refining loss length calculations.

This work is based on the research supported in part by the Japan-South Africa Bilateral Funding from JSPS with a grant number of JPJSBP 120216502 and from NRF with grant number 132993, the National Research Foundation of South Africa through Grants No. 129411, and 118846 and the SARCHI grant number 180529336567 and supported in part by the National Research Foundation (NRF) of South Africa grant number 118846, the Romanian Ministry of Research, Innovation and Digitization, CNCS - UEFISCDI, project number PN-III-P4-PCE-2021-0595, within PNCDI III

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None

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Yes, I ACCEPT

Poster Session / 160

Surface Properties of Nickel and Silver Metals

Authors: Malili Matshaba[1]; Mashilo Matlala[None]; Mokete Mahladisa[None]; Thuto Mosuang[None]

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Molecular dynamics (MD) simulation methods were used to study the surface properties of nickel (Ni) and silver (Ag) metals. Calculations were performed at room temperature with the help of DLPOLY computer code. The many-body Sutton-Chen potentials were used to understand the interactions between atoms in both Ni and Ag surface systems. Stability patterns of three basic surfaces {(100), (110) and (111)} of Ni and Ag were determined from the calculated individual surface energies. Radial distribution functions were also extracted for different surface planes. Data extracted from the radial distribution functions suggest that the surface planes studied have solid crystal structures. The (111) surfaces were found to be the most stable for both Ni and Ag metal and the correct stability pattern was confirmed in both metals.

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None

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Yes, I ACCEPT

Astrophysics & Space Science / 161

Probing Dark Matter Signatures in IceCube Astrophysical Neutrino Data

Authors: Khushboo Dixit[1]; Soebur Razzaque[2]; Gopolang Mohlabeng[3]

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[3] *Simon Fraser University*

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Dark Matter (DM) makes up a significant portion of the universe's mass-energy content, yet its fundamental nature remains elusive. Neutrinos are nearly massless particles that interact weakly with ordinary matter and may provide evidence of subtle interactions with DM. One possibility is that dense DM spikes, which form around supermassive black holes, can weaken the high-energy neutrino flux emitted from the host galaxy. Therefore, observing high-energy neutrinos from active galactic nuclei (AGN) can offer a unique opportunity to investigate these interactions. Recent observations of point-like neutrino sources, such as the blazar TXS 0506+056 and the radio galaxy NGC 1068 by the IceCube observatory, present a valuable chance to explore DM interactions beyond standard astrophysical scenarios. In this context, we aim to constrain the neutrino-DM scattering cross-section by combining data from all these sources, leveraging the public information provided by IceCube.

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Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 162

Optimisation-Deposition and Conversion of Lead Halide Thin Films to 2D Metal Halide Perovskite Thin Films via Low-Pressure CVD

Author: MONGEZI SEAN MTHIMKULU[None]

Co-authors: Buyisiwe Sondezi [1]; Christopher Arendse [2]; Machaba Leanyatsa Abraham Letswalo [1]; Siphelo Ngqoloda [3]

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Two-dimensional (2D) metal halide perovskite (MHP) thin films were synthesised by the conversion of lead halide thin films to 2D MHP thin films using a two-step low-pressure chemical vapour deposition (LPCVD) method. The first step involved the deposition of lead halide thin films (i.e., PbI₂, PbBr_{0.6}I_{1.4}, PbBr_{1.1}I_{0.9}, PbBr_{1.5} and PbBr₂) on glass/FTO/TiO₂ substrates via LPCVD, the second step exposed the as prepared lead halide thin films to phenethyl-ammonium iodide (PEAI) vapour during the conversion process. The conversion process was investigated at two different temperatures (170 ℃ and 190 ℃) using phenethyl-ammonium (PEA⁺) as the cation. The structural and optical properties of the converted thin films were characterised using X-ray diffraction (XRD), ultraviolet-visible (UV-Vis) spectroscopy, and photoluminescence (PL) spectroscopy. The results show that the conversion process is influenced by bromine (Br) ions in the precursor lead halide thin films, which enhances the conversion process. However, the converted thin films do not fully convert to 2D MHPs, as evidenced by lead iodide (PbI₂) diffraction peaks in the XRD patterns. The optical properties of the converted thin films show a blueshift in the absorption and PL peaks as the Br content increases, indicating the formation of 2D MHPs with a stoichiometry of (PEA)₂PbBr_xI_{4-x} (0 ≤ x < 1). The results suggest that the conversion temperature of 170 ℃ is more suitable for obtaining high-quality 2D MHP thin films due to the lower defect density, and the presence of Br ions enhances the conversion. The findings provide insights into the conversion process and the potential applications of 2D MHP thin films in optoelectronic devices.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Photonics / 164

The efficacy of PAM fluorometry as a tool to quantify heat stress in wheat

Author: Sarah Burnett[1]

Co-authors: Almuth Hammerbacher [1]; Tjaart Krüger [1]

[1] *University of Pretoria*

Fluorescence (spontaneous emission) is a highly sensitive probe for a multitude of molecular processes during the light-dependent steps of photosynthesis in numerous organisms. In living organisms, the fluorescence signal is dwarfed by reflection and scattering; however, the signal-to-noise ratio can be significantly enhanced by gating the fluorescence to sub-ms excitation pulses through a non-invasive technique known as pulse-amplitude-modulated (PAM) fluorometry. Wheat is an economically important crop that is susceptible to heat stress and consequent yield reduction at temperatures above 30℃. However, the changes to molecular processes that cause the decrease in yield have not been well reported. In this study, PAM fluorometry was used to investigate the effects of high temperatures on the energy transfer pathways during the light-dependent steps of photosynthesis. The quantum efficiency of energy conversion from light to chemical energy was not significantly altered at 30℃ but was reduced by 10.7% at 35℃. We show that the biological changes due to the heat shock response can be measured at a time resolution of 30 seconds. PAM fluorometry, and thus fluorescence, is able to provide information about the effects of heat stress on electron transport during light-dependent photosynthesis. This opens many possible directions of study, such as investigating the effects of different types of stress on photosynthesis or further modelling the photosynthetic energy-transfer pathways under heat stress.

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MSc

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Yes, I ACCEPT

Physics of Condensed Matter and Materials / 165

Effect of metal ions of different oxidation states Mx+ (x = 1 to 4) on the photoluminescence properties of Zn4B6O13:Eu3+ phosphor material.

Author: Edwin T. Maleho[1]

Co-authors: Buyisiwe Sondezi [1]; Machaba LA Letswalo [1]

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In this study, Eu³⁺ (fixed at 1 mol.%) activated Zn₄B₆O₁₃ phosphors incorporated with metal ions of different oxidation states M^{x+} (x = 1 - 4) were successfully prepared by combustion synthesis method using urea as a fuel. Partial substitution of metal ions with varying oxidation states enhanced the luminescence properties of Zn₄B₆C
The crystal structure properties of the prepared materials were studied by X-ray diffraction (XRD), which revealed the formation of a zinc metaborate cubic crystal structure for all the samples. Surface features and the elemental analysis of the phosphor materials were studied by SEM and EDS respectively. The optical properties analysed by the UV-Vis show that the metal ions that cause high reduction in the band gap of the material is that with M³⁺ oxidation state. The Fourier transform infrared spectroscopy (FTIR) method was used to study the molecular structure and chemical bonding of the prepared phosphors. Excitation and emission scans were recorded for different metal ions. Upon excitation at 395 nm, the emission spectrum exhibited five distinct peaks at 580 nm, 592 nm, 614 nm, 653 nm, and 706 nm, corresponding to the ⁵D₀ ⟶ ⁷F_J (J = 0 - 4) transitions, confirming the presence of the Eu³⁺ ion. The optimal emission of the Eu³⁺ dopant into the Zn₄B₆O₁₃ host was of M³⁺ substitution, which resulted in the phosphor achieving an excellent PL intensity and a color purity of 91.16%. Tunable luminescence from the reddish-orange area (0.620, 0.355) of Commission Internationale de l'éclairage (CIE) towards the red area (0.641, 0.351) was achieved by substituting different oxidation states M^{x+} (x = 1 - 4). Therefore, different oxidation states M^{x+} (x = 1 - 4) and Eu³⁺ doped Zn₄B₆O<sub>13<
phosphor may be suitable candidates for the development of display devices and white light emitting diodes.
Keywords: Phosphor, Luminescence, Metal ion, Color purity.

Apply for student award at which level::

PhD

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Yes, I ACCEPT

Photonics / 166

Riboflavin-mediated Photodynamic Therapy Induces Cytotoxic Effects in A549 Lung Cancer Cells

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Cancer is a deadly disease that continues to claim the lives of its victims on a global scale. Lung cancer, a prevalent and deadly malignancy, arises from the uncontrolled growth of cells within the lungs. Comprising of non-small cell lung cancer (NSCLC) and small cell lung cancer (SCLC), this disease poses significant challenges in diagnosis and treatment. Therefore, there is a dire need to develop and introduce innovative solutions to effectively eradicate the disease. Photodynamic therapy has promising therapeutic effects while causing minimal harm to healthy cells and tissues. In the pursuit of advancing cancer treatments, this study explores the therapeutic potential and impact of riboflavin, a natural photosensitizer, and photodynamic therapy (PDT) against A549 lung cancer cells. The cells were treated with riboflavin at variable concentrations and irradiated using a laser of wavelength 470 nm and a fluency of 5 J/cm2. Following a period of 24 hrs post-irradiation, the A549 lung cancer cells were analyzed using a range of biochemical assays, namely adenosine triphosphate (ATP) and lactate dehydrogenase (LDH) assays to determine half maximal inhibitory concentration (IC50). In addition, morphological analysis post-irradiation and localization studies were performed to determine where the drug localizes in the organelles using a range of organelle-specific trackers, including markers for mitochondria, lysosome, and the endoplasmic reticulum. Moreover, a reactive oxygen species (ROS) detection assay was also performed for ROS quantification as a result of PDT. Changes in cell viability and morphology were observed post-treatment, indicating the cytotoxic effects of riboflavin-mediated PDT on A549 lung cancer cells. These findings suggest that riboflavin-mediated PDT has potential as an anticancer treatment for lung cancer.

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PhD

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Poster Session / 167

Study on the impact of Pr3+, Ce3+, and Pb2+ ions on luminescence properties of BaB8O13:Gd3+ for potential applications in phototherapy.

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A series of BaB₈O₁₃ phosphors doped with different concentrations of (2.0 mol.%) Gd³⁺ ions and 1.0 mol.% co-doped with Pr³⁺, Pb²⁺, and Ce³⁺ ions were synthesized by solid-state synthesis method. The X-ray powder diffraction (XRD) analysis confirmed the pristine crystalline structure and uniformity of the compounds, with an average crystalline size of around 33 - 45 nm. Scanning Electron Microscopy (SEM) was performed to study the surface morphology of the compound and Fourier Transform Infrared (FT-IR) spectroscopy measurements determined the nature of bonding between elements of the compounds. The photoluminescence (PL) excitation spectra of BaB₈O₁₃:Gd³⁺ phosphor showed excitation peaks at 274 nm. The crucial role of gadolinium (Gd³⁺) ions in barium-based hosts lies in their narrowband emission spectrum, specifically at 311–315 nm, which is in narrow band ultraviolet B (NB-UVB) range and is attributed to the ⁶P_{7/2} to ⁸S_{7/2} transition and the prominent emission peak was observed at 340 nm that could result in oxygen vacancy from the BaB₈O₁₃. The effects of co-doping Pr³⁺, Pb²⁺ and Ce³⁺ ions with Gd³⁺ ions were observed. Emission at 313 nm can be used for the treatment of skin diseases. Based on phosphor host materials in Gd³⁺ activated materials or through energy transfers from sensitized dopant ions, enhanced PL emissions that are observed are pertinent for treatments of many skin diseases such as psoriasis, vitiligo, eczema, and many other skin conditions.

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None

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Photonics / 168

Increased exciton annihilation in incrementally aggregated photosynthetic antenna complexes from plants

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The automatic photoprotective mechanisms of photosynthetic antenna complexes that initiate light-harvesting have been a subject of great interest for potentially improved solar energy technology, enhanced crop efficiencies, and biosensing. Light-Harvesting Complex II (LHCII) is the main pigment-protein antenna in green plants and exhibits the remarkable capability to switch between a light-harvesting and a photoprotective state when exposed to fluctuating sunlight intensities. The in-vivo conditions that activate this switch can be mimicked by aggregation of LHCII. Despite more than three decades of research, the molecular mechanism responsible for the strong energy quenching in these aggregates is still unknown. We investigated LHCII aggregation in a stepwise manner and performed fluorescence correlation spectroscopy (FCS) along with time-correlated single-photon counting (TCSPC) on a home-built experimental setup to correlate the aggregate composition with their excited-state lifetimes. We discovered a non-linear relationship between the steady-state intensities and average lifetimes, which is explained well by increased annihilation of diffusing singlet excitons due to an accumulation of triplet excitons in aggregates. An approximated model of this singlet-triplet annihilation showed excellent correspondence with the experimental data. These results demonstrate the importance of distinguishing non-linear exciton annihilation from exciton quenching in photoprotective studies of plants.

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PhD

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Yes, I ACCEPT

Poster Session / 169

Understanding Interacting Dark Energy from a Dynamical Systems Analysis Approach

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Cosmological models in which dark matter and dark energy interact in a non-gravitational manner are known as Interacting Dark Energy (IDE) models and have been proposed to address many long-standing shortcomings and tensions in standard cosmology. Furthermore, recent results from the DESI Collaboration have suggested hints of dynamical dark energy, for which IDE models could provide a viable explanation. The relevance of IDE models underscores the need to understand their parameter space and their potential limitations. In this study, we apply a dynamical systems analysis to a class of IDE models, analysing the critical points and the behaviour of the system at these points. From our analysis, we derive theoretical constraints that avoid common pitfalls such as negative energy densities and future singularities. We also investigate how these models may address the coincidence problem and permit phantom crossing, a phenomenon also hinted at by the recent DESI results. In general, we find a clear preference for interaction models where energy flows from dark energy to dark matter. Lastly, we emphasize the importance of considering theoretical constraints on cosmological systems alongside observational data.

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PhD

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Physics for Development, Education and Outreach / 170

Learning from Kahoot

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Kahoot is a popular learning platform with a quiz-show format which is used for a quick review of student knowledge or to provide some variety in how material is presented. It is one of the most popular worldwide with over 70 million users per month. Many papers have been written on the effectiveness on using Kahoot in the classroom but few focused specifically on Physics. In addition most papers focus on formal classroom use of Kahoot, whereas this study took place in an interactive Science Centre (Unizulu Science Centre) and integrated Kahoot with simulations from PhET.
Unizulu Science Centre has served the rural communities surrounding the University of Zululand for almost 40 years. Obtaining feedback and research data from visitors is challenging as contact time is limited. In the past clickers were used to this end but this paper explores using Kahoot instead of clickers and utilising a pre- and post- test format to gather data on student learning. The author extended the clicker-based study performed for his Masters and PhD degrees (and presented at various stages at SAIP Conference) to one utilising Kahoot. Methodology and results will be presented and suggestions made for the effective use of this dynamic tool in out of school settings (like Science Centres) and also in the classroom or lecture theatre.

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None

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Yes, I ACCEPT

Poster Session / 171

Luminescence Study on the Impact of Alkaline Earth Metal Ions on Na3PO4:Ce3+ Phosphors for Colour Display Applications.

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This study explores the impact of metal ions (Mg, Ca, Sr, and Ba) on the properties of Na₃PO₄ The resulting nanophosphors, NaMgPO₄, NaCaPO₄, NaSrPO₄, and NaBaPO₄, were synthesized using solid-state reaction techniques and doped with 1 mol% Ce³⁺. The synthesized nanophosphors were annealed at 900℃ for 4 hours, except for NaMgPO₄, which was annealed at 780℃ for the same duration. A combination of characterization techniques, including XRD, FE-SEM, UV-Vis, FTIR and PL spectroscopy, were employed to comprehensively characterize the phosphor materials. Additionally, Commission Internationale de l'Eclairage (CIE) plots were generated from the PL data to evaluate and compare the colour tuning properties of each phosphor material. XRD analysis revealed that NaMgPO₄ and NaSrPO₄ phosphors adopted monoclinic phase structures, whereas Na₃PO₄, NaCaPO₄, and NaBaPO₄ phosphors crystallized in orthorhombic phase structures. Notably, doping with 1 mol% Ce³⁺ did not alter the crystal structure phases of these phosphor materials. However, the particle sizes are confirmed to be in the range of 40 nm to 75 nm in all the prepared samples. SEM analysis revealed that all the prepared samples exhibited micrometer-scale dimensions, with varying sizes and shapes. Complementary energy-dispersive X-ray spectroscopy (EDS) spectra confirmed the presence of the expected chemical elements in the synthesized nanophosphors. The incorporation of Ce³⁺ ions into the NaSrPO₄ resulted in reduced absorption, confirming the presence of Ce³⁺ ions in the UV-visible region. The photoluminescence (PL) spectra of the Ce³⁺-doped samples were recorded with an excitation wavelength of 281 nm, and the emission spectra were monitored between 300-400 nm. A strong emission band centered at 385 nm was attributed to the 5d ⟶ 4f transition of the Ce³⁺ ions observed for all the doped nanophosphors. NaBaPO₄: Ce³⁺ exhibited the most intense photoluminescence. The CIE colour coordinates of the synthesized nanophosphors revealed a tunable light emission spanning from the blue to violet colour region with a range of colour purity of 58% to 97 %, respectively. This suggests that these nanophosphors have great potential for use in colour display systems as blue to violet light-emitting components.

Keywords: Nanophosphors, luminescence, solid-state reaction, effect of Mg, Ca, Sr, and Ba, Ce³⁺, and Colour tuning

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PhD

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Yes, I ACCEPT

Applied Physics / 172

Transforming Coherent Telecom Receivers into Current Sensors

Author: Alice Drozdov[1]

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Lightning-induced damage poses a major threat to infrastructure, particularly in power and telecommunications networks. Accurate current measurements are essential for designing protective systems and assessing damage. While traditional sensors such as shunt resistors and Rogowski coils offer high accuracy, they must be installed at the strike point, making them unsuitable for wide-area deployment. Remote sensing approaches can scale across many installations; however, current estimates derived from measured fields and empirical models limit their accuracy. Achieving the precision of local measurements through remote means remains an open challenge. This research explores a novel method for distributed lightning current measurement using deployed fibre telecom infrastructure.

Lightning-induced magnetic fields cause polarisation changes in the light transmitted through optical fibre via the Faraday effect. By monitoring these changes, both fast and slow current measurements can be made. In contrast, many existing lightning current measurement techniques struggle to detect slow changes due to their reliance on measuring the time derivative of the current or field. Coherent optical receivers in telecom systems already track polarisation changes to compensate for environmental effects that alter the transmitted optical signal. This raises an important question: can polarisation information from these receivers be repurposed for lightning current sensing?

This study investigates the feasibility of using polarisation data from coherent receivers for current measurement. We experimentally compare this approach with a standard fibre optic current sensor, assessing its ability to measure fast- and slow-changing currents. Performance is evaluated in terms of linearity, resolution, sensitivity, and noise immunity, laying the groundwork for scalable lightning current measurement using deployed optical networks.

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PhD

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Poster Session / 175

First-principles study of adsorption mechanisms of various sodium-oxides on N-doped graphene cathode for efficient sodium-oxygen battery

Authors: Chewe Fwalo[1]; Refilwe Edwin Mapasha[1]

Co-author: Aleksey Kochaev [2]

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[2] *Ulyanovsk State University, Russia*

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The threats posed by climate change have been reported to be driven by use of fossil fuels. Therefore, to effectively mitigate these challenges, there is need of transitioning to renewable energy sources such as solar and wind. A critical component of this transition is developing energy storage devices that not only match but exceed the energy and power densities of fossil fuels. Batteries are pivotal in this journey, as their performance is heavily influenced by the materials used in their electrodes. By tailoring and fabricating these materials, we can significantly enhance battery performance. Two dimensional materials like nitrogen-doped graphene, which offer exceptional structural and electronic properties can revolutionize these energy storage systems.
In this study, density functional theory (DFT) was used to investigate the adsorption mechanisms of sodium-oxides (NaxO2, where x = 1, 2, 3, and 4) and their impact on the electronic properties of N-doped graphene cathode for efficient sodium-oxygen battery. The findings showed that various sodium-oxides, including isolated Na and O2 species, spontaneously anchor on the surface of N-doped graphene, with adsorption energies ranging from -0.31 to -0.89 eV. Additionally, the calculated charge density transfer values of 0.68, -0.33, 0.04, 0.45, 0.95, and 1.0 |e| for Na, O2, NaO2, Na2O2, Na3O2, and Na4O2 , respectively, reflect significant electronic interactions within the systems. Notably, the calculated band structures indicated enhanced metallic characteristics, suggesting that the electronic conductivity of N-doped graphene improves with the adsorption of various sodium-oxides, which is critical for electronic transport during charging processes.

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2. P. Giannozzi, O. Andreussi, T. Brumme, O. Bunau, M.B. Nardelli, M. Calandra, R. Car, C. Cavazzoni, D. Ceresoli, M. Cococcioni, et al., Advanced capabilities for materials modelling with Quantum ESPRESSO, J. Phys.: Condens. Matter 29 (46) (2017) 465901.

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PhD

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Yes, I ACCEPT

Astrophysics & Space Science / 176

Investigating the influence of Boundary Layer Dynamics on Aerosol Optical Properties Using Ceilometer and Cimel Sun Photometer.

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Monitoring atmospheric conditions is crucial for understanding the behaviour of aerosols, which directly impact air quality, climate, and satellite-based remote sensing applications. In this study, we focus on the atmospheric boundary layer (ABL), which regulates the dispersion, transport, and transformation of aerosols. Ceilometers, which measure the height of the boundary layer by detecting the backscatter of laser pulses, are used to observe ABL dynamics, including variations in boundary layer height (BLH), aerosol stratification, and vertical mixing. The Cimel Sun Photometer, a ground-based instrument that measures aerosol optical depth (AOD) and radiative properties of aerosols through direct sunlight measurements, is employed to provide insights into columnar aerosol loading, size distribution, and optical properties. This study examines the correlation between ABL height, as measured by the ceilometer, and AOD trends from the Cimel Sun Photometer over Pretoria, a region with high pollution sources such as industrial areas and significant seasonal changes. By integrating these datasets, we assess how fluctuations in BLH influence aerosol concentration and optical properties across different seasons (summer, autumn, and winter). This research contributes to improving air quality assessments, validating aerosol models, and enhancing the parameterisation of aerosol dynamics in climate models

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None

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Poster Session / 179

Multiple Outer-Shell Ionization Induced by Heavy Ion Impact on Bi, Gd, and Y Targets.

Author: ernest ejeh[1]

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The phenomenon of multiple ionization induced by heavy ion impact plays a significant role in altering the atomic structure during inner-shell ionization processes. In this work, we investigate the degree of multiple ionization in the outer shells (M, N, etc.) accompanying L-shell ionization of Bi, Gd, and Y targets bombarded by carbon ions with incident energies ranging from 0.33–1.0 MeV/u. The degree of outer-shell ionization was estimated from observed shifts in L x-ray line energies and deviations in intensity ratios, in comparison to both standard values and those obtained using proton impact. The presence of outer-shell spectator vacancies leads to complex electronic configurations and results in measurable shifts in the L x-ray diagram lines. Analysis of the recorded spectra reveals a clear dependence of multiple ionization effects on the charge state and energy of the carbon projectiles. The results contribute to a better understanding of heavy-ion induced atomic processes and their dependence on projectile parameters, offering valuable insights for theoretical modelling of ion-atom collisions.

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None

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Yes, I ACCEPT

Poster Session / 180

Polyethylene glycol stabilized rGO/AuNP nanocomposites: Enhanced stability for sensing and biomedical applications.

Author: Eldas Maesela[1]

Co-authors: Manfred Scriba [2]; Saturnin Ombinda-Lemboumba [3]; Tsholo Talane [4]; Vusani Mandiwana [2]; Mandla Msimanga [4]

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Abstract: Reduced graphene oxide/gold nanoparticle (rGO/AuNP) nanocomposites emerge as versatile materials for sensing, and biomedical applications; however, their practical implementation is frequently hindered by poor colloidal stability and aggregation mainly attributed to the stripping of ligands by rGO, inadequate anchoring of AuNPs, and electrostatic disturbances. In this study, we addressed these issues by developing polyethylene glycol (PEG)-stabilized rGO/AuNP nanocomposites that demonstrate improved stability. The intention was to synthesize and characterize PEGylated rGO/AuNP hybrids, assessing their enhanced dispersibility and long-term stability in comparison to their unstabilized counterparts. A simple one-pot synthesis method was employed, utilizing PEG both as a reducing agent for graphene oxide (GO) and a stabilizing agent to inhibit AuNPs aggregation. AuNPs were synthesized using the Turkevich method, while the rGO was prepared and dispersed in deionized water. The nanocomposites were prepared by combining rGO dilutions and AuNPs at a ratio of 1:1 (v/v), followed by sonication and stabilization with PEG. Transmission electron microscopy (TEM) revealed a uniform distribution of the AuNPs on the rGO sheets, with particle sizes averaging between 20 - 25 nm, verifying the efficacy of PEG in inhibiting aggregation. Additionally, Raman spectroscopy indicated better dispersion, improved hydrophilicity and colloidal stability. Ultraviolet-visible (UV-Vis) spectroscopy validated the successful integration of AuNPs within the rGO matrix. These results offer a scalable approach to address instability and aggregation issues in nanocomposite engineering, thereby facilitating improved performance in catalytic, sensing, and biomedical applications.

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MSc

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Applied Physics / 181

Physical Principles to Translate from Phase Contrast Imaging to Absorption Contrast Imaging

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Artificial Intelligence (AI) classification as a methodology and approach to identify Tuberculosis (TB) in patients has become a topic of increasing interest in the past few decades. This is in large part due to the increasing demand for faster methods of detecting TB to reduce spread. However, such methodologies require large datasets so that algorithms can learn the manifestations of TB in the lung. Some of these datasets are private due to patient confidentiality, and the publicly available ones are limited in number. The AI industry has exhausted publicly available chest X-ray (CXR) scans and now look for alternate methods to further develop research in the field. The study focuses on developing methods to translate 3D information on effective electron density from Hierarchical Phase Contrast tomography (HiP-CT) of a human lung to 3D segmented images based on differentiated effective atomic number and mass density. The purpose of this methodology is to create a digital phantom as a synthetic model of a human lung where pathologies of the various stages of TB can be inserted. Monte Carlo modeling of X-ray radiography can then be performed on sets of such digital phantoms to produce a library of 2D conventional X-ray radiographs labeled with details of the occurrence of TB pathologies. This synthetic data set can be used to train an AI classifier.

The study will leverage HiP-CT scans produced by the European Synchrotron Research Facility (ESRF) beamline BM18. These are high-resolution 3D scans (~20μm) of complete human organs. To create a synthetic dataset, the Geant4 toolkit will be used to simulate the properties and physiological conditions of a lung. This information is gathered from the HiP-CT images; to understand the material properties of the HiP-CT images, the phase shift (δ) and the effective mass densities (ρ_{eff}) of the organic materials within the lung must be known. Thus, this research builds on the derivation of equations and the calculation of these parameters as inputs for simulation.

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PhD

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Poster Session / 182

TGF-β Pathway Modulation: A Key Mechanism of Photobiomodulation Induced Tenogenesis

Author: AMARACHI ALBERT[1]

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ABSTRACT:
The transforming growth factor-beta (TGF-β) pathway is a pivotal regulator in directing adipose-derived stem cells (ADSCs) toward tenogenic lineage, making it a vital focus in tendon tissue engineering. Concurrently, photobiomodulation (PBM) has gained attention as a non-invasive technique to influence cell behavior and support tissue repair. Its potential to interact with signaling mechanisms during stem cell differentiation is of growing interest, though its specific effects on TGF-β-driven tenogenic differentiation remain insufficiently understood.
This research explores the influence of PBM on the tenogenic commitment of ADSCs via modulation of the TGF-β signaling cascade. ADSCs were maintained in 2D culture and subjected to green light PBM (525 nm, 5 J/cm²), with analyses conducted on Day 10. Cell viability and metabolic activity were assessed through biochemical assays, while gene expression profiling, focusing on tenogenic and TGF-β-related markers, was performed using qPCR. Histological techniques further validated protein expression and extracellular matrix development.
Initial data reveal that PBM supports tenocyte differentiation by enhancing the expression of key markers such as SCX and TNMD, and encouraging collagen synthesis, all while preserving cellular health. These outcomes indicate that PBM could effectively aid tendon-like tissue development by influencing TGF-β signaling. Continued research will aim to uncover the molecular basis of this modulation and refine PBM parameters for clinical applications, offering valuable insights for non-invasive tendon regeneration strategies.
Keywords: Photobiomodulation, TGF-β-pathway,qPCR,Adipose-derived stem cells (ADSCs), Tenogenic differentiation

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None

Consent on use of personal information: Abstract Submission:

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Theoretical and Computational Physics / 183

Quantum Complexity in Neutrino Flavour Oscil- lation

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Co-authors: Khushboo Dixit [2]; Shajid Haque [3]; Soebur Razzaque [1]

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Neutrino flavour oscillation offers a valuable avenue to probe physics beyond the Standard Model. Despite significant progress, key questions remain unresolved particularly the neutrino mass hierarchy and the constraints on parameters governing flavour oscillation, such as the mixing angle theta;₂₃ and the Charge-Parity (CP) violating phase delta;_{CP}. In this study, we aim to explore these questions by applying a concept from Quantum Information Theory: quantum complexity.Quantum complexity quantifies the "difficulty"of constructing a given quantum state from a reference state using a set of universal unitary operations (quantum gates). Specifically, we will use Nielsen's geometric approach to complexity, which focuses on the geometry of the space of unitary operators. In this operator approach, complexity is defined as the minimal geodesic distance from the identity operator to a target unitary. In our case, the target unitary is the time evolution operator governing neutrino oscillation. We first compute the complexity of two-flavour neutrino oscillation, and then extend our analysis to the three-flavour case. We investigate how the oscillation parameters influence the complexity and compare our findings with conventional probabilistic approaches.

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PhD

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Poster Session / 184

Density functional Theory study of $NaMnO_2F$ as a Cathode Material for Sodium-Ion Batteries

Authors: Damuleli Thivhafuni Edgar[1]; Tshifhiwa Ranwaha[1]; Ratshilumela Steve Dima[2]; Lutendo Phuthu[3]; Eric Maluta[4]; Regina Maphanga[5]

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Sodium-ion batteries (SIBs) represent a cost-effective and sustainable alternative to lithium-ion batteries, especially in the context of large-scale energy storage applications. This study utilized first-principles calculations grounded in density functional theory (DFT) with a spin-polarized generalized gradient approximation (GGA + U), applying a U value of 4.0 eV for all transition metals. This study examines the structural, electronic, mechanical, and thermodynamic properties of pristine $NaMnO_2$ and its fluorinated variant, $NaMnO_2F$, as potential cathode materials for sodium-ion batteries (SIBs). Our results indicate that the Mn d-orbitals and F-2p orbitals are predominant in the conduction and valence bands of the density of states (DOS). Fluorination significantly decreased the band gap and induced half-metallic behavior, resulting in enhanced electronic conductivity and improved electrochemical performance. The partial density of states (PDOS) revealed shifts in the energies of Mn-3d and F-2p orbitals, which contributed to an increase in states near the Fermi level. This indicates that fluorination improves charge carrier mobility and lowers the activation energy for conduction. The structural properties calculation indicates that fluorination results in local distortion, lattice parameter stretching, and a minor increase in volume. Mechanical stability was validated through elastic constants that meet Born stability criteria; however, both materials demonstrated brittle behaviour. Thermodynamic analyses indicate that specific heat and entropy increase with temperature, whereas Helmholtz free energy decreases, suggesting favourable thermal behaviour. Our results indicate that fluorination significantly improves the structural, electronic, and thermodynamic properties of $NaMnO_2$, positioning $NaMnO_2F$ as a highly promising cathode material for next-generation sodium-ion batteries. Oxyfluoride compositions are particularly appropriate for strained electrode configurations and thin-film battery applications. The computational insights establish a basis for the advancement of fluorine-containing intercalation frameworks in practical sodium-ion battery systems.

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Honours

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Yes, I ACCEPT

Astrophysics & Space Science / 185

A Search for Transient and Variable Radio Sources in the NGC 5068 field Using MeerKAT MHONGOOSE data.

Author: Vhuthu Tshilengo[1]

Co-authors: Eric Maluta [2]; Patrick Woudt [3]; Zwidofhela Khangale [3]

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Transient surveys play a crucial role in understanding the dynamic Universe, with radio transients serving as indicators of explosive and energetic astrophysical events. Despite their importance, conducting commensal radio imaging surveys for transients often demands extensive computational resources, data storage, and processing time. The MeerKAT radio telescope, with its high sensitivity and large field of view, presents an excellent opportunity to explore the transient radio sky efficiently. This study analysed MeerKAT observations of the NGC 5068 field from the MHONGOOSE Large Survey Project (LSP) to search for radio transient and variable sources. The dataset comprises ten distinct epochs, spanning timescales from approximately one month to over a year. The analysis was carried out using the Transients Pipeline (TraP) on the Inter-University Institute for Data Intensive Astronomy (IDIA) cloud computing platform. While no transient sources were detected, we identified 12 variable radio sources within the field.

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MSc

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Poster Session / 186

How to Build and Benchmark an Optical Neural Network Using Multimode Fibres

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The utilisation of mode division multiplexing, where multiple spatial modes transmit data simultaneously, holds significant promise for enhancing bandwidth in free space optical communication systems. However, atmospheric turbulence can compromise the reliability of these systems. To address this longstanding problem, traditional neural networks have been employed to classify modes in turbulence. However, these neural networks face challenges relating to energy efficiency, computational speed, and latency. In contrast, optical neural networks offer a potential solution by providing the computational capabilities of traditional networks while mitigating these limitations. In our approach, modal crosstalk within a multimode fibre acts analogously to the weighted sums performed by each layer in a traditional neural network. We demonstrate how to build an all optical neural network using different configurations of multimode fibres, and how to benchmark their classification ability using the MNIST and FMNIST datasets.

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MSc

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Nuclear, Particle and Radiation Physics-1 / 187

Coupling the MAGNEX focal-plane detector to the K600 high-resolution magnetic spectrometer for the NUMEN project

Author: Thuthukile Khumalo[1]

Co-authors: JW Brümmer [2]; Lindsay Donaldson [3]; Luna Pellegri [4]; Manuela Cavallaro [5]; Retief Neveling [2]

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The NUMEN (NUclear Matrix Elements for Neutrinoless double-beta decay) project aims to obtain the nuclear matrix elements (NME) to be used as inputs in models to determine the lifetime of neutrinoless double-beta ($0\nu\beta\beta$) decay, which is related to the absolute mass of the neutrino 1. This will be achieved by conducting heavy-ion double charge-exchange (DCE) reactions and measuring the cross sections of these reactions for all isotopes that have been identified to undergo $0\nu\beta\beta$ decay 1. The occurrence of the $0\nu\beta\beta$ decay will imply that the lepton number is violated [2]. It is, therefore, very important to determine the NMEs as they will assist in elucidating Physics beyond the Standard Model [2]. The transition operators of the $0\nu\beta\beta$ decay and DCE reactions have a similar mathematical structure with a combination of short $0\nu\beta\beta$ decay range Fermi, Gamow-Teller, and rank-2 tensor components [3]. The weights of such components are different, being controlled by the coupling constants in the weak sector and by the energy-dependent isospin, spin-isospin, and tensor coupling strengths for the strong interaction [3]. Therefore, more experimental data are required from a range of incident beam energies for DCE measurements. Additionally, to explore the candidate nuclei of $0\nu\beta\beta$ decay in a systematic way, more experimental data are required. Previous experiments for the NUMEN project at Istituto Nazionale di Fisica Nucleare-Laboratori Nazionali del Sud (INFN-LNS) have suffered from high signal rate due to the interaction of the target and projectile, which greatly outnumber any potential DCE events. Additionally, the limited energy resolution of the MAGNEX spectrometer for DCE measurements makes it a cumbersome task to decouple transitions of interest relevant to the NUMEN project. Particle-γ coincidence measurements are a plausible attempt at a solution for this problem. Thus, a high-resolution magnetic spectrometer like the K600 at the iThemba Laboratory for Accelerator Based Sciences (iThemba LABS), which is already used for coincidence measurements, is a perfect candidate for baseline measurements especially given that the LNS facility is still under upgrade. However, in its current design, the existing K600 detection system is limited in the detection of heavy ions (e.g. ^{6}Li,^{12}C,^{18}O,^{18}Ne) at moderate kinetic energies ($\approx$ 10 MeV/u) and light ions at low energies ($\approx$ 5 MeV/u) [4]. The development of a new low-pressure detection system for the K600 is currently underway to expand the spectrometer research program [4]. Thus, an already existing detection system from the MAGNEX large-acceptance spectrometer at INFN-LNS has been coupled to the K600 to provide a baseline as to how the K600 will operate with a low-pressure detection system. The coupling of the MAGNEX focal-plane detection system with the K600 is also beneficial for other nuclear-structure studies to be conducted with the K600 spectrometer. This talk will present preliminary results from the commissioning experiment, where the K600 was coupled to the MAGNEX focal-plane detector.

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None

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Poster Session / 188

Computational insights into the bulk and surface properties of cobaltite: A combined DFT-D+U and atomistic simulation study

Author: Segoarihle Ntobeng[1]

Co-authors: Mofuti Mehlape [1]; Peace Mkhonto [1]; Phuti Esrom Ngoepe [2]

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Cobaltite (CoAsS) possesses a similar structure to that of pyrite (FeS₂), exhibiting a semiconducting behaviour. Its X-ray diffraction pattern has been shown to closely resemble that of FeS₂ with the cleavage occurring along (100), (021), (111) and (110) planes in order of decreasing prominence. Cobaltite is commonly found in a variety of ore deposits, particularly in high temperature veins or in metamorphosed rocks. The mineral undergoes oxidation when exposed to oxygen and water producing a solution containing acid and heavy metals; therefore, understanding its surface stability is crucial for the extraction of valuable minerals. The density functional theory with dispersion correction and U parameter (DFT-D+U) and atomistic simulation with novel potentials were employed to correctly predict the bulk and surface properties of cobaltite. It was found that the d-orbital of cobalt (Co) with U = 1.0 eV was optimum to correctly predict a band gap of 0.589 eV for the bulk cobaltite model. The interatomic potentials used in atomistic simulations were able to predict lattice parameters of a = b = c = 5.543 Å, which correlate very well with the DFT-D+U value of 5.549 Å. The DFT-D+U calculations indicate that the surface stability in cobaltite follows the order (100) > (021) in decreasing rank, suggesting that the (100) surface is the most stable. This trend is corroborated by atomistic simulations results, which also show that the surface energy of (100) is lower than that of (021), further confirming its stability. This study showed the consistency between the DFT-D+U and atomistic simulations, providing insights into the surface stability that offer a fundamental understanding of the cleavage of cobaltite during mineral processing.

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PhD

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Astrophysics & Space Science / 189

Constraining the Teleparallel Universe

Author: Robert Rugg[1]

Co-authors: Amare Abebe [1]; Shambel Akalu [1]

[1] *North-West University*

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The latest DESI results, suggesting a dynamical dark energy equation of state, have reinvigorated interest in modified teleparallel theories, such as $f(T)$ gravity, as viable alternatives to the standard cosmological model. In this talk, I present a systematic investigation of several popular and novel $f(T)$ models, examining their viability in light of current observational data. By applying recent cosmological datasets, including Type Ia Supernovae, Plank 2018, BAO, and Hubble parameter measurements, we derive constraints on key model parameters and explore the sensitivity of each model to different datasets using Monte-Carlo-Markov-Chains. The analysis not only highlights which forms of $f(T)$ are most favored by data but also identifies unique signatures that could distinguish torsion-based gravity from curvature-based frameworks. This work contributes toward the broader goal of building a consistent, observationally viable theory of gravity beyond the standard paradigm.

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MSc

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Astrophysics & Space Science / 190

Stochastic particle acceleration by multifractal MHD turbulence in strong magnetic fields

Authors: Anton Dmytriiev[1]; Frans van der Merwe[1]

Co-author: Markus Böttcher [1]

[1] *North-West University*

Corresponding Author: 33716722@mynwu.ac.za

Enrico Fermi first proposed the stochastic acceleration of protons due to interactions with parsec-scale interstellar magnetic fields as a method of cosmic ray acceleration around the time of the 1950s. Since then, the theoretical framework of stochastic acceleration in magnetohydrodynamic (MHD) turbulence has undergone significant refinement with recent numerical simulations incorporating more realistic multifractal MHD turbulence yielding previously unknown effects, such as intermittent particle energization characterized by large jumps in particle momenta. In this work, we numerically simulate the intermittent acceleration of a population of relativistic electrons as a continuous-time random walk, i.e., the time between energization events is described by a continuous random variable, based on the methodology developed in previous studies. We developed a Monte-Carlo code to simulate the effects of intermittent energization on the electron spectrum. This methodology was extended by incorporating intermittent synchrotron cooling into the existing theory for which an analytical expression for the change in electron momentum was found and incorporated into the Monte-Carlo approach. Our findings suggest particle spectra characterized by distinct low- and high-energy tails, differing significantly from those predicted by the standard Fermi theory.

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MSc

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Poster Session / 191

First-Principles Study of $NaMnPO_4F$ as a Cathode for Sodium-Ion Batteries

Authors: Mudimeli Vusani Mangalani[1]; Tshifhiwa Ranwaha[1]; Ronel Ronella Randela[1]; Ratshilumela Steve Dima[2]; Eric Maluta[3]; Regina Maphanga[4]

[1] *University Of Venda*

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Polyanionic phosphate-based materials have gained significant interest as cathode materials for sodium-ion batteries (SIBs) owing to their intrinsic thermal stability, structural integrity, and elevated operating voltage. This study employed first-principles density functional theory (DFT) computations with the generalized gradient approximation (GGA + U) in Materials Studio, applying an effective U value of 4.5 eV to all transition metals. The investigation concentrated on the structural, electrical, mechanical, and sodium-ion transport features of fluorine-doped $NaMnPO_4F$ as a prospective high-voltage cathode material. Our results indicate that the electronic band structure and density of states (DOS) influenced by fluorine exhibit a diminished band gap and an increase in electronic conductivity. The partial density of states (PDOS) exhibited substantial alterations in the contributions of the Mn-3d and F-2p orbitals, accompanied by a marked increase in the density of states proximate to the Fermi level. These modifications signify increased charge carrier mobility and reduced activation energy for electronic conduction, crucial for improved electrochemical performance. The computation of structural characteristics indicates that the insertion of fluorine caused little lattice distortion and an increase in lattice parameters, due to the local strain and polyhedral modifications induced by the dopant. As a result, the total volume of the $NaMnPO_4F$ unit cell shown a slight increase, aligning with the development of a more open framework that could enhance sodium-ion diffusion. Mechanical stability was validated via calculations of elastic constants, with all stability criteria met. Fluorine doping markedly enhanced resistance to shear deformation, and the material exhibited a Pugh's ratio over 1.75, signifying ductile behavior. This differs from the fragile characteristics typically seen in undoped equivalents and indicates enhanced mechanical reliability during cycling settings. This study demonstrates that the incorporation of fluorine into $NaMnPO_4$ boosts electronic conductivity via band gap reduction and PDOS modification while also facilitating advantageous structural expansion and better mechanical properties. These results confirm $NaMnPO_4F$ as a mechanically robust and electronically conductive cathode material appropriate for advanced sodium-ion battery applications.

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Honours

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Photonics / 192

Ag-H2O nanofluids by pulsed laser liquid-solid interaction for heat removal in electronics devices

Author: Snenkosi Dlamini[1]

Co-authors: Ceboliyazakha L Ndlangamandla [1]; Mahmud Akbari [2]; Malik Maza [2]; Mathew Moodley [3]; Mokhotjwa S. Dhlamini [4]

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We present Pulsed Laser Ablation in Liquid Solution (PLAL), a one-step pulsed laser ablation technique that produces a stable Ag-H2O nanofluid with improved thermal conductivity. Throughout the synthesis procedure, several deposition durations and fluences of the Nd YAG. Spherical nanoparticles (21–37 nm) having instability at higher concentrations are revealed by characterization. At 45℃ (ta = 5 min), the thermal conductivity improvement is readily visible and reaches a maximum within 14–20%. In terms of the contact angle, laminar flow at the Cu interface is most likely indicated by ΔΘ<95 Deg. The impact of fluid flow is highlighted by concentration-dependent effects on the contact angle. Tube surface design emphasises design considerations via influencing flow.

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MSc

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Theoretical and Computational Physics / 193

Advancing Thermal Field Theory: NLO Calculations for Finite Size Systems

Author: Rens Roosenstein[1]

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Understanding the behavior of matter under extreme conditions is one of the key goals of high-energy physics. In particular, the study of the quark-gluon plasma (QGP) offers insights into the early universe and the dynamics of strongly interacting matter. A powerful way to study such systems in thermal equilibrium is through the thermal partition function, which encodes the statistical properties of a quantum field theory at finite temperature. This formalism is often called Thermal Field Theory, and it will be the topic of my talk. Specifically, I would discuss the next-to-leading order finite-size corrections to the partition function in ϕ^4 theory.

In order to compute the partition function from first principles, we begin in the Hamiltonian operator formalism and move toward a path integral representation. A crucial step in this transition involves coherent states, which form a natural basis for extracting information about quantum fields. These states are particularly useful when computing the trace in the partition function, as they allow us to capture the field configurations involved in the system's dynamics. Their algebraic properties, particularly the eigenstate property of the annihilation operators, make them especially effective for deriving the path integral in a controlled way.

$$Z = Tr[e^{-\beta H}] = \int D\phi \, e^{-\frac{1}{2}\int_0^\beta d\tau \int d^n\mathbf{x}\left[\dot{\phi}^2+(\nabla\phi)^2+m^2\phi^2\right]}$$

Working in imaginary time and employing periodic boundary conditions in the temporal direction naturally leads to the Matsubara formalism. This framework allows us to express field configurations as discrete Fourier series in terms of Matsubara frequencies. Once this setup is in place, the path integral can be explicitly computed in the free theory, yielding a compact and elegant form of the partition function from which thermodynamic quantities such as the free energy and the pressure can be extracted.

$$Z = C\frac{T}{m}\prod_m' \frac{\omega_\ell^2}{\left(\omega_\ell^2+E_{\mathbf{p}m}^2\right)}$$

$$f = \frac{F}{V} = -\frac{T}{V}\ln Z, \qquad P = \frac{\partial(T\ln Z)}{\partial V}.$$

We then consider the extension to interacting theories, where the presence of interaction terms complicates the structure of the path integral and the use of coherent states as a bridge from operators to classical field configurations. The coherent state techniques must be treated with care, especially since time evolution is now governed by the full Hamiltonian and not just the free part. The interaction picture becomes essential, but its use in imaginary time raises subtle issues, particularly in how time ordering and commutators behave in the thermal trace. These complications are closely related to the need for more sophisticated contour prescriptions in the complex time plane. The appropriate prescription is the Schwinger-Keldysh contour, which is necessary when studying real-time dynamics in combination with thermal processes.

Through this careful computation, we have found additional correction terms to the path integral representation of the partition function that do not appear in existing literature. As a preview, we show the current result of the discretized finite path integral interacting partition function including these corrections:

$$Z = \int D\phi \, e^{-\frac{1}{2}\int_0^\beta d\tau \int d^n\mathbf{x}\left[\dot{\phi}^2+(\nabla\phi)^2+(m^2+\frac{\lambda}{4!}\langle 0|\hat{\phi}^2|0\rangle)\phi^2+\frac{\lambda}{4!}\phi^4+\frac{\lambda}{4!}\langle 0|\hat{\phi}^4|0\rangle\right]}$$

The precise interpretation of these corrections is still under investigation, but they may have important implications for how interacting thermal systems are treated beyond the leading order. By the time of the conference, I expect to have resolved the origin of these terms and to have explicitly evaluated the path integral for the fully interacting theory. I may already be able to present preliminary results on the renormalized computation of next-to-leading order finite-size corrections to the pressure.

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MSc

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Poster Session / 194

The evolution of the 98 GHz ACT source population since z = 4.5

Author: Obakeng Phiri[1]

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This research focuses on more than 15,000-millimetre wavelength sources observed using the Atacama Cosmology Telescope. These sources cover an area of approximately 18,000 square degrees and the ACT data observed at 98 GHz allows us to have a large population of AGNs at different redshift bands. This makes it possible to study the light these AGNs released at a redshift of up to 4.5, corresponding to the lookback time of about 11.9 Gyr. We also cross-matched the ACT data with radio data from RACS, MALS, VLASS, and FIRST surveys, enabling us to look at sources that other surveys could not detect (as the sources are faint). Also, we use redshift data from the Gaia-unWISE Quasar catalogue, which consists of spectrophotometric redshifts. We will look at luminosity functions for the number density of these sources at different redshift bands. We will fetch images from different wavelengths (radio, infrared, optical, and X-ray) to look at the environments and morphologies of these sources and see if they have common structures at different redshift bands.

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Photonics / 195

Deep Learning the Digital Twin of Bent Optical Fibre.

Author: Joshua Jandrell[1]

Co-author: Mitchell Arij Cox [2]

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Physical perturbations (bends) in optical fibre cause mode-mixing: energy coupling and interference between the fibre's (otherwise propagation invariant) eigenmodes. This mode-mixing can be described using a complex transmission matrix (TM). The ability to predict the effect of physical bends on the TM can help improve mode division multiplexing, imaging, and endoscopy; furthermore, it enables more efficient wavefront modulation via TM engineering, which has applications in optical machine learning and optical quantum circuit construction. Accurately modelling the effects of bends analytically or numerically is non-trivial due to non-linear interdependence between bends. Convolutional neural networks have been used to create optical digital twins: models which predict the impact of bends on the propagating wavefront. Current optical digital twins simply generate images of the predicted output field given an input field (image) and the bend information. This approach fails to describe the TM directly and relies on extensive training to accurately capture physical trends. We investigate the suitability of a new deep learning approach for optical digital twins: physics-informed neural networks (PINNs). PINNs create a compressed model of physical phenomena within the neural network by explicitly encoding physical relationships into the model's architecture and cost function. We design a PINN to directly predict the TM of a bend fibre while ensuring adherence to the law of conservation of energy. The PINN is compared to a traditional neural network in terms of output prediction accuracy, convergence rate, and number of neurons required.

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Theoretical and Computational Physics / 196

Analytical Regularization

Author: Jarryd Bath[1]

Co-author: William Horowitz [2]

[1] *University of Pretoria*

[2] *University of Cape Town*

Corresponding Author: u19034777@tuks.co.za

We present a novel regularization scheme in quantum field theory, analytic regularization. In our regularization scheme, we modify the action such that convergence is guaranteed before quantization. In particular, using Riesz derivatives, we analytically continue the power of the kinetic term in the action leading to an analytic continuation of the power of the propagator. This power is then treated as the parameter that regulates the UV divergences of the theory. It is a regularization scheme in quantum field theory that modifies the power of the propagators of a theory. We explicitly demonstrate how our scheme self-consistently regularizes massless and massive ϕ^4 theory and, time permitted , discuss the consistency of our regularization scheme in gauge theories and their related Ward identities.

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Theoretical and Computational Physics / 197

Numeric exploration of Non-trivial emergent phenomena in Quark-Gluon Plasma

Author: Nia O'Callaghan[1]

Co-author: William Horowitz [1]

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With the ultimate goal of analysing probe quarks in a Quark-Gluon Plasma via the AdS/CFT correspon-

dance, we explore here the motion of fundamental strings in a curved target spacetime. Specifically, our goal will
be a target space of AdS5 –Schwarzschild, which under the correspondance is dual to a conformal field theory
approximating Quantum Chromodynamics. We will model both the case of a heavy, on-mass-shell quark, corre-
sponding to a string with endpoints fixed at the horizon of a black hole and at the boundary of AdS spacetime,
as well as a light, off-mass-shell quark, which corresponds to a string with one endpoint fixed on the horizon
and the other free to fall. In either case, modes on the string are excited by the black hole, giving rise to motion
of the endpoints of the string, dual to the Brownian motion of the probe quarks in the boundary theory.
We will begin with the analytic results for the equations of motion of these strings under the relavent boundary conditions, where available in the cases of flat and AdS3 –Schwarzschild target spacetimes, and make
use of tools built into Wolfram Mathematica to numerically solve the same equations of motion in the
remaining case. This will allow comparison between the numeric and analytic cases, allowing us to verify the
results of the numeric simulations. Once agreement has been established, we will extend this to the cases for
which there are no analytic solutions, and interpret the results thereof. Finally, we will then be able to extract
observables relevant to the behaviour of the probe quarks from these solutions.

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MSc

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Physics for Development, Education and Outreach / 198

Transforming Physical Sciences Teaching through Targeted Professional Development

Author: Mark Herbert[1]

Co-author: Bako Audu [1]

[1] *University of the Western Cape*

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Physical Sciences teachers in under-resourced South African schools often face systemic challenges, including limited access to continuous professional development, inadequate teaching resources, and insufficient support for both content and pedagogy. These challenges frequently result in teacher-centred practices that hinder learners'development of conceptual understanding and procedural knowledge. This paper presents findings from a professional development initiative led by the Department of Physics and Astronomy at the University of the Western Cape, aimed at addressing these issues in surrounding schools. The programme included interactive workshops, collaborative lesson planning, and classroom-based support, with a particular focus on promoting learner-centred approaches such as Modeling Instruction. Data were collected through teacher surveys, pre- and post-tests, and reflective activities to assess changes in content knowledge and pedagogical practice. The findings reveal increased teacher confidence and notable improvements in both content knowledge and the adoption of learner-centred teaching strategies. This study contributes to the ongoing discourse on designing contextually relevant and sustainable professional development models for science educators in resource-constrained environments.

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Physics for Development, Education and Outreach / 199

Attitudes and Approaches to Problem Solving as Predictors of Physics Achievement Among First-Year Students

Author: Mark Herbert[1]

Co-author: Bako Herbert [1]

[1] *University of the Western Cape*

Corresponding Author: msherbert@uwc.ac.za

Students'success in physics is influenced not only by their content knowledge but also by their attitudes and approaches to problem solving. This study investigates the correlation between first-year mainstream physics students'attitudes and approaches to problem solving and their academic achievement in the subject. A sample of 100 first-year students from the Department of Physics and Astronomy at the University of the Western Cape participated in the study. Students completed the Attitudes and Approaches to Problem Solving (AAPS) survey, and their responses were compared to their performance on a curriculum-aligned physics assessment designed to evaluate conceptual understanding and procedural skills. The findings reveal a moderate to strong positive correlation between students'problem-solving attitudes and their academic performance, suggesting that those who adopt more expert-like approaches—such as drawing diagrams, reflecting on their solutions, and persisting through challenges—tend to achieve better results. These outcomes underscore the importance of fostering productive problem-solving mindsets alongside traditional content instruction. The study offers valuable insights for improving teaching strategies, curriculum design, and learner support within South African physical sciences education.

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Poster Session / 200

Investigation of X-rays and Gamma-ray Shielding Properties of Heavy Metal Oxide Glass Materials

Author: Nosihle Msabala[1]

Co-authors: Amanda Percy Sefage [2]; Linda Mdletshe [1]; Sifiso Ntshangase [3]; Vincent. B Kheswa [4]; bonginkosi zikhali [1]

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As technology advances, ionizing radiation has become an essential tool in various fields such as medicine, industry, and research. However, excessive exposure poses serious health risks, including cancer. This study investigates the radiation shielding properties of heavy metal oxide (HMO) glasses to provide safer, lead-free alternatives for X-ray and gamma-ray protection. A series of glasses with the chemical composition $xBi_2O_3-(55-x)B_2O_3-15BaO-10ZnO-18SiO_2-2Nd_2O_3$ (x = 15, 20, 25, 30, and 35 mol%) were synthesized using the melt quenching technique at the University of Johannesburg. The radiation shielding capabilities of these glasses were tested at the University of Zululand, utilizing the facilities in the Modern African Nuclear DEtector LAboratory (MANDELA). The radiation attenuation performance of the investigated glasses was evaluated by calculating mass attenuation coefficients (μ/ρ) using XCOM and Phy-X/PSD software programs and further validated through Monte Carlo simulations with Geant4 and MCNP6. Key shielding parameters such as linear attenuation coefficient (LAC), mean free path (MFP), effective atomic number (Z_eff), effective electron density (N_eff), half-value layer (HVL), tenth-value layer (TVL), effective atomic mass (A_eff), exposure buildup factors (EBF), and energy absorption buildup factors (EABF) were also analyzed over the photon energy range of 0.03–0.3 MeV.

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MSc

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Theoretical and Computational Physics / 201

Spin chains for N=2 quiver theories

Author: Jarryd Bath[1]

Co-author: Konstantinos Zoubos [1]

[1] *University of Pretoria*

Corresponding Author: u19034777@tuks.co.za

Integrability of gauge theories in the planar limit is a very powerful property which allows for a complete determination of the spectrum of the theory, but so far it has mostly been relevant for the most supersymmetric theory, $\mathcal{N} = 4$ super Yang-Mills and we would like to extend this to a much larger class of theories. In this talk, I will focus on $\mathcal{N} = 2$ superconformal theories obtained by orbifolding $\mathcal{N} = 4$ super Yang-Mills and then marginally deforming by varying the values of the couplings. We have determined the Lagrangians of these theories in terms of factors arising from the representation theory of the discrete groups and deformation parameters. From these Lagrangians, we were able to determine the corresponding dilatation operator for the theories, in terms of the representation theory factors and deformation parameters. It is known that, before marginally deforming, the integrability structure of the N=4 SYM is retained by these theories. Our results are the first step to determining whether or not this structure remains after marginal deformations.

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MSc

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Poster Session / 202

Probing the catalytic effects of beta-12 borophene cathode on various lithium and sodium oxide discharge products: A first-principles study

Authors: Chewe Fwalo[1]; Refilwe Edwin Mapasha[1]

Co-authors: Aleksey Kochaev [2]; Basia David Mahapane [1]; Malama Chisanga [3]

[1] *University of Pretoria*

[2] *Ulyanovsk State University, Russia*

[3] *Dalhousie University*

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To mitigate challenges of climate change, transitioning from fossil fuels to renewable energy sources is crucial. At the center of this shift is the energy storage systems, particularly batteries with energy densities exceeding that of fossil fuels. Since an electrode of a battery determine the energy density, 2D materials like beta-12 borophene have emerged as exceptional electrode due to their excellent electronic properties. While there has been extensive research on the capabilities of beta-12 borophene as an electrode, its potential as a cathode in lithium and sodium oxygen batteries has remained unexplored, especially concerning the complete mechanisms of discharge products for lithium (LixO2) and sodium-oxides (NaxO2 , where x = 1, 2, 3, and 4). In this study, density functional theory (DFT) was used to investigate the catalytic effects of beta-12 borophene on various LixO2 and NaxO2 discharge products. The results revealed spontaneous adsorption of these products with remarkable adsorption energies ranging from -2.92 to -5.93 eV for LixO2 and -3.20 to -4.93 eV for NaxO2 systems. Additionally, low Gibbs free energy changes indicated impressive overpotentials of 3.01 V for lithium and 1.73 V for sodium systems. Our investigations also highlighted exceptionally low diffusion energy barriers between 1.05 and 0.25 eV for LixO2 and from 1.04 to 0.05 eV for NaxO2 systems. Furthermore, density of states analysis confirmed that beta-12 borophene retained its metallic characteristics, even after adsorbing insulating discharge products. The structure remained stable after heating the systems at varying temperatures of 50 to 400 K. Moreover, thermoelectric investigations revealed a slight decrease in electrical conductivity after adsorption, measuring from 1.471 × 1020 (Ω·m)−1 for the pristine material, shifting to 3.95 × 1019 (Ω·m)−1 and 1.57 × 1019 (Ω·m)−1 for Li4O2 and Na4O2 , respectively, indicating that the electrical conductivity of the material is well-maintained. Overall, our findings position beta-12 borophene as an exceptional cathode for efficient lithium and sodium oxygen batteries.

NB: This work is currently under review in the journal of energy storage

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PhD

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Nuclear, Particle and Radiation Physics-2 / 204

Ongoing validation of the High Granularity Timing Detector (HGTD) demonstrator for the ATLAS phase II upgrades

Authors: Mukesh Kumar[1]; Rachid Mazini[1]; Thabo James Lepota[1]

[1] *School of Physics and Institute for Collider Particle Physics, University of the Witwatersrand*

Corresponding Author: thabo.james.lepota@cern.ch

The High Granularity Timing Detector (HGTD) demonstrator was developed to validate the design and performance of its components. The setup included a printed circuit board (PEB), 54 modules, flex tails, a cooling system, and a data acquisition (DAQ) server. Tasks performed involved connecting flex tails, conducting alignment and I2C tests, and performing scanning tests to check bump connections. Threshold voltage (Vth) scans were conducted with high voltage (HV) off at different injected charge values to verify electrical contact between readout electronics and the sensor. Module tuning and charge scans were performed by analysing the time-over-threshold (TOT). A comparison of Vth scans with HV both off and on was done to validate module performance. I2C test failures and high voltage issues, such as large leakage current causing modules to turn off, were identified. Furthermore, clock jitter measurements and calibration methods, mitigating pile-up effects in the forward region, were intended to ensure that the detector's timing capabilities meet specifications and to identify potential issues with clock distribution or signal integrity. In parallel, work progressed on the second-generation demonstrator, incorporating a slice of the prototype vessel with final design features and an increased number of active components to further refine and validate the HGTD design and its integration aspects, such as the Faraday cage.

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Physics of Condensed Matter and Materials / 205

Investigation of the transport properties of Co2Ti(1−x)Cr(x)Al (x = 0, 0.25, 0.5, 0.75, 1) Heusler compounds

Author: Murei Mulibana[1]

Co-authors: Aletta Prinsloo [1]; Charles Sheppard [1]; Susan Jacobs [1]

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The discovery of half-metallic property in the ferromagnetic compound Co₂MnZ (Z = Al, Sn) by Ishida <i>et al</i>. 1 and Kübler <i>et al</i>. [2] has prompted an extensive search for new Co₂YZ materials that exhibit the half-metallic ferromagnetic (HMF) property. Half-metallic ferromagnets are characterized by the presence of a gap at the Fermi energy (<i>E</i>_F) of the minority band of the electronic density of state (DOS) [1,2]. The presence of such a gap is expected to reveal exotic and unique transport properties [1,2]. Furthermore, half-metallic ferromagnetic materials are promising candidates for the development of spintronic storage devices with increased data processing speed and decreased electric power consumption.

In the present study, the transport properties of half-metallic ferromagnetic (HMF) Heusler compounds, Co₂Ti_(1−<i>x</i>)Cr_(<i>x</i>)Al (<i>x</i> = 0, 0.25, 0.50, 0.75, 1), are investigated using temperature dependent of zero-field resistivity, <i>ρ</i>(<i>T</i>). The bulk Co₂Ti_(1−<i>x</i>)Cr_(<i>x</i>)Al (<i>x</i> = 0, 0.25, 0.50, 0.75, 1) samples were synthesized using the arc melting technique. It has been observed that the zero-field <i>ρ</i>(<i>T</i>) for Co₂Ti_(1−<i>x</i>)Cr_(<i>x</i>)Al for <i>x</i> = 0, <i>x</i> = 0.25, <i>x</i> = 0.50 and <i>x</i> = 0.75 decreases linearly with decreasing temperature, indicating metallic behaviour. Below 100 K, <i>ρ</i>(<i>T</i>) deviates from the high-temperature linear behaviour, indicating the different scattering mechanisms present at various temperatures. The linear behaviour (<i>ρ</i> ∝ <i>T</i>) at high temperature is attributed to the scattering of electrons from phonons (<i>ρ</i>_{e-ph}). The behaviour of <i>ρ</i>(<i>T</i>) below 100 K originates from electron-magnon scattering (<i>ρ</i>_{e-mag}) and electron-electron scattering (<i>ρ</i>_{e-e}). Due to the half-metallic nature of these compounds, the low-temperature behaviour is found to follow a <i>T</i>^{9/2} behaviour, indicating the presence of a gap in the density of states (DOS) at the Fermi level (<i>E</i>_F) for the minority states. Moreover, the residual resistivity (<i>ρ</i>₀) increases with increasing <i>x</i> from 0 to 0.5 followed by a decrease for <i>x</i> = 0.75, which is attributed to an increase in atomic disorder with increasing <i>x</i>. <i>ρ</i>(<i>T</i>) for Co₂CrAl decreases with increasing temperature, demonstrating semiconducting-like behaviour. The origin of the semiconducting-like behaviour arises from the presence atomic disorder which results in the localization of conduction electrons and the presence of a band gap in the DOS for the minority state. The presence of a band gap in the minority states was confirmed from the electronic band structure and electronic DOS calculations.

References
1 S. Ishida, Y. Kubo, J. Ishida, and S. Asano. J. Phys. Soc. Jpn. 48 (1980) 814.
[2] J. Kübler, A. R. William, and C. B. Sommers, Phys. Rev. B 28 (1983) 1745.

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PhD

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Photonics / 206

Dual Fabry-Perot Interferometric Fiber Sensors for Refractive Index Monitoring of Salt and Sugar Solutions Using Broadband Spectral Analysis

Author: Sandisiwe Bangani[1]

Co-author: David Waswa [1]

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Abstract
The precise monitoring of chemical concentrations in liquids is critical for environmental, industrial, and biomedical applications. Optical fiber sensors, particularly those based on Fabry-Perot interferometry (FPI), offer high sensitivity, tolerance to harsh environments, and multi-sensing capabilities, making them ideal for detecting refractive index changes in various solutions. This study presents the design and implementation of an FPI sensor for real-time monitoring of refractive index changes in salty and sugary aqueous solutions. The sensor comprises two distinct open-cavity Fabry-Perot sensor heads, each tailored to a specific solution. The cavities are fabricated by chemically etching the tip of a single-mode optical fiber using Hydrofluoric acid (HF) and then splicing it with a cleaved single-mode fiber to form air-gap microcavities. The two sensor heads differ in cavity length, allowing them to produce unique interference patterns within a combined reflected spectrum. A broadband light source is directed into the system via a circulator and a 50/50 coupler, enabling simultaneous interrogation of both sensors. The reflected signals from each sensor are recombined and analyzed using an optical spectrum analyzer (OSA). As the concentrations of salt and sugar are gradually increased, corresponding shifts in the interference fringes are observed due to changes in the refractive indices of the solutions. The difference in cavity lengths enables spectral separation of the two sensor signals. A Fast Fourier Transform (FFT) is applied to the combined spectrum to isolate each sensor's contribution based on their distinct spatial frequency responses. The change in the refractive index of the solution can be estimated using the Free Spectral Range (FSR - distance between two adjacent peaks). The proposed FPI sensor system successfully demonstrates the ability to simultaneously monitor and distinguish refractive index changes in two different liquid solutions using a compact and cost-effective optical setup. The technique shows strong potential for multi-parameter sensing applications in chemical, biomedical, and environmental monitoring.

Keywords: Fabry-Perot Interferometer, Concentration, Fast Fourier Transform, Free Spectral Range

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MSc

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Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-2 / 207

Particle Flow Algorithm (PFA) development for forward jet reconstruction with the ATLAS ITk detector setup at the HL-LHC

Authors: Mukesh Kumar[1]; Rachid Mazini[1]; Thabo James Lepota[1]

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The ATLAS experiment at the High-Luminosity Large Hadron Collider (HL-LHC) will require advanced reconstruction techniques, particularly in the forward region, to cope with increased pile-up. This work presents a Particle Flow Algorithm (PFA) development for the ITk detector, focusing on tower clusters rather than traditional topological clusters in the $\eta = \langle 0 - 1.5 \rangle$ region. The forward region indicates $\eta = \langle 2 - 4 \rangle$. The strategy integrates tracker momentum measurements with calorimeter energy deposits through cell-based subtraction, prioritising energy density layers to resolve overlaps between tracking and calorimetric data. By employing tower clusters, which aggregate calorimeter cells into fixed $\eta \times \phi$ grids, we aim to improve computational efficiency while maintaining spatial granularity critical for forward jet reconstruction. The framework processes Event Summary Data (ESD), containing raw detector-level information (tracker hits, calorimeter clusters), and it is processed into Analysis Object Data (AOD), a condensed format storing high-level physics objects (jets, leptons) optimised for analysis. The algorithm refines energy subtraction and calibration by implementing Gaussian fitting of $\langle E/p \rangle$ distributions across calorimeter layers, mitigating pile-up effects in the forward region. This approach addresses the high-pileup HL-LHC environment, balancing precision in jet energy resolution with computational scalability for the ITk detector's upgraded granularity.

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PhD

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Poster Session / 208

TileCoM Firmware Development for ATLAS Tile Calorimeter Phase-II Upgrade

Author: Brenton Munhungewarwa[1]

Co-author: Mpho Gololo [1]

[1] *University of Johannesburg*

Corresponding Authors: brenton.tapfumanei.munhungewarwa@cern.ch, mphog@uj.ac.za

The High-Luminosity Large Hadron Collider (HL-LHC) necessitates a comprehensive electronics upgrade of the ATLAS Tile Calorimeter (TileCal) to ensure robust operation under increased radiation and data-rate conditions. To address this, the ATLAS TileCal has introduced the Phase-II upgrade, which involves a complete replacement of the existing electronic system. As part of the Phase-II upgrade, the Tile Computer-on-Module (TileCoM) has been developed to enable real-time monitoring and control of the TileCal Preprocessor (TilePPr) sub-modules. Built on the Zynq UltraScale+ MPSoC platform, TileCoM provides a critical interface between the Detector Control System (DCS) and TilePPr modules, including the Compact Processing Module (CPM), Advanced Telecommunications Computing Architecture (ATCA) carrier, and Trigger Data Acquisition Interface (TDAQi). TileCoM's firmware integrates the IPbus protocol for register access, I^2C for low-level sensor control, and Gigabit Ethernet for high-throughput data transfer, together with a custom Open Platform Communications Unified Architecture (OPC UA) server. This server ensures secure, standardized access to configuration parameters and sensor data across the TilePPr. Initial validation tests at CERN, conducted using the Avnet Ultra96-V2 development board, successfully demonstrated reliable TileCoM-CPM communication and firmware functionality, marking a key milestone toward current developments.

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MSc

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Yes, I ACCEPT

Poster Session / 209

Real-Time Indoor Air Quality Monitoring and Adaptive Ventilation in Scientific Workspaces

Author: Brenton Munhungewarwa[1]

Co-authors: Bruce Mellado [2]; Isaiah Chiraira [3]; Mukesh Kumar [4]

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Real-time monitoring and control are essential in particle physics environments, where experimental precision depends not only on instrumentation stability but also on the well-being of personnel. Technicians and physicists at CERN often work long hours on sensitive detector systems within confined spaces, where elevated CO_2 levels can impair cognitive function and reduce operational efficiency. Ensuring optimal indoor air quality in such high-performance settings is a critical aspect of experimental infrastructure.

To address this, the South African Consortium of Air Quality Monitoring (SACAQM) has developed an IoT-enabled Indoor air quality monitoring system. The network supports real-time sensing of particulate matter (PM1, PM2.5, PM5, PM10), volatile organic compounds (VOx), nitrogen oxides (NOx), and carbon dioxide (CO_2). A pilot deployment at Evotel offices has revealed clear links between CO_2 accumulation and occupancy patterns. In response, an adaptive ventilation system using automated fans has been introduced to maintain CO_2 levels within healthy limits. This low-cost feedback loop is currently under performance evaluation.

The aim of developing and validating this system in South Africa, is to demonstrate its applicability in research environments like CERN. Implementing real-time indoor air quality monitoring and adaptive ventilation in CERN's workspaces could support cognitive well-being, reduce fatigue, and maintain high operational standards.

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MSc

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Yes, I ACCEPT

Physics for Development, Education and Outreach / 210

Reimagining Curriculum Renewal: A case study of Physics and Astronomy

Author: Bako Nyikun AUDU[1]

Co-authors: Admire Dube [1]; Christiana Conana [1]; David Holgate [1]; Delia Marshall [1]; Mark Herbert [1]; Mfundo Zwane [1]; Siyabulela Sabata [1]; Trevor Volkwyn [1]

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This study provides an introduction to the University of the Western Cape case study on curriculum renewal. It explores different conceptions of curriculum and curriculum renewal. It offers a critique of existing thinking about curriculum renewal as something that occurs within refined phases within the education system, where the thinking often sees curriculum renewal as occurring through linear and hierarchical chains of command from policy to practice. Drawing upon previous conceptualizations of curriculum renewal at the Faculty of Natural Sciences of the University of the Western cape, this study explores a bottom-up approach to curriculum renewal. A rather non-linear process, framed around the concept of intertwined phases of engagements within the higher education system and national imperatives, noting that disciplinary actors, social actors and organizational bodies envision curriculum in different ways for different historical, political, sociocultural and economic reasons. The study contradicts widespread perceptions of the curriculum as a text designed by government official authorities to be implemented in the institutions. It illustrates how the physics and astronomy curriculum renewal involves dynamic processes of interpretation, mediation, negotiation and institutional quality assurance processes across multiple departments and interconnected discipline-applicable arrangements.

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Poster Session / 211

ZnMn₂O₄-Based Anode Materials for Advanced Li-ion Batteries: A Study on the Impact of Co, Ni, and Cu partially substitution on Electrochemical Performance.

Author: Samkelo Bixa[None]

Co-authors: Buyi Sondezi [1]; Machaba Leanyatsa Abraham Letswalo [1]

[1] *University of Johannesburg*

Corresponding Author: samkelobixa3@gmail.com

A series of ZnMn₂O₄ samples partially doped with 1.0 wt% Co, Ni, and Cu were synthesized via combustion method and evaluated for improved electrochemical performance. The synthesized powders were thoroughly characterized using XRD, FE-SEM, FTIR, and electrochemical techniques (GCD, CV, and EIS) to evaluate their performance as anode materials for supercapacitor batteries. The XRD results revealed that the incorporation of Co, Ni, and Cu metals did not alter the crystal structure of ZnMn₂O₄. However, the FE-SEM data showed that the addition of these metals modified the particle shapes and sizes. The optimum particle size of the doped ZnMn₂O₄ was found to be in the range of 36.33 - 41.29 nm. Notably, the Co-doped ZnMn₂O₄ exhibited superior performance in battery cycling tests (GCD), demonstrating exceptional discharge capacity, cycling stability, and rate capability compared to other manganites with 686.88 Fg⁻¹ specific capacitance. Furthermore, the Co-doped ZnMn₂O₄ showed great performance in (CV) at low scan rate of 5 mVs ⁻¹ with 48.85 Fg⁻¹ specific capacitance it also displayed a pseudo-capacitance behiviour. EIS demonstrated a great perfomenace for Cu-doped ZnMn₂O₄ having lowest resistance due to smallest-sermicircle. Furthermore due to it having a steeper vertical line, which suggests that it is good for supercapacitor applications. The excellent high-rate capability of the as-synthesized Co-doped nanocomposite indicates its promising potential as an anode material for high-power lithium-ion batteries.

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MSc

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Nuclear, Particle and Radiation Physics-1 / 212

Detecting Anomalies in Measured Thermal Neutron Flux Profiles of SAFARI-1 Research Reactor.

Author: Rethabile Kgolobe[None]

Co-authors: Bongani G. Maqabuka [1]; Charis Harley [2]; Lesego E. Moloko [3]; Pavel M. Bokov [3]; Rian H. Prinsloo [3]; Simon H. Connell [4]

[1] *University of Johannesburg, Mechanical Engineering Science*

[2] *University of Johannesburg, Data Science Across Disciplines (Research & Development), Department of Electrical and Electronic Engineering Science*

[3] *NECSA*

[4] *Department of Mechanical Engineering Science, University of Johannesburg, Auckland Park, Johannesburg, South Africa*

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The accurate measurement, analysis, and correct interpretation of the neutron flux distribution within the reactor core are essential for reactor safety, optimum performance, and understanding of reactor operations. In the SAFARI-1 research reactor, axial thermal neutron flux profiles of fuel-containing assemblies are measured at the beginning of each operational cycle by activating natural copper wires. This study investigates the variation in measured flux profiles by considering the movement of the control rod bank and copper wire axial positioning. The analysis is focused on the key features of the neutron flux profile: the bottom minimum, peak maximum, and top minimum and their axial location, with the goal of using this information to identify inadvertently axially shifted measurements. The research approach involved data preprocessing, visualization, and statistical analysis. The analysis produced 1D, 2D, and 3D flux representations, which can be related to the control rod bank movement, axial wire insertion in the fuel-containing assemblies, and fuel assembly position. A polynomial fit was applied to estimate the location of the flux profile's key features, and the distribution of these points as well as their correlation to bank positions were analysed. The standard deviation along with the Median Absolute Deviation and Pearson's Correlation Coefficient were used to characterize the sensitivity of the flux profiles to control bank positions. Results of the study show that peak maximum points exhibit higher variability and a stronger positive correlation to the bank positions than the bottom and top minimum points. The bottom minimum points have lower variability and are less correlated to the bank positions. However, this is due to some points missing in this case, causing inconsistency and biased results. The top minimum points remain consistent and positively correlate to the bank positions and may thereby be the most suited for the measurement shift characterization. This study's findings demonstrate the effectiveness of the proposed approach in identifying and correcting the shift in flux profile measurements resulting from improper copper wire insertion. The study ensures a more accurate interpretation of neutron flux profiles by distinguishing the actual variations from apparent anomalies.

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Yes, I ACCEPT

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MSc

Poster Session / 213

Comparative Analysis of Deep Neural Networks and XGBoost for $\gamma\gamma + \tau$ Signal-Background Classification Using Monte Carlo Data at the LHC

Author: Nidhi Tripathi[1]

Co-authors: Bruce Mellado [2]; Kutlwano Makgetha ; Mukesh Kumar [2]; Njokweni Mbuyiswa ; Vuyolwethu Kakancu

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In this study, we present a comparative analysis of deep neural networks (DNN) and XGBoost for the classification of $\gamma\gamma+\tau$ final states to separate rare signal events from background using Monte Carlo data. The dataset is preprocessed to exclude energy-related features and focus on the kinematic variables of the first identified tau lepton (τ_1). A DNN model is a machine learning model that consists of multiple layers of interconnected neurons, which learn from the data to make predictions. Each node uses activation functions like ReLU or sigmoid to help the model capture more complex patterns in the data. On the other hand, XGBoost is a gradient-boosted decision tree algorithm where multiple decision trees are built sequentially, with each tree correcting the errors of the previous one. It applies powerful regularization methods to improve generalization and minimize overfitting. A comprehensive performance evaluation, using accuracy, AUC-ROC, and other relevant metrics, will be conducted to enhance the classification model processes. This study is being carried out to visualize prospects of proposed analysis in the ATLAS experiment.

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PhD

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Astrophysics & Space Science / 214

Exploring Long-term trends in total electron content over South Africa.

Author: Modiri Mokaila[1]

Co-authors: Daniel M. Moeketsi [2]; John Bosco Habarulema [3]

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The ionosphere is a dynamic, inhomogeneous and conductive plasma formed from the interaction of solar Extreme Ultraviolet (EUV) and X-ray radiation with the quasi-neutral atmosphere of the Earth, found at 60 −1000 km above sea level. With different peak levels of ionization, it is predominantly studied by determining the total number of particles that pass through a square meter area between a ground-based station and a GPS satellite −Total Electron Content (TEC). The importance of TEC is owed by its effect in radio communication, position, telemetry and tracking. An abundance of free electron gas in the ionosphere causes a delay of signals in the radio band. This study explores the long-term trends in TEC over South Africa at 2 GPS stations located 1000 km apart. TEC was computed using the IONOLAB software over SUTH and HRAO stations for a period of 25 years. The TEC trend analysis was performed using 3 solar proxies (sunspot numbers, MgII and F10.7). Preliminary results show a negative TEC trend between 1998 and 2023 over these mid-latitudes stations in South Africa. This is consistent with related global studies reported in the literature.

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MSc

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Yes, I ACCEPT

Poster Session / 215

Structural and Optical properties of rare-earth doped Magnesium ferrites

Author: Ncembu Onke Ngubelanga[1]

Co-authors: Ceboliyazakha L. Ndlangamandla [1]; Prince S. Mkwae [1]; Sunday A. Ogundipe [1]

[1] *University of Zululand*

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Nanoparticles of magnesium ferrite ($MgFe_2O_4$) and rare earth (RE)(La, Sm)-doped magnesium ferrite ($Mg(RE)_{0.2}Fe_{1.8}O_4$) were synthesized via the hydrothermal method and annealed at 500℃, 700℃, and 900℃. X-ray diffractometry (XRD), Ultraviolet-Visible Spectroscopy (UV-Vis), High-Resolution Transmission Electron Microscopy (HRTEM), and Photoluminescence (PL) spectroscopy were utilised for structural and optical characterization. XRD confirmed the formation of a cubic spinel structure, with Bragg peak intensity increasing at 900℃ across all samples. Crystallite size decreased with increasing molecular weight, indicating enhanced structural refinement. HRTEM further confirmed improved crystallinity at 900℃. UV-Vis analysis revealed a notable reduction in bandgap upon La and Sm doping, suggesting enhanced electronic properties. PL spectra indicated dual-wavelength photon emission (495 nm and 503 nm) for pure $MgFe_2O_4$, while doping significantly suppressed PL intensity, leading to single-wavelength emission at 500 nm (2.48 eV).

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MSc

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Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 216

Investigating the photon shielding factors of the silicate glass system from 1 MeV up to 15 MeV, Using the X-COM and GEANT4 simulating software

Author: Mfundo Zuma[1]

Co-authors: Busani Bhengu [1]; Linda Mdletshe [1]; Sifiso Mthalane [1]; Sifiso Ntshangase [1]

[1] *University of Zululand*

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This study investigates the radiation shielding capabilities of silicate glasses (S1–S4) across photon energies ranging from 1 to 15 MeV. Using Phy-X, XCOM, and GEANT4 simulations, key shielding parameters were estimated, including the mass attenuation coefficient (MAC), linear attenuation coefficient (LAC), half-value layer (HVL), tenth-value layer (TVL), mean free path (MFP), and effective atomic number (Z_{eff}). The glasses exhibited maximum photon shielding performance at 1 MeV, with LAC values of 0.18398, 0.17842, 0.17696, and 0.14718 cm^{-1} for S1 through S4, respectively.

The LAC was observed to decay exponentially with increasing energy, while the MAC began to decrease exponentially around 4 MeV. These reductions in shielding effectiveness are attributed to increased Al_2O_3 content and decreased CaO content within the glass matrix. Additionally, HVL and TVL were analyzed in relation to material density. As density decreased from 2.90 to 2.76 g/cm^3, HVL increased correspondingly, with values at 1 MeV measured as 3.76758 cm (S1), 3.88481 cm (S2), 3.91705 cm (S3), and 3.97937 cm (S4). The HVL also increased significantly with photon energy, nearly tripling between 1 and 15 MeV.

These results provide a comprehensive assessment of silicate glasses as potential materials for high-energy radiation shielding applications, highlighting their energy-dependent attenuation behavior and compositional influence on shielding performance.

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None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Astrophysics & Space Science / 217

Astrophysical origin of the highest-energy neutrino event

Author: Soebur Razzaque[1]

[1] *University of Johannesburg*

Corresponding Author: srazzaque@uj.ac.za

Recently the KM3NeT neutrino telescope detected the most-energetic neutrino event ever, dubbed KM3-230213A, at an estimated energy of 220 PeV. Given its near horizontal direction and exceptionally high energy, the most likely explanation is that the muon resulted from interaction of a muon neutrino of cosmic origin. In this talk I will explore an astrophysical source origin, both transients and steady, of this intriguing event.

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Applied Physics / 218

Nanocrystal Enhancement of Low-Cost Scintillators for PET Imaging Application

Author: Declan Mahony[1]

Co-author: James Keaveney [1]

[1] *University of Cape Town*

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Positron emission tomography (PET) is a valuable medical imaging technique widely used in the early diagnosis of cancer, as well as in the assessment of cardiovascular, neurological, and metabolic disorders. PET scanners detect pairs of 511 keV gamma rays emitted via the annihilation of positrons from a radioactive tracer injected into the patient. The industry standard detectors used in these systems are typically made from monolithic crystal scintillators, which are costly and contribute significantly to the overall expense of PET scanner production. This greatly restricts access to PET scanners to populations in Africa and the Middle East. Alternative scintillators, such as ceramics and plastics, offer cost advantages but are currently limited by their low light yield, slow scintillation response times, and minimal stopping power at the required energies. In this study, we aim to enhance the scintillation properties of such low-cost scintillators by suspending high-Z nanocrystals in the matrix. This approach aims to combine the favorable characteristics of ceramics and plastics, offering a potential route to affordable and efficient PET detectors suitable for resource-limited settings. To this end, we suspended CdS nanocrystals fabricated by our collaborators at the University of Zululand in epoxy-resin pixels at concentrations ranging from 0.05% to 0.6%, which we characterised at CERN. Standard optical characterisation revealed a red-shift in the emission spectrum with increasing nanocrystal concentration, accompanied by greater light absorption. Scintillation decay times were measured using a time-correlated single photon counting (TCSPC) technique under soft (0–40 keV) pulsed x-ray excitation in reflection mode.

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Nuclear, Particle and Radiation Physics-2 / 219

South Africa's Contribution to the Phase-II Upgrade of the ATLAS Hadronic Tile-Calorimeter Low-Voltage Power Supply

Author: Ryan Mckenzie[1]

Co-authors: Bruce Mellado [1]; Thabo Pilusa [1]; Vongani Chabalala [1]

[1] *University of the Witwatersrand*

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The High-Luminosity Large Hadron Collider (HL-LHC) is scheduled to begin operation in 2030. While the increased luminosity presents exciting opportunities for new scientific discoveries, it also introduces significant technical challenges for the ATLAS detector systems. To meet these demands, the ATLAS Hadronic Tile Calorimeter (TileCal) will undergo a comprehensive Phase-II upgrade during the third long shutdown (LS3) of the LHC.

A key component of this upgrade is the replacement of the on-detector electronics, which are powered by 256 Low-Voltage Power Supplies (LVPS). Each LVPS unit contains eight transformer-coupled buck converters, known as "Bricks," which step down the power delivered from off-detector bulk supplies to the required levels for the front-end electronics.

The South African cluster, led by the University of the Witwatersrand, is responsible for the research and development, production, quality assurance testing, and integration of half of the required Bricks for the Phase-II upgrade.

This presentation will provide an overview of South Africa's contributions to the LVPS Brick development for the TileCal upgrade. It will highlight key project milestones such as the recent pre-production, an essential step in preparing for full-scale production, and will conclude with a forward-looking perspective on the upcoming main production of the final Brick units.

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None

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Yes, I ACCEPT

Physics of Condensed Matter and Materials / 220

Unconventional transport behavior in some ultra pure systems

Author: Abhishek Pandey[1]

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Most monoatomic paramagnetic metals show a monotonic increase in electrical resistivity ρ with increase in temperature T. This behavior can be quite efficiently described by Bloch-Grüneissen (BG) model of conduction carrier scattering from acoustic phonons. The scope of the BG model that leads to a linear $\rho(T)$ at sufficiently high temperatures and $\rho \propto T^5$ at low temperatures is, however, not limited to monoatomic metals and it often accurately describes the electrical transport characteristics of multiatomic compounds. Depending upon the complexity of interactions and transitions, deviation from this behavior is not uncommon. However, the $\rho(T)$ of metallic compounds rarely shows a positive curvature. So far only four compounds belonging to two different families, delafossites and layered pnictides, have shown this feature. Here we discuss the observation of this unusual behavior along with a few other uncommon transport properties of some novel compounds.

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Yes, I ACCEPT

Photonics / 221

Decay of stationary entanglement mediated by one-dimensional plasmonic nanoarrays

Authors: Luke Ugwuoke[1]; Mark Tame[None]; Tjaart Krüger[2]

[1] *Stellenbosch University*

[2] *University of Pretoria*

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Metal nanoparticles have been shown to be good mediators for entanglement generation in plasmonically-coupled quantum dot qubits. These mediators enable entanglement to be sustained over long qubit-qubit distances. We investigate the impact of the number of mediating particles on the generation of bipartite entanglement by considering both parallel and perpendicular nanoarrays with respect to the interaction axis of the qubits and the polarization of the driving field. The plasmonically-coupled qubits were investigated within the framework of cavity quantum electrodynamics. The metal nanoparticles were arranged in a collinear fashion using a periodic spacing and a particle size that allow their interactions to be treated within the dipole approximation. We employ an effective approach that enables the investigation of plasmon-mediated stationary entanglement in the coupled qubits. We show that our approach agrees with simulations. The degree of stationary entanglement was found to decay exponentially with increase in the number of mediating particles in the nanoarray.

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None

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Yes, I ACCEPT

Astrophysics & Space Science / 222

Investigation of Altitude and Solar Cycle Variation of DDM Occurrence Using Ionosonde Observations

Author: Fanelesibonge Khoza[1]

Co-authors: Zama Katamzi-Joseph [2]; Emmanuel Nahayo [2]; Judy Stephenson [1]

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The diurnal variation of plasma density in the ionosphere is largely characterized by a single peak around local noon. However, diurnal double maxima (DDM) is sometimes observed when two distinct peaks and one valley in plasma density appear during the local daytime. Understanding DDM structures is essential for studying ionospheric dynamics and their key drivers, including neutral winds, $\mathbf{E} \times \mathbf{B}$ drift, and solar irradiation, as these variations impact radio wave propagation and space weather forecasting. This study investigates DDM occurrences using ionosonde observations from stations in Hermanus (34.4°S, 19.2°E, magnetic latitude: 42.08°S) and Grahamstown (33.3°S, 26.5°E, magnetic latitude: 41.06°S) during solar cycle 24 (2008–2019). A robust automated algorithm was developed to detect DDMs based on the presence of two fully formed peaks separated by a depletion (valley), all occurring between local sunrise and sunset. The algorithm established the criteria using a minimum peak-to-valley ratio of at least 6% to ensure significant peak prominence, a minimum peak-to-peak interval of 40 minutes to capture the time difference between two peaks, and an extra peak prominence threshold not exceeding 5% to filter out additional peaks. These thresholds ensure that only well-defined DDM structures are identified. The method was validated through visual inspection, achieving a detection accuracy of 97%. Using this approach, we identified 1,532 and 1,270 DDM events at Hermanus and Grahamstown from a total of 3,534 and 2,835 observation days, respectively, over the whole solar cycle. This translated to an occurrence rate of 43% at Hermanus and 45% at Grahamstown. We will explore statistical trends in terms of seasonal and solar cycle variations for each ionosonde station. Comparing and contrasting the trends between the stations may provide indications about possible mechanisms influencing DDM development. Furthermore, we will explore whether there are DDMs that are common between the two stations, as this may indicate the scale size and/or propagation of these events.

Apply for student award at which level::

MSc

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Yes, I ACCEPT

Poster Session / 223

First-Principles Study of Anion-Doped $LiTi_2(PO_4)_3$ Solid Electrolytes.

Author: Leago Heaven Pitsa[1]

Co-authors: Khomotso Maenetja [1]; Phuti Ngoepe [1]; kemeridge Tumelo Malatji [1]

[1] *University of Limpopo*

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Abstract:
Solid-state electrolytes face critical challenges in achieving sufficient ionic conductivity and structural stability for practical battery applications. NASICON-type $LiTi_2(PO_4)_3$ (LTP) offers a promising framework due to its 3D ion diffusion channels and thermal stability, but its bulk conductivity remains limited by restricted Li^+ migration pathways. Anion doping presents a strategic solution by modifying the host structure's chemical environment while preserving its NASICON framework. This study employs density functional theory (DFT) calculations to investigate how anion substitution ($PO_4^{3-} \longrightarrow X^{n-}$) alters LTP's bulk properties. The results demonstrate that larger anions induce structural expansion, reducing Li^+ migration barriers by 30–40% while maintaining mechanical integrity. The r^2SCAN functional reveals enhanced bond strength and formation energy compared to GGA-PBE, with C_{11}/C_{22} stiffness values confirming structural robustness. Electronic structure analysis shows preserved semiconductor behaviour (bandgap Eg = 2.504 eV) after doping. These findings establish anion doping as a viable approach to improve LTP's bulk transport properties while retaining its intrinsic advantages. The study provides insights for advancing the development of high-performance solid electrolytes.

Keywords: solid electrolyte, NaSICON-type, anion doping.

Apply for student award at which level::

MSc

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Yes, I ACCEPT

Poster Session / 224

Investigation of the radiation shielding properties of borosilicate glass configurations with varying concentration of Ta_2O_5, La_2O_3, and Sm_2O_3

Author: Bonginkosi Richard Zikhali[1]

Co-authors: Amanda Percy Sefage [2]; Linda Mdletshe [1]; Nosihle Msabala [1]; Sifiso Senzo Ntshangase ; Vincent. B Kheswa [3]

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Ionizing radiation, comprising high-energy particles and electromagnetic waves, is prevalent in medical physics, nuclear research, and reactor operations, posing significant biological risks. Effective shielding is critical to minimize radiation exposure, traditionally relying on dense materials like lead and concrete. Lead offers high atomic number advantages but is toxic, while concrete, though less hazardous, is heavy, prone to structural degradation, and reduces visibility. Glass has emerged as a promising alternative, offering transparency, cost-effectiveness, and durability under harsh conditions. This research evaluates glass compositions for their potential to attenuate ionizing radiation, focusing on the material properties such as mass attenuation coefficient (MAC), linear attenuation coefficient (LAC), effective atomic number (Zeff), mean free path (MFP), half-value layer (HVL), and other radiation interaction parameters, which are determined using the Phy-X/PSD, XCOM and Geant4 software programs. The glass samples studied includes (79-x)SiO_2-3Al_2O_3-5Na_2O-13B_2O_3-xTa_2O_3, (79-x)SiO_2-3Al_2O_3-5Na_2O-13B_2O_3-xLa_2O_3, and (79-x)SiO_2-3Al_2O_3-5Na_2O-13B_2O_3-xSm_2O_3, with varying concentration of Ta_2O_3, La_2O_3, and Sm_2O_3, where x = 5, 10, 15, 20, and 25. The synthesis of these glass samples was carried out at the University of Johannesburg, while the testing of their radiation shielding capabilities was performed at the University of Zululand using the MANDELA facility.

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PhD

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Applied Physics / 225

DFT Study of the (210) TiO_2 Brookite Surface Doped with V and Zr for Application in DSSCs

Authors: Tshifhiwa Ranwaha[1]; Ratshilumela Steve Dima[2]; Eric Maluta[3]; Regina Maphanga[4]

[1] *University Of Venda*

[2] *CSIR*

[3] *University of Venda*

[4] *Council of Scientific and Industrial Research (CSIR)*

Corresponding Author: tshifhiwa.ranwaha@univen.ac.za

Dye-sensitized solar cells (DSSCs) present a promising photovoltaic technology due to their cost-effectiveness, high efficiency, and flexible device design. DSSCs generally use titanium dioxide (TiO_2) as a photoanode material. Brookite TiO2 phase provides special electrical characteristics fit for maximum solar energy conversion. However, the broad bandgap of bulk TiO_2 limits its absorption in the visible light range.
In this work, density function theory has been used to explore the properties of (210) TiO_2 brookite surface doped with vanadium (V) and zirconium (Zr). Generalized gradient approximation was used to define the exchange-correlation function within the scheme of Perdew-Burke Ernzerhof, as implemented in Material Studio. The results show that doping greatly lowers the energy bandgap of TiO_2 Brookite (210) surface, therefore improving the visible light absorption. Also, doped surfaces show less reflectance, desired for light harvesting. From computation of formation energies, the stability of the doped systems is verified as V and Zr dopants efficiently integrate into the TiO_2 surface without sacrificing structural integrity. The study reveals that Vand Zr doping enhances the optical and electrical characteristics of the TiO_2 Brookite (210) surface, therefore offering a suitable material for effective DSSC uses.
Keywords: Semiconductor, band gap, density functional theory, dye-sensitized solar cells, TiO2 brookite.

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PhD

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Yes, I ACCEPT

Poster Session / 227

First-principles investigations of structural properties and energies stabilities of W-Re alloy for fusion reactor application

Author: Cambel Thaba[None]

Co-authors: Donald Mkhonto ; Maje Phasha ; RE Mapasha

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Tungsten (w) is considered as the potential plasma facing material for fusion reactor application due to its exceptional mechanical and thermal properties. The notable properties of tungsten are its high melting point, high thermal conductivity, hardness, and low sputtering yield. However, tungsten also presents a very low fracture toughness limiting its application as plasma coating material. To enhance the ductility of W material, in this study, we investigate the structural, mechanical and energetic properties of Tungsten-Rhenium (W-Re) alloys at various rhenium (Re) concentrations ranging from 6% to 37%, using first-principles density functional theory (DFT) calculations. The energies stabilities and equilibrium volumes of W-Re alloyed material were calculated following full volume-cell relaxation (V-C relax) procedures. Our results reveal systematic trends in lattice constant contraction leading to volume reduction (249.79Å3 to 244.47Å3) as the concentration increases. The increase in W-Re alloy concentration leads to different lattice constant sizes a≠b≠c leading to anisotropic geometry, suggesting the symmetry change from BCC counterparts. Energetic stability based on mixing enthalpies shows that Re alloy further stabilizes the structure with concentrations increment. These findings provide a go ahead for further intensive and extensive investigations of W-Re alloys material for ductility.

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PhD

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Yes, I ACCEPT

Theoretical and Computational Physics / 228

Parameterizing the Geometry of the QGP on an Event-by-Event Basis

Author: Ben Bert[1]

Co-authors: Coleridge Faraday [1]; William Horowitz [1]

[1] *University of Cape Town*

Ultra-relativistic heavy-ion collisions create a nuclear fireball that serves as a powerful laboratory for probing the frontiers of Quantum Chromodynamics (QCD). In recent years, there has been growing interest in the study of small collision systems—such as proton-proton (pp) and proton-nucleus (pA) interactions—at facilities like RHIC and the LHC. Many of the assumptions underlying the energy loss formalism developed in the Djordjevic-Gyulassy-Levai-Vitev (DGLV) model, break down in these small systems. In this work, we present an extension of the DGLV formalism that specifically accounts for the unique features of small system dynamics. This is achieved by relaxing the large formation time approximation and introducing an additional correction term that accounts for short path lengths in the medium. By relaxing these assumptions, one encounters a more intricate analytic structure for the energy loss, and thus increased computational demands; we address this challenge by developing a novel numerical scheme. Our approach accurately parametrizes the geometry of the quark-gluon plasma (QGP), resulting in a dramatic computational speedup—improving efficiency by up to seven orders of magnitude.

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MSc

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Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-2 / 229

Parton Production Spectra and Energy Loss in High-Energy OO Collisions

Author: Mohammad Alam[1]

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We compute the production spectra for high-momentum light quarks and gluons in high-energy hadron collisions at a variety of center-of-mass energies, some of which are previously unstudied. These spectra provide the foundation for making quantitative predictions of parton energy loss in high-multiplicity hadronic collisions at RHIC and the LHC. Thus these spectra are necessary in order to use high-momentum partonic probes as a femtoscope to quantitatively characterize the properties of the novel state of matter produced in high-multiplicity hadronic collisions, the quark-gluon plasma. We demonstrate the success of our methodology and implementation by reproducing previously known theoretical results; we then successfully compare our calculations with recent experimental data; finally, we make quantitative first predictions for the production spectra necessary for the future $O + O$ collisions at LHC in the second half of 2025.

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None

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Yes, I ACCEPT

Poster Session / 230

Effects of calcium oxide and iron (III) oxide on biogas production and hydrogen sulphide mitigation

Author: Takalani Nethavhanani[1]

Co-authors: Vhutshilo Nekhubvi [1]; Lutendo Mathomu [1]; Eric Maluta [1]

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Corresponding Author: takalani.nethavhanani@univen.ac.za

Biogas, as a renewable energy source, has gained attention due to its potential to reduce greenhouse gas emissions and provide sustainable alternatives to fossil fuels. However, its widespread adoption is hindered by challenges such as low methane (CH₄) content and corrosive impurities such as hydrogen sulphide (H₂S), which limit its efficiency and application. This ongoing study explores the influence of metal oxide additives, specifically calcium oxide (CaO) and iron (III) oxide (Fe₂O₃), on methane concentration and hydrogen sulphide monitoring during the anaerobic digestion of cow dung in a control temperature of 37deg;C. The experimental investigation involves treating cow dung with varying concentrations of CaO and Fe₂O₃, ranging from 20 mg/L to 100 mg/L, to determine the optimal dosage for enhancing methane concentration and quality. The results will highlight the varying effectiveness of these metal oxides in enhancing CH₄ concentration and reducing H₂S levels, providing valuable insights for optimizing anaerobic digestion towards more efficient and sustainable biogas production.

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Yes, I ACCEPT

Photonics / 231

Voltage-Based Wavelength Tuning of a DFB Laser Using an Enhanced LM331 Frequency-to-Voltage Converter for OPLL Applications

Author: Lilian Mutia[1]

Co-authors: James Jena [1]; David Waswa [1]

[1] *Nelson Mandela University*

Corresponding Author: s230110703@mandela.ac.za

This research demonstrates voltage-based control of a Distributed Feedback (DFB) laser, forming a foundational step toward the implementation of an Optical Phase-Locked Loop (OPLL). The voltage control mechanism is realized through a Frequency-to-Voltage Converter (FVC) using the LM331, which converts an offset frequency - generated by frequency mixing of a signal generator and a stable crystal oscillator - into a corresponding DC voltage signal. This voltage is then fed directly into the DFB laser, effectively tuning its emission wavelength. The tuning behavior is monitored using an Optical Spectrum Analyzer (OSA), providing real-time feedback on the laser's spectral response. A key challenge addressed in this work is the inherent 100 kHz upper limit of the LM331-based FVC. By carefully modifying the circuit design, the conversion range is extended to accommodate frequencies up to 3 MHz.The experimental results show a clear voltage response starting from 40 kHz, reaching approximately 4.6 V at 3 MHz, and remaining at 0 V at 0 kHz—demonstrating a consistent and usable voltage-frequency relationship. This extended range enables more flexible and precise laser control, which is essential for the operation of OPLLs. Such systems require accurate phase locking between optical sources, a capability critical in high-speed optical communication, coherent detection schemes, and technologies like Radio over Fiber for 5G and beyond. By successfully enhancing the FVC's range and demonstrating practical wavelength tuning of the DFB laser, this work contributes a crucial building block toward scalable and stable OPLL systems.

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PhD

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Yes, I ACCEPT

Poster Session / 232

Exploring the bulk and surface structures of ZnS, FeS2 and PbS minerals using AIMD-MLFF technique.

Author: Thato Manyama[1]

Co-authors: Peace Mkhonto [1]; Phuti Esrom Ngoepe [2]

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Sphalerite (ZnS), pyrite (FeS₂), and galena (PbS) are found in association with each other in the mineral's ore deposits. The separation of these minerals is critical and these require fundamental understanding from the surface properties. The study investigated the behaviour of the surface properties of these minerals at room temperature (300 K) utilizing the ab-initio molecular dynamic (AIMD) with machine learned force fields (MLFF) methods in comparison with the standard ab-initio simulations. The methods are integrated into the Vienna Ab Initio Simulation Package (VASP) code. The MLFF training of the bulk unit cells generated the force fields which were applied on the 4x4x4 supercells of ZnS, FeS₂ and PbS and produced lattice parameters of 5.405 Å, 5.420 Å and 6.014 Å, respectively. These were in good agreement with the experimental values of 5.410 Å, 5.419 Å and 5.999 Å, respectively. The most stable surfaces were cleaved and the surface energies for ZnS (110), FeS₂ (100) and PbS (100) surfaces were computed from the training and from the force fields generated. It was found that the surface energies ZnS (0.71 J/m²), FeS₂ (1.66 J/m²) and PbS (0.73 J/m²) were in good agreement with those obtained from the standard ab-initio calculations ZnS (0.68 J/m²), FeS₂ (1.32 J/m²) and PbS (1.11 J/m²). These surface energies suggested that pyrite is harder than the sphalerite and galena, which indicated that the grinding of the ore with these minerals may require more time for fine griding of pyrite compared to sphalerite and galena.
 Keywords: VASP code; AIMD-MLFF; Surface energies; lattice parameters; ZnS (110); FeS₂ (100) and PbS (100).

Apply for student award at which level::

PhD

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Yes, I ACCEPT

Poster Session / 233

Interaction of modified heterocyclic collectors with chalcopyrite mineral surface

Author: Peace Mkhonto[1]

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[1] *University of Limpopo*

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Chalcopyrite is a major source of copper and its significance extends to a wide range of applications. Although chalcopyrite mineral recovery is achieved to some satisfactory, there is still a need to improve its recovery in particular the low grade and hard to float chalcopyrite. This requires a highly selective collector to target and float the desired mineral. The modification of collectors offers hope to enhance the performance of the collectors to have strong binding with high selectivity. The density functional theory (DFT) within the Vienna ab-initio simulation package (VASP) technique was used to modify and adsorb heterocyclic collectors such as 2-mercaptobenzothiazole (MBT), 2-mercaptobenzoxazole (MBO) and 2-mercaptobenzimidazole (MBI) by addition of an allyl group. The adsorption mechanisms showed that the collectors preferred to bind on the Cu atoms than the Fe atoms on chalcopyrite (112) mineral surface. Furthermore, the adsorption energies showed that the modified MBO gave strong adsorption (–89.42 kJ/mol). This suggested that the modified MBO may be used to enhance the recovery of chalcopyrite amongst the modified heterocyclic collectors.

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Photonics / **234**

Synthesis and characterization of Cerium III ion doped zinc selenide thin films prepared by chemical bath technique for luminescence application

Author: Donald Dehiin Hile[1]

Co-authors: H.C. Swart [2]; L.F. Koao [3]; S.V. Motloung [4]; R.E. Kroon ; P.S. Mkwae [5]; A. Reyes-Rojas [6]; C.L. Ndlagamandla [5]

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ZnSe:*x*% Ce³⁺ (*x* = 0, 2, 4, 6, 8 and 10) thin films were deposited using chemical bath technique. All the films samples revealed wurtzite phase ascribed to ZnSe and the presence of the Ce³⁺ did not change the films structure apart from the shift in peak position to longer wavelength when compared to the undoped sample. The red shift is due to the incorporation of the dopant ions into the host matrix. Raman spectroscopy revealed two optical phonon peaks due to first and second order longitudinal modes. The films samples showed flakes-like morphological while the presence of the anticipated elements was confirmed by energy dispersive X-ray spectroscopy. The cross sectional SEM morphology has shown increase in the thin films thickness with increased Ce³⁺ ion concentration. FTIR revealed O-H stretching vibration modes as well as inorganic bands attributed to ZnSe. Atomic force microscopy showed a decrease in surface roughness with increased Ce³⁺ concentration although with fluctuation. The ultraviolet-visible spectroscopy results showed increased band gap energy with an increase in Ce3+ concentration and the values were dependent on the crystallite size. The undoped sample showed three luminescence peaks, which are due to the band-to-band and defects within the host material. Although there was no evidence of emission from the Ce³⁺ ions, increasing the Ce³⁺ doping concentration resulted in enhancement of the emission peak intensities. The enhanced emission luminescence due to Ce³⁺ ion doping, wide band gap, the stable structure and morphology make the deposited thin films good candidates for optical applications especially in LEDs.

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Yes, I ACCEPT

Poster Session / 235

Ab Initio Studies of Structural, Thermodynamic, Magnetic, and Mechanical Properties of Mn-Ir Alloys

Authors: Maje Phasha[1]; Ndanduleni Lethole[2]; Sikho Maxhayi[2]

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Mn-Ir bimetallic alloys have emerged as promising candidates for spintronic applications due to their attractive properties, such as high thermal stability, large exchange bias fields in Antiferromagnetic/ferromagnetic (AFM/FM) layers. However, the properties of certain phases remain unexplored. In this study, we employed ab initio simulations using the CASTEP code within Materials Studio 2020 with the GGA-PBE functional to investigate the structural, thermodynamic, magnetic, and mechanical properties of disordered L1₀ P4/mmm-MnIr, L1₀ R3m-MnIr, and ordered L1₂ P6₃/mmc-Mn3Ir alloys at 0 K. Our findings reveal that the L1₀ phases exhibit strong magnetism, whereas the ordered L1₂ phase orders zero magnetic moments, a feature that could enhance the intrinsic anomalous Hall effect. Further analysis suggests that the considered MnIr alloys are thermodynamically and mechanically stable. This study provides a valuable insight into the structural, thermodynamic, magnetic, and mechanical properties of disordered L1₀ P4/mmm-MnIr, L1₀ R3m-MnIr, and ordered L1₂ P6₃/mmc-Mn₃Ir alloys.

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MSc

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Nuclear, Particle and Radiation Physics-2 / 236

Dark photons search with the ATLAS detector at the LHC

Author: Rachid Mazini[1]

Co-authors: Karabo Tau [1]; Mukesh Kumar [2]; Thabo James Lepota [3]

[1] *School of Physics, The University of the Witwatersrand*

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Many extensions to the Standard Model (SM) introduce a hidden or a dark sector rising from an additional $U(1)_d$ gauge symmetry, to provide candidates for dark matter in the universe and a possible explanation to astrophysical observations such as the positron excess observed in the cosmic radiation flux. The gauge boson of the dark sector would be either a massless or a massive dark photon that can either kinetically mix with the SM photon, or couple to the Higgs sector via some mediators. If dark photons decay back to the SM particles with a significant branching ratio, we could either observe measurable deviations in some Higgs decay channels or new exotic signatures that would be accessible at the LHC energies. An overview of current results on dark photon searches with the ATLAS detector will be presented, targeting a wide range final states using different data analysis techniques. Finally, new ideas for dark photon searches using Run 3 data and their current status will be discussed.

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Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-2 / 237

Overview of the current status of the High Granularity Timing Detector for the ATLAS phase 2 upgrade

Author: Rachid Mazini[1]

Co-authors: Katlego Machethe [2]; Mukesh Kumar [3]; Thabo James Lepota [4]

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[2] *iThemba Labs*

[3] *School of Physics and Institute for Collider Particle Physics, University of the Witwatersrand*

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The increase of the particle flux (pile-up) at the HL-LHC with instantaneous luminosity up to $L\ 7.5{\times}10^{34} cm^{-2}.s^{-1}$ will have a severe impact on the ATLAS detector reconstruction and trigger performance. The end-cap and forward region where the liquid Argon calorimeter has coarser granularity and the inner tracker has poorer momentum resolution will be particularly affected. A High Granularity Timing Detector (HGTD) will be installed in front of the LAr end-cap calorimeters for pile-up mitigation and luminosity measurement. The HGTD is a novel detector introduced to augment the new all-silicon Inner Tracker in the pseudo-rapidity η range from 2.4 to 4.0, adding the capability to measure charged-particle trajectories in time as well as space. Two silicon-sensor double-sided layers will provide precision timing information for minimum-ionising particles with a resolution as good as 30 ps per track in order to assign each particle to the correct vertex. Readout cells have a size of 1.3 mm $\times$ 1.3 mm, leading to a highly granular detector with 3.7 million channels. Low Gain Avalanche Detectors (LGAD) technology has been chosen as it provides enough gain to reach the large signal over noise ratio needed. The requirements and overall specifications of the HGTD will be presented as well as the technical design and the project status. The R&D effort carried out to study the sensors, the readout ASIC, and the other components, supported by laboratory and test beam results, will also be presented. Finally, the involvement of the ATLAS Wits/ICPP group in several HGTD activities will be discussed.

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Theoretical and Computational Physics / 238

Shock Wave Propagation in Core-Collapse Supernovae: A One-Dimensional Study with Magnetic Fields

Author: Azwinndini Muronga[1]

Co-author: Magdeline Seabi [1]

[1] *Nelson Mandela University*

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Core-collapse supernovae involve extreme conditions where gravity, nuclear physics, and shock hydrodynamics interact to drive the explosive disruption of a massive star. In this study, we investigate shock wave propagation using a one-dimensional piston-driven model as a proxy for the bounce shock that forms during core collapse. A polytropic equation of state is employed to represent thermodynamic behavior, and magnetic fields are included to examine their role in modifying shock dynamics and matter compression. Numerical simulations, complemented by analytical estimates, reveal how magnetic effects alter post-shock structures and energy transport.

This model offers a simplified but physically insightful framework for studying magnetically influenced shocks in astrophysical environments. It also provides conceptual parallels with shock propagation in high-energy nuclear collisions, where similar compressional dynamics are observed. By combining tractable fluid models with magnetic fields, the study contributes to the theoretical and computational understanding of both stellar collapse and strongly interacting matter under extreme conditions.

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None

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Poster Session / 239

Thermodynamic Properties of (Pr,Gd)OsGa4 Intermetallic Compounds

Authors: Buyisiwe. M Sondezi[1]; Redrisse Djoumessi Fobasso[1]

[1] *University of Johannesburg*

Corresponding Author: redrisse.djoumessi@aims-cameroon.org

Polycrystalline samples of PrOsGa4 and GdOsGa4 were prepared by arc-melting technique using high-purity elemental constituent elements. They were melted on a water-cooled copper plate under ultra-high pure argon atmosphere. The Rietveld crystal structure refinement of powder X-ray diffraction patterns with a full-profile refinement confirms that both samples crystallize in the hexagonal CeOsGa4-structure type with space group Pmma (number 51). The structure exhibits two types of two dimensionally alternating layers that are slightly puckered, having OsGa3 layer sandwiched between Pr(Gd)Ga layers. Here, we present the physical properties of these compounds through temperature (T) dependent magnetic susceptibility $\chi(T)$ and magnetization M(B), heat capacity Cp(T), and electrical resistivity ($\rho(T)$). They consistently reveal that the compounds undergo an antiferromagnetic type ordering below 16 K. The ⊠(T) data obey the Curie-Weiss law above 50 K. The study may contribute towards a better understanding of the physics of this class of materials.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 240

Using Machine Learning algorithms in the search for dark photons with the ATLAS detector at the LHC.

Authors: Karabo Tau[1]; Rachid Mazini[1]

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The search for new physics is one of the key goals of the ATLAS Collaboration. With the discovery of the Higgs boson in 2012, the Standard Model (SM) gained an essential ingredient towards the understanding of fundamental particles and their interactions –but it cannot yet be considered complete. The nature of Dark Matter (DM), which constitutes about 27% of the Universe, remains a major open question. Dark matter might be part of a complex "dark sector"of particles beyond the Standard Model, with its own internal symmetry structure and interactions. Among these "dark particles", the "dark photon"(gamma;_d) is a predicted mediator particle for interactions in this new sector. If dark photons interact with Standard Model particles, they could be produced in high-energy proton-proton collisions at the LHC and be detected by the ATLAS experiment. We will explore the use of the ATLAS experiment collected data in proton-proton collisions at the LHC to explore the production of a dark photon originating from the Higgs boson portal to DM, via the decay H ⟶ Z + gamma;_d . The Z boson decays to two same-flavour, opposite-sign leptons (either e+e- or μ+ μ-) while the undetected gamma;_d produces a missing transverse energy E_T^{miss} in the detector. Hence a final state: e+e- /μ+μ- + E_T^{miss} that would give an indication to the existence of gamma;_d. However, the SM presents several physics processes with similar final state that are produced with a higher probability in pp collisions. To separate these background processes from the gamma;_d signal, Machine Learning (ML) algorithms offer a powerful tool to analyse large amount of data using multi-variables models. Algorithms such as Boosted Data Three (BDT), Deep and Graphical Neural Networks (DNN,GNN) are applied to ATLAS Monte Carlo Simulation data to investigate to most efficient one, before applying the results to collected data for signal-to-background discrimination and searches for gamma;_d.

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MSc

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Yes, I ACCEPT

Poster Session / 241

Perovskites in the Quantum Age: Bridging Materials Science and Technologies

Authors: Redrisse Djoumessi Fobasso[1]; Buyisiwe. M Sondezi[1]

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Getting affordable and clean energy is the 7th UN Sustainable development goal. One way of achieving this goal is to ensure that renewable energy sources like solar, wind, and thermal energy are accessible at reasonable prices to everyone. Solar energy is recognized as an effective way to deal with environmental pollution and global warming and, most importantly, make electricity accessible to everyone. Most of the photovoltaic cells were silicium-based. Discovered in the 1830's, the existence of perovskites revolutionized the world of science 180 years later. Indeed, it was only in 2010 that Tsutomu Miyasaka highlighted its potential in the photovoltaic industry. Due to their characteristics, perovskite materials have significant technical significance across various real-world applications such as solar cells, photocatalysts, light-emitting devices, energy conversion and storage, spintronic devices, gas sensing, etc… [1 - 4]. This paper includes a review of the literature summarizing the reported advancements in the properties of the perovskite type RTX3, which are potentially important materials for technological applications, especially in solar cells, including their potential in advanced battery systems, solar cells, catalysis, and magnetic devices. Finally, the review highlights the challenges and future prospects for the development of RTX_3 materials in both fundamental research and practical applications.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 242

Study of the K quantum number of pygmy states in 154Sm

Author: Refilwe Emil Molaeng[1]

Co-authors: Akaa Daniel Ayangeakaa [2]; Amrita Gupta [3]; Antonella Saracino [2]; Bastian Löher [4]; Benjamin Wellons [5]; David Gribble [2]; Deniz Savran [4]; Iyabo Usman [6]; Johann Isaak [3]; John Santucci [5]; Jörn Kleemann [3]; Kiriaki Prifti [3]; Lindsay Donaldson [7]; Luna Pellegri [1]; Norbert Pietralla [3]; Oliver Papst [3]; Philip Adsley [8]; Robert Janssens [2]; Samantha Johnson [2]; Sean Finch [9]; Tyler Kowalewski [2]; Xavier James [2]

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This study aims to investigate the Pygmy Dipole Resonance (PDR) in the deformed ¹⁵⁴Sm nucleus. The present study employs the (gamma; , gamma; ′) reaction to examine dipole states in the energy range 3.5 MeV to 7.05 MeV (close to the neutron separation threshold (8 MeV)). The experiment was carried out using the Clover Array at the HIgamma;S facility of the Triangle Universities Nuclear Laboratory. The polarised beam produced at the facility enables measurements through the asymmetry method to characterize the nature of populated transitions, allowing differentiation between 1⁻ and 1⁺ states, an essential aspect in the study of the dipole response of nuclei. Furthermore, the high-resolution beam mode (< 2%) available at HIgamma;S makes the determination of the decay branching ratio to the first 2⁺ state possible. This will aid in identifying the K quantum number of various excited states and in analyzing the PDR as a function of excitation energy. The validity of the Alaga rules in the region of the PDR will also be investigated in this work. The motivation behind this study, along with experimental details, will be presented. Preliminary data analysis will be discussed and an outlook on future comparisons will be provided.

This work is based on the research supported in part by the National Research Foundation of South Africa (Grants No. MND210503598725, No. REP_SARC180529336567) and the US Department of Energy (Grants No. DE-FG02-97ER41041 (UNC), No. DE-FG02-97ER41033 (TUNL)).

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Applied Physics / 243

Deep Learning for High Throughput Decision Making on Diamond Content of PET Activated Kimberlite Rocks

Authors: Nicholas Connell[1]; Richard Andrew[2]

Co-authors: Charis Harley [3]; Martin Cook [4]; Simon Connell [5]; TIEGO MALESELA MPAI [4]; Thendo Emmanuel Nemakhavhani [4]; Tim Brook [4]

[1] *University of Johannesburg*

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The MinPET research team is developing novel computer-vision capabilities for crushed rock sorting in diamond mines. Traditional diamond extraction methods employ multi-stage rock-crushing where stages are chosen such that a mine's diamond-size distribution is balanced against the crush size at each stage so that an overall acceptable rate of diamond breakage is maintained. Positron emission tomography (PET) techniques can be used to reconstruct a density map of the distribution of PET isotopes within the rock. PET isotopes in diamond ores such as kimberlite can be activated with a high energy gamma ray beam, and can penetrate to a depth of more than 30 cm. An upper bound of 10 to 15 cm on the crush size is given by the attenuation of 511 keV gammas in the rock. This sorting capacity decreases the rate of diamond breakage. Computer-vision and deep-learning methods can produce autonomous agents capable of on-the-fly decision making, these agents can then identify which rocks contain diamonds and extract them for further careful processing. The expected mass ratio of kimberlite to diamond is about a few billion to 1, thus a fairly accurate agent can reduce processing needs by at least 1000 times, we aim to reduce it by 10,000 times. This talk describes the combination of synthetic data generation and AI training needed to create such agents and outlines our current achievements.

Apply for student award at which level::

PhD

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Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 244

Comparison of Full and Fast Simulation Efficiencies in the ATLAS Detector Using Tag-and-Probe and EGamma MC Comparison Frameworks

Author: Abdool Sattar Cassim[1]

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Monte Carlo (MC) simulated data are essential for modeling events in the ATLAS Inner Detector. However, full Geant4-based simulations have become increasingly computationally demanding, with approximately 80% of the processing time attributed to shower simulation and detailed ATLAS detector geometry modeling. To address this, the new ATLAS Fast Simulation (AF3) framework provides a parameterized response for particles entering the calorimeters, using a simplified detector geometry to approximate energy deposition in calorimeter cells.

In this study, identification and reconstruction efficiencies—and their associated scale factors—were evaluated to compare the performance of Full and Fast simulations. Two methods were employed: the conventional Tag-and-Probe technique, which operates at the event level, and the new EGamma Full-Fast MC Comparison tool (EGMCE), which applies a particle-counting approach for assessing efficiencies.
Results showed overall good agreement between Fast and Full simulations across both methods showing the accurate modelling of Fast simulations whilst retaining similar results to Full simulations. However, the EGMCE framework exhibited lower reconstruction efficiencies, primarily due to challenges in correctly identifying electrons reconstructed as photons. Similarly, discrepancies were observed in identification efficiency: while the EGMCE tool showed agreement with AF3 efficiencies in the 80–90% range, it deviated from those obtained via Full simulation.

The findings demonstrate the need for further refinement of the EGMCE framework in its particle selection algorithms to ensure consistency with the Tag-and-Probe method and reliability for future physics analyses within analysis groups

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Applied Physics / 246

IoT-Based Environmental Monitoring in a Sawtooth Greenhouse: Foundations for CFD, Anomaly Detection, and Environmental Prediction

Authors: Abdool Sattar Cassim[1]; Charis Harley[None]; Emmanuel Igumbor[2]; Kondwani Chafulumira Chumachiyenda Mwale[3]; Loan Truong[4]; Mbolahasina Ralijaona[2]; Michael Rudolph[1]; Rethabile Kgolobe[None]; Simon Connell[1]

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The global agriculture sector faces mounting challenges due to climate change, rising atmospheric CO_2 levels, and increasing food demand from growing urban populations. Greenhouses have emerged as vital solutions to ensure improved food production. In earlier work, a real-time Internet of Things (IoT) sensor network was deployed in a sawtooth-shaped greenhouse to monitor temperature and humidity distributions. This provided key insights into the microclimate and laid the groundwork for future integration with computational fluid dynamics (CFD) simulations, aimed at optimizing natural ventilation, energy use, and environmental control.

Expanding on that framework, this study implements an enhanced IoT-based sensing network in a greenhouse, monitoring temperature, humidity, CO_2 equivalence (CO_2eq), and total volatile organic compounds (tVOC) across nine spatially distributed locations grouped into three zones (high-irradiation vent, middle, and far end). Over a 50-day period, a statistical filtering algorithm was used to remove sensor noise and quantify uncertainty, ensuring high data integrity from these locations. Results showed elevated temperatures and poor air quality (high CO_2eq and tVOC) at the high solar radiation vent, while the middle and far-end zones exhibited more favorable conditions due to high ventilation.

This dataset offers a valuable foundation for future CFD studies by providing detailed spatial and temporal environmental insights essential for model validation and simulation benchmarking. This is the basis for a digital twin that can be used to optimise crop yield growth and updated by real-time sensor data. Additionally, the high-resolution data and established patterns open new avenues for anomaly detection and predictive modeling of environmental conditions within greenhouses. These capabilities are critical for developing intelligent climate control strategies and advancing precision agriculture technologies for an increase in crop production.

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MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Theoretical and Computational Physics / 247

Classical and Quantum Mechanics of Non-holonomic Constraints

Author: William Horowitz[1]

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Modern classical and quantum physics is based on Hamilton's variational action principle. Holonomic constraints, constraints that depend on coordinates alone, can be incorporated into a modified Hamilton's variational action principle through the use of Lagrange multipliers. Non-holonomic constraints, those that depend on coordinates and velocity, such as rolling without slipping, have for 180 years eluded a variational action formulation. We present first results on incorporating non-holonomic constraints into a variational action principle and discuss the implications for classical and quantum mechanics.

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Yes, I ACCEPT

Poster Session / 248

Modelling the thermodynamic properties of TiCl3 medium

Author: Andile Mazibuko[1]

Co-authors: Hasani Chauke [1]; Phuti Ngoepe [1]

[1] *University of Limpopo*

Corresponding Author: andilezibu@gmail.com

The reduction of titanium tetrachloride ($TiCl_4$) with magnesium (Mg) results in the production of intermediates such as titanium trichloride ($TiCl_3$) and titanium dichloride ($TiCl_2$). Experimental work has been done to develop a continuous reduction process using $TiCl_3$ and $TiCl_2$. However, more investigations still need to be done to understand these mediums and their interactions. In this study, we will be looking at two $TiCl_3$ polymorphs as a potential medium for titanium production. We employ the DL_POLY code to understand the effect of temperature on the $TiCl_3$ mediums with R-3 and P3112 space groups. It was noted from the Gibbs free energy that reactions in the R-3 medium are not favourable at 50 K –2000 K. The results of this study give us more insight into the $TiCl_3$ medium as a potential medium for evaluating titanium.

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PhD

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Poster Session / 249

Optimising Buckingham interatomic potentials for use in molecular dynamics using DFT total energies Na-doped Li-rich Li1.2Mn0.8O2 Cathode Simulation

Author: Njabulo Sithole[1]

Co-authors: Kenneth Kgatwane [1]; Phuti Ngoepe [1]

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In the current study, we are exploring the Li-rich cathode material Li2MnO3 which is generally electrochemically passive. Li2MnO3, as a Li-ion and structural stabilizer, can offer higher capacity and is thought to be a promising alternative to traditional cathode materials, such as LiCoO2, in the form of Li-rich Mn-based layer-structured oxides, xLi2MnO3-(1-x)LiMO2 (M = Ni, Co, Mn, etc.). we have constructed the Li1.2 Mn 0.8 O 2 structure from Li2MnO3 with space group R-3m, and intend to study the effect of doping Li with Na on the properties of the nanostructured Li-rich Li1.2Mn0.8O2 cathode. The interatomic potentials of Li were available, except for those of the Na-Li interaction. We calculated the properties of LiNaO using DFT for fitting the Na-Li potential parameter as there were no experimental properties in the literature. We calculated the short-ranged repulsive potential of Na-Li from the DFT total energies of the LiNa system, fitted the Buckingham potential parameters to it, and obtained A = 28250.5, ρ = 0.231, and C = 0. These interatomic potential parameters were used as a starting point in GULP and further fitted against the DFT-calculated properties of the LiNaO structure and obtained A = 38500.5, ρ= 0.177,and C = 0. The obtained Li-Na Buckingham interatomic potential parameters in conjunction with existing interatomic potentials for O-O, Li-O, Li-Li, Na-O, Na-Na reproduced the lattice parameters a=b and c of LiNaO to within 1.52 and -1.7 %, respectively. The elastic constants obtained were reasonable when compared to their DFT values. Fitting the initial Buckingham interatomic parameters to the repulsive potential greatly reduced the fitting time. The deduced potentials are then going to be used to amorphize and recrystallize the doped Na-Li 1.2 Mn 0.8 O 2 structure.

Apply for student award at which level::

PhD

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Yes, I ACCEPT

Poster Session / 250

Quality Assurance for LVPS Bricks in the Phase-II Tile Calorimeter Upgrade.

Author: Vongani Chabalala[1]

Co-authors: Bruce Mellado [2]; Chuene Mosomane [2]; Ryan Mckenzie [2]; Thabo Pilisa [1]

[1] *University of Witwatersrand*

[2] *Ithemba Labs*

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The Phase-II upgrades focus on enhancing the Tile Calorimeter's capabilities in ATLAS detectors, essential for high-energy physics research. Led by Wits University, these upgrades involve improving LVPS bricks, which convert 200V DC to 10V DC for detector operations, ensuring radiation resistance and reliability. Over a thousand LVPS bricks will be produced, each undergoing initial and final testing. Several test stations will support the process, using LabView for hardware and software testing. After testing, data will be collected and analyzed to ensure optimal performance.

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PhD

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Yes, I ACCEPT

Applied Physics / 251

Synopsis of the prototype parabolic trough

Author: Philippe Ferrer[1]

Co-author: khaled Mohamed [2]

[1] *Wits*

[2] *wits*

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The 20kW prototype parabolic trough was completed and the novel receiver performance measured in a realistic setting, completing a project that has led to this point over many years. The final analysis veers away from the original theoretical description, using a more conventional approach and detailed thermal network, necessitated by the insufficient vacuum levels obtained during testing. We fit the new theoretical description to the data, approximating parameters for both the cooling and heating regime, and extrapolate the performance of a similar system with added insulation instead of an evacuated annulus.

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None

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Yes, I ACCEPT

Applied Physics / 252

Density Functional Theory Study of Azo Dye Molecules Adsorbed onto Anatase TiO2 (112) Surface for Application in Dye-Sensitized Solar Cells

Authors: Ronel Ronella Randela[1]; Tshifhiwa Ranwaha[1]; Lutendo Mathomu[2]; Regina Maphanga[3]; Eric Maluta[2]

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The escalating costs of fossil fuels and the finite nature of accessible reserves the indispensable need of studying alternative energy sources. Organic solar cells present a practical and economical technology for capturing solar energy, utilizing materials that are often both accessible and recyclable. Conventional silicon solar cells demonstrated significant reliability; however, their costs remain a barrier. Dye-sensitized solar cells (DSSCs) present a compelling alternative at a significantly reduced cost. In this study, density function theory has been used to explore the adsorption behavior of synthetic dye on the surface of (1 1 2) TiO2 anatase polymorph. Generalized gradient approximation was used to define the exchange-correlation function within the scheme of Perdew-Burke Ernzerhof as implemented in the Material Studio.The effectiveness of the dye-sensitized solar cell is dependent upon the electronic configuration of the dye-sensitizer and its excitation properties. Our results show the UV-Vis absorbance of Azo dye 1, Azo dye 2, Azo dye 3 and Azo dye 4 at 570 nm, 428 nm, 439 nm, and 648 nm, respectively, along with a calculated light harvesting efficiency of 51.3%, 29.5%, 50.58%, 74.8%, respectively. Among the computed four Azo dyes, the results indicate that Azo dye 4 has a stronger sensitization capability relative to the others, with a small HOMO-LUMO gap. Furthermore, the band gap of the anatase is reduced after Azo dye adsorption. The calculated adsorption energies are found to be negative, implying that Azo dyes molecules are electron-donating substituents, and strongly bind strongly to the anatase surface.
Keywords: Azo dyes, semiconductor, band gap, density functional theory, Dye-sensitized solar cells, TiO2

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 253

The South African contribution based on the TileCoM and Tile GbE Switch to the Tile Pre-Processor Modules for the ATLAS Tile Calorimeter: Progress and Current Status.

Author: Mpho Gololo[1]

[1] *University of Johannesburg*

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University of Johannesburg contributes 25% to the final design of the Tile Pre-Processor Modules for the ATLAS Tile Calorimeter at the High-Luminosity Large Hadron Collider (HL-LHC). This work focuses on the status of the Tile Computer-on-Module (TileCoM) and the Tile Gigabit Ethernet Switch (Tile GbE) in terms of firmware, software and hardware integration. The procurement of 62 Xilinx FPGAs for the Control Processing Module (CPM) and 60 Zynq FPGAs for the TileCoM has been initiated, ensuring robust data processing capabilities. Additionally, a dedicated test station at the University of Johannesburg has been established to integrate the TileCoM, Tile GbE, and CPM for validation in terms of sensor data acquisition and performance testing. Significant progress has also been made on the TileCoM's Open Platform Communications Unified Architecture (OPC UA) server, a key component for remote control and monitoring. This presentation provides an update on these developments, highlighting South Africa's vital contributions to the ATLAS Tile Calorimeter Phase-II upgrade.

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None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 254

Search for variable stars in Kepler database

Author: Sello Motsoane[None]

Corresponding Author: sellomotsoane5@gmail.com

Variable stars are stars whose brightness varies with time when observed from Earth. The change in brightness may
be due to changes in star's luminosity, and obstructions in the amount of light that reaches Earth. Studying variable
stars helps understand stellar evolution and properties. The project aims to search for and classify variable stars using
photometric time-series data from the Kepler database. By applying Fourier analysis, it seeks to identify variability
periods and classify stars based on their frequency spectra. The ultimate goal is to determine their physical properties,
including luminosities, absolute magnitudes, and distances, contributing to a deeper understanding of stellar variability
and its implications for stellar astrophysics. The data utilized in this paper is from K2 database (Mikulski Archive
Space Telescope) which was published by the Nainitial-Cape survey stars. A total of eight stars were retrieved from
the K2 database (Mikulski Archive for Space Telescopes). Each star was analyzed to determine the underlying cause
of its variability and to identify potential associations with known variable stars. Light curves were examined for
distinct varability patterns, and Fourier analysis was performed to extract amplitude and frequency values, allowing
for precise determination of each star's variation period. Additionally, the spectral classification of each star from the
literature was utilized to correlate observed variability with previously identified variable stars. The calculated periods
facilitated distinguishing between variability due to stellar pulsation or rotation, based on whether the periods exceeded
the typical pulsation period for each star's spectral type. Noise reduction, including prewhitening, was applied to all
data sets to extract other frequencies of significant amplitudes. Results confirmed that the observed variability across
the sample could be attributed to either pulsation or rotational phenomena. This research successfully achieved its
objective of identifying and categorizing variable stars using photometric data from the Kepler database. Among the
eight stars analyzed, three variable stars were identified and classified as Delta Scuti, Cepheids, and RV Tauri types.
These findings contribute to the growing catalog of known variable stars and provide a foundation for future studies
on their physical and evolutionary properties

Apply for student award at which level::

Honours

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 255

Effect of hydrogen in the migration of Sr implanted into SiC

Author: Khulekani Manqele[None]

Co-authors: C Mtshali [1]; H. A. Ali [2]; S.S. Ntshangase [2]; TT Hlatshwayo [3]

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[2] *University of Zululand*

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Effect of hydrogen in the migration behavior of strontium implanted into SiC was investigated. Polycrystalline SiC samples were first implanted with 300 keV Sr ions to a fluence of 2×10^{16} ions/cm^2 at room and 350 oC. Some of the implanted samples were then co-implanted with hydrogen ions of 15 keV at RT and 350 oC, to the fluence of 1x1017
ions/cm-2. The samples were then annealed at 1000 oC for 5 hours. Both the as-implanted and annealed samples were characterized by Raman spectroscopy and Rutherford backscattering spectroscopy (RBS). SRIM simulation indicated that Sr and H have approximately the same projected range. Co-implantation at RT amorphized SiC while co-implantation at 350 oC retained crystallinity with defects. Annealed caused some recrystallization in both samples which were accompanied by migration of Sr in RT co-implanted SiC and no migration in the 350 oC co-implanted SiC.

Apply for student award at which level::

PhD

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Yes, I ACCEPT

Physics of Condensed Matter and Materials / 256

Computational study of TiNbVZrX (X= Hf, Cr) refractory high entropy alloys

Author: Lebogang Motsomone[1]

Co-authors: Hasani Chauke [1]; Phuti Ngoepe [1]; Ramogohlo Diale [2]

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High entropy alloys (HEAs) are a new class of materials that exhibit promising structural and functional properties, particularly in the field of hydrogen storage. However, the materials and methods used for hydrogen storage currently pose challenges, resulting in the limited storage capacity. Refractory elements are identified as potential candidates for developing effective materials for hydrogen storage. To enhance our understanding of refractory HEAs, the structural and mechanical properties of these alloys were investigated using density functional theory (DFT). The results indicate that both alloys primarily adopt a body-centered cubic (BCC) configuration. TiNbVZrHf and TiNbVZrCr alloys demonstrate excellent stability and mechanical strength, making them promising candidates for hydrogen storage and high-temperature applications. Furthermore, the alloys were found to have high thermal stability which is crucial for long-term hydrogen storage solutions. These findings highlight the potential of refractory HEAs in advancing hydrogen storage technologies.

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PhD

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Yes, I ACCEPT

Theoretical and Computational Physics / 257

Energy Loss as a Probe of Quark-Gluon Plasma Formation Across Collision System Size

Author: Coleridge Faraday[1]

Co-author: William Horowitz [1]

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The quark-gluon plasma (QGP) is formed when protons and neutrons melt at temperatures over 100,000 times hotter than the Sun's core. These conditions are achieved in high-energy heavy-ion collisions, such as those involving lead or gold nuclei at the Large Hadron Collider (LHC) and the Relativistic Heavy Ion Collider (RHIC). More recently, signs suggest that small droplets of QGP may also form in rare, high-activity proton-proton and proton-lead collisions. One way to study the QGP is by measuring how much energy high-momentum particles—produced early in the collision—lose to the medium. If QGP forms in small systems, a suppression of high-momentum particles should also be observed; however, there is currently no conclusive evidence of energy loss in small systems. In this work, we use a statistically driven analysis of R_{AA} data from heavy-ion collisions to constrain the effective strong coupling in our energy loss model, which includes corrections for small system sizes. We also quantitatively estimate various theoretical uncertainties to evaluate the robustness of our conclusions. With the model constrained using only large-system data, we make predictions for small systems with no further tuning and compare them to experimental results at RHIC and LHC. We find that high-momentum particle suppression in central small systems is comparable to that in peripheral heavy-ion collisions, consistent with RHIC data and with LHC heavy-ion results—but in stark disagreement with LHC small-system measurements. We show that this equal suppression in peripheral large systems and central small systems holds across a variety of simple energy loss models. We argue that the LHC small-system discrepancy is likely due to event selection biases in the measurements, to which RHIC data are less sensitive.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-2 / 258

Observation of 152 GeV charged scalar at future lepton colliders

Authors: Andreas Crivellin[1]; Bruce Mellado[2]; Mukesh Kumar[3]; Paballo Ndhlovu[3]; Phodiso Maroeshe[3]; Rachid Mazini[3]; Siddharth Prasad Maharathy[3]

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The statistical significance of the "multi-lepton anomalies"—the discrepancies in the channels with multiple leptons, missing energy, and potentially (b)jets in the final states with the SM prediction—indicates the production of a scalar with a mass between 145 GeV and 155 GeV that is beyond the standard model. The associated production of a narrow scalar resonance of mass $\approx$ 152 GeV, with a significance of 5.4 σ has been reported with the $\gamma\gamma$, $Z\gamma$, and WW final state. The requirement of the new scalar to decay dominantly to WW final state by the anomalies and the absence of any excess in ZZ final state significantly predicts the new scalar to be part of $Y = 0$ scalar-triplet. The model contains a CP-even neutral Higgs (Δ^0), and two charged Higgs bosons ($\Delta^\pm$), which are quasi-degenerate in mass. In this article, we focus on the possibility of finding the aforementioned predicted $\approx$ 152 GeV BSM charged scalar at the future proposed e^+e^- collider. We emphasize on the pair production of the charged scalars, $e^+e^- \to \Delta^\pm\Delta^\mp$ and scrutinize various signal regions depending on the decay products of $\Delta^\pm$.

Apply for student award at which level::

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Applied Physics / 259

Simulation and Image Reconstruction for a Low-Cost PET Detector Concept

Author: Jemma Bagg[1]

Co-authors: James Keaveney [1]; Ryan Justin Atkin [1]

[1] *University of Cape Town*

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A simulation of a low-cost PET detector concept is presented. The model is used to evaluate the imaging potential of the proposed detector, to optimise image reconstruction techniques for this design, and to feed back performance metrics to the detector design process.

The PET system was developed with GATE (Geant4 Application for Tomographic Emission), incorporating a detector layout based on modular scintillators and SiPM arrays. Simulation-based and analytic models of module and channel occupancies are used to assess the feasibility of signal multiplexing to reduce data acquisition electronic costs.

Reconstruction of simulated data is performed using both Filtered Back Projection (FBP) and Maximum Likelihood Expectation Maximisation (MLEM). The performance of these classical algorithms is compared for the low-cost detector concept, with and without integration of time-of-flight (TOF) and depth-of-interaction (DOI) information. Due to the reduced system size and sparse detector layout, TOF and DOI have limited impact, and this comparative study aims to demonstrate that high-quality, clinically usable images can still be obtained despite these constraints.

Benchmark studies using realistic brain phantoms are used to compare image quality from the low-cost system with that of a standard full-ring commercial PET scanner. These studies aim to establish the viability of simplified PET detector designs in producing clinically relevant imaging, contributing to more accessible diagnostic tools in low-resource settings.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 260

Effects of Earth Metal Dopants on the Properties of a Neodymium Magnet Using a First-Principles Approach.

Author: Lesego Miya[1]

Co-authors: Enoch Sithole [2]; Rosinah Modiba [3]

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Rare-earth (RE) ions enhance the stability of permanent magnets against demagnetization, making them vital in wind turbines, electric vehicle engines, magnetic resonance imaging machines, and cell phone devices. However, the rising costs and dwindling reserves of RE materials necessitate the development of RE-free permanent magnets for a sustainable economy. This study uses first-principles calculations to investigate the magnetic properties and electronic structure of $RE_2Fe_{14}B$ (RE = Nd, Dy, Y, La, and Ce). Spin-polarized density functional theory, using the generalized gradient approximation and Perdew–Burke–Ernzerhof
function was performed to predict the properties of $RE_2Fe_{14}B$ permanent magnets. The study found that the spin and orbital magnetic moments of Nd, Dy, Y, La, and Ce atoms are opposite, consistent with Hund's rule, with the total orbital magnetic moment exceeding the total spin magnetic moment. Y prefers the 4f site, while La prefers the 4g site. Ce showed specific magnetic moments at the 4f and 4g sites, contributing oppositely to the total magnetic moment. Substitutions of nonmagnetic La and Ce
reduced the total magnetic moments of the cells. The bandwidth of the Fe d states in $La_2Fe_{14}B$ is shorter than those of the Nd, Dy, Y, and Ce structures because the lattice parameter of $La_2Fe_{14}B$ was more significant than those of all other structures. The findings align well with previous experimental and theoretical data, indicating that substituting Dy, Y, La, and Ce affects the properties of permanent magnets, where Ce has the highest magnetic moments and Dy has the highest Curie temperature compared to the other RE substitutes.

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PhD

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Yes, I ACCEPT

Photonics / 261

Turmeric silver nanoparticles in melanoma photodynamic therapy

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Co-author: Heidi Abrahamse [1]

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Abstract. Melanoma is a very aggressive and lethal type of skin cancer due to its elevated propensity to spread to other organs. Melanoma treatment has advanced significantly in the past decades, with different treatment modalities, including chemotherapy, surgery, radiotherapy, immunotherapy, and targeted therapy, utilized to treat melanoma. However, these treatment options remain limited because of their inability to prevent resistance and disease progression. Photodynamic therapy (PDT) is a promising, less-invasive therapeutic method for treating neoplastic and premalignant lesions. It utilizes light of a specific wavelength to activate a photosensitizer, triggering reactive oxygen species production and subsequently causing cytotoxic cell damage and death. The purpose of this study is to examine the efficacy of turmeric-derived silver nanoparticles (TuAgNPs) in mediating melanoma PDT. TuAgNPs were synthesized and characterized using UV-vis spectroscopy, zeta potential analysis, and high-resolution transmission electron microscopy (HRTEM). A375 cells Melanoma cell lines (A375) were seeded and cultivated in complete media in an incubator set at 37℃, 85% humidity, and 5% CO_2. The cells were treated with different concentrations of TuAgNPs, then irradiated using laser light at a 430 nm wavelength and 5 J/cm^2. Post-laser irradiation assays, including MTT (3-(4,5-dimethylthazolk-2-yl)-2,5-diphenyl tetrazolium bromide), localization analysis, and morphological studies, were conducted to evaluate the cellular response of the treated cells. The TuAgNPs characterization analysis confirmed the formation of stable and spherically shaped nanoparticles. The localization analysis showed the cellular uptake and internalization of TuAgNPs in A375 cells. The MTT results indicated increased cytotoxicity in the treated cells, and morphological changes and deformations were observed in the PDT-treated cells. These findings suggest that TuAgNPs can serve as effective photosensitizers in melanoma PDT. Further, in vivo research could be required to assess the clinical efficacy of TuAgNPs-mediated PDT.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Applied Physics / 262

Design considerations for a low-cost PET brain scanner

Authors: James Keaveney[1]; Simon Carthew[1]

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Medical PET is an expensive metabolic imaging technique that has applications in cardiology, oncology and neurology and is primarily limited to high income countries. A low-cost PET detector concept would likely extend its application to middle and low income countries. This work aims to find the optimal physical parameters that minimizes the cost of the detector while still producing clinically relevant images. The detection method used by the proposed detector is a combination of pixelated scintillation material and silicon photomultipliers. The performance of said detector is described by how many of the produced photon pairs are captured (sensitivity) and how accurately it measures the photon pairs traveled path (spatial resolution). The primary factors that affect the cost are the total amount and type of scintillation material, the number and type of silicon photomultipliers and the number of electronic readout channels. The means of cost reduction for the traditional PET ring design that will be explored are reducing the ring diameter to restrict its function to brain PET, manufacturing custom SiPM arrays, reducing the total number of electronic readout channels with multiplexing schemes and utilizing larger cheaper SiPMs, strictly FPGA based DAQ hardware, sparser SiPM arrays and cheaper scintillation material. The performance reductions introduced by these design choices are to be overcome by using finer grained pixels to increase spatial resolution, integrating the scanner into a low-field MRI and using single-sided readout depth-of-interaction to reduce parallax error and maintain low-cost. Beyond the traditional detector design, novel mechanical detector designs are explored. Mathematical modeling is used to understand how the alterations in physical parameters affect cost and performance and how the proposed performance enhancing methods may combat the reduced performance. Preliminary designs for a low-cost PET detector concept that are ready for integration into a low-field MRI are presented.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 263

The Evolution of the Infrared–Radio Correlation with Redshift and Stellar Mass for galaxies in the MIGHTEE COSMOS field.

Author: Thando Kekana[1]

Co-authors: Kshitij Thorat [2]; Soebur Razzaque [1]; Sthabile Kolwa [3]

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We investigate the evolution of the infrared–radio correlation (q_{IR}) as a function of redshift (z) and stellar mass (M_*) for star-forming galaxies (SFGs) in the COSMOS field, using MIGHTEE Early Science data. We use radio-detected galaxies with multi-wavelength counterparts to classify sources as radio-quiet AGN (RQ AGN), radio-loud AGN (RL AGN), and SFGs over the redshift range $0 < z < 6$. We calibrate the star formation rate (SFR)–1.4 GHz radio luminosity ($L_{1.4\ \mathrm{GHz}}$) relation for both SFGs and RQ AGN. Both populations exhibit a positive correlation between SFR and $L_{1.4\ \mathrm{GHz}}$, and we find that RQ AGN have similar SFR–$L_{1.4\ \mathrm{GHz}}$ calibrations as SFGs. We further examine the evolution of q_{IR} (infrared-radio luminosity ratio) with redshift in different M_* bins. For high-mass galaxies (M_* $>10^{9.5}$ M), q_{IR} declines with increasing redshift and stellar mass due to enhanced magnetic fields in star-forming regions that elevated radio luminosities in massive star-forming galaxies.

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PhD

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Physics of Condensed Matter and Materials / 264

Silver (Ag) co-implanted with helium (He) into polycrystalline SiC at 350 °C: Structural evolution of SiC and migration behaviour of Ag after annealing

Author: Sive Mtsi[1]

Co-authors: ZAY Abdalla [1]; HAA Abdelbagi [2]; TT Hlatshwayo [1]

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Polycrystalline SiC samples were implanted at 350 °C with 360 keV Ag ions (Ag-SiC), and some of the Ag-SiC samples were co-implanted with 17 keV He ions (Ag+He-SiC). The Ag-SiC and Ag+He-SiC samples were annealed isochronally at 1000 to 1300 °C in steps of 100 °C for 5 h. Before and after annealing, samples were characterized using Raman spectroscopy, transmission electron microscopy (TEM), scanning electron microscopy (SEM), atomic force microscopy (AFM), and Rutherford Backscattering Spectrometry (RBS). Our investigation found that Ag implantation and Ag and He co-implantation resulted in defects in SiC structure without amorphization and the formation of He bubbles (manifested as blisters on the surface) in the damaged layer of co-implanted samples. Annealing caused the formation of voids (on the surface) and cavities (in the damaged layer) in the co-implanted samples due to the diffusion of He bubbles. Voids acted as diffusion pathways for Ag and assisted in significant loss, while practically no loss was observed in the Ag-SiC samples annealed under the same conditions. Limited recrystallization was observed in the co-implated samples due to large cavities in the projected range of He, which acts as entrapment for the precipitation of Ag atoms.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Poster Session / 265

The influence of helium (He) bubbles on the migration behavior of silver (Ag) and strontium (Sr) co-implanted into polycrystalline silicon carbide (SiC) during isochronal annealing.

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Co-authors: ZAY ABDALLA [1]; HAA Abdelbagi [2]; TT Hlatshwayo [1]

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The migration of silver (Ag) and strontium (Sr) ions co-implanted into polycrystalline silicon carbide (SiC) in the presence of helium (He) was studied using Raman spectroscopy, scanning electron microscopy (SEM), atomic force microscopy (AFM), Rutherford backscattering spectrometry (RBS), and transmission electron microscopy (TEM). 360 keV Ag ions were first implanted into SiC, followed by 280 keV Sr ions at 600 ℃ (Ag+Sr-SiC). Ag+Sr-SiC were further implanted with 17 keV He ions at 350 ℃ (Ag+Sr+He-SiC). Both samples were isochronally annealed at temperatures from 1000 ℃ to 1300 ℃ for 5 h. Implantation introduced defects in the SiC without amorphization. He implantation led to the formation of elongated He bubbles, surface blisters, and holes. Sr promoted the precipitation of the pre-implanted Ag. Annealing at 1000 ℃ initiated partial recovery of structural defects in both samples. Moreover, annealing the Ag+Sr+He-SiC from 1000 to 1300 ℃ led to loss and deep voids in the implanted region, accompanied by migration toward the surface. No significant migration of Ag and Sr was observed in the Ag+Sr-SiC after annealing up to 1300 ℃. These results suggest that He played a critical role in the migration of Ag and Sr ions.

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PhD

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Yes, I ACCEPT

Theoretical and Computational Physics / 266

From Matrices to Spacetime: Probing Symmetry Breaking in the Type IIB Matrix Model

Author: Anosh Joseph[1]

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One of the significant challenges in superstring theory is understanding how the extra dimensions of space might shrink down to sizes we cannot see - something called dynamical compactification. The type IIB matrix model is a robust mathematical framework that aims to describe this process in ten dimensions. In this model, space itself is expected to emerge from the behavior of large matrices, which can break the original symmetry of the model. However, studying this model is extremely difficult because of a technical issue known as the sign problem, which arises from complex numbers in the calculations. The complex Langevin method has recently shown success in dealing with this challenge. In this work, we apply this method to explore whether the symmetry in the model is spontaneously broken. Our findings suggest that the complex part of the model plays a key role in triggering this symmetry breaking, helping us understand how space and its structure might emerge from fundamental theory.

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None

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Yes, I ACCEPT

Poster Session / 267

Surface Modified Glassy Carbon for Improved Fibronectin Protein Adsorption and Bioactivity in Bone Implants

Author: Thabiso Mathews[1]

Co-authors: Thabisile Thabethe [1]; Tshegofatso Mashabela [1]; Tshepo Ntsoane [2]; Unaisa Dockrat [1]

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Abstract:
Glassy Carbon (GC) has gained attention as a potential substrate for bone-implant application owing to its excellent properties such as biocompatibility, chemical stability, and mechanical strength. Despite these benefits, tissue integration and cellular adherence are restricted by it's inherently bio inert surface. To increase bioactivity and encourage osteointegration, protein adsorption on GC must be improved.In this study, we investigate the protein adsorption behaviour of fibronectin (a key extracellular matrix protein involved in osteoblast attachment and spreading) on GC surfaces subjected to various physicochemical modifications. To enhance surface reactivity, GC samples will undergo different surface pre-treatment, including polishing, polishing followed by biomimetic coating of apatite (HAp) layer on GC surface , acid etching (with HNO3) and acid etching followed by HAp coating. Fibronectin adsorption will be evaluated in vitro by immersing the treated surfaces in a fibronectin solution at 37 ℃ for 4 hours. Surface morphology before and after each treatment will be assessed using Scanning Electron Microscopy (SEM), while Atomic Force Microscopy (AFM) will quantify surface roughness, adhesion forces, and mechanical properties (Young's modulus) to assess protein-surface interactions. Fluorescence microscopy, including confocal imaging, will be used to analyse protein coverage, distribution, and potential conformational differences across treatments. Additionally, SEM will be used in visualizing fibronectin localization and structure on the surface.
Key words: Fibronectin Adsorption, apetite, Osteointegration, Surface Roughness.

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PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Astrophysics & Space Science / 269

Cosmic-Ray Neutron Detectors for Soil Moisture Monitoring

Author: Aimee Dumont[None]

Co-author: Katlego Moloto [1]

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Primary cosmic rays are high-energy particles that enter the Earth's atmosphere via the heliosphere, which generate cascades of secondary cosmic-ray particles when interacting with atmospheric atoms. These secondary cosmic-rays interact inversely with hydrogen atoms in soil moisture, providing a non-invasive method for monitoring moisture levels. Continuous measurements of neutron flux in soil can establish predictive models for heatwaves, droughts, and floods that significantly impact South Africa's agricultural sector. This study employs a cosmic-ray neutron sensor (CRNS) probe equipped with a Boron trifluoride (BF^3) detector positioned 1-2 m above ground that is capable of measuring soil moisture across a footprint of approximately 20 hectares width and up to 0.3 m depth. We detail the calibration process relating measured neutron intensity to volumetric water content, validated against gravimetric soil sampling and point sensor data, which will assist in precision agriculture that can enhance water resource management in diverse agricultural landscapes across South Africa.

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None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 270

AB-INITIO study of structural, elastic, electronic and optical properties of ABX3 based perovskites for solar cell application

Author: BRIDGETTE KABEKWA[None]

Co-authors: Mulatedzi Gandamipfa [1]; Petros Ntoahae [1]; Rapela Maphanga [2]

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In this theoretical study, the structural, electronic and optical properties of KBX3 (B = Ge, Sn; X = Cl, I) based perovskites are systematically studied using first principle density functional theory. Self-consistent calculations are performed using plane wave ultra-soft pseudopotential technique and the generalized gradient approximation of Perdew–Burke–Ernzerhof scheme is used to treat the exchange-correlation interactions. The calculated structural parameters are in good accordance with the existing experimental data and theoretical calculations. Elastic constants, Pugh's ratio, bulk modulus, Poisson's ratio and anisotropy factor are studied for the analysis of elastic characteristic. The band structures are calculated and analyzed with respect to variation; (i) as B varies from Ge to Sn and (ii) as X ranges from Cl to I. Furthermore, optical properties of the ABX3 compounds are investigated in details and the analysis reveals that KGeCl3, and KSnCl3 and KSnl3, are promising materials for solar cell applications.

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MSc

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Yes, I ACCEPT

Poster Session / 272

Structural and optical properties of natural single crystalline TiO2

Authors: Arnold Mutubuki[1]; Assane Talla[1]; Zelalem Urgessa[1]; Johannes R. Botha[1]

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Titanium dioxide (TiO2) is a promising material for applications in photocatalysis and photo-electrochemical water splitting. However, very few studies have been reported on the properties of bulk, single crystalline material. As a consequence, there is a substantial lack of understanding of some of the basic fundamental properties of this important compound, including its accepted band gap energy (3.2 eV, at room temperature) and the origin of near band edge emission (from 2.9 to 3.4 eV) sometimes reported in literature. Optical properties of semiconductor materials are intrinsically linked to their crystal structures. Therefore, a high-resolution X-ray diffractometer is employed to examine the crystalline phase, in order to link the unique luminescent properties observed for bulk single crystalline anatase TiO2 to existing knowledge of the band structure and phonon dispersion relations. The structural properties of natural single crystal anatase TiO2 is studied under different modes of measurement namely: rocking curve (ω) scans, ω - ϕ scans and θ–2θ scans. The standard θ–2θ scans show an extremely sharp diffraction peak with a full-width at half-maximum (FWHM) of ~0.025. However, the rocking curve revealed multiple peaks which is unusual of a single crystalline material. The rocking curve peak positions are also found to depend on the azimuthal angle ϕ. This study seeks to identify the primary impurities present in the natural crystals through the application of secondary ion mass spectroscopy. Additionally, it aims to ascertain whether they can be correlated with specific near band edge photoluminescence lines observed at low temperatures (~5 K).

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PhD

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Yes, I ACCEPT

Astrophysics & Space Science / 273

Late-time spectropolarimetry of GRB 250129A: evidence of an off-axis Gaussian jet

Author: Ankur Ghosh[1]

Co-authors: A.S Moskvitin [2]; Anshika Gupta [3]; Brian van Soelen [4]; David Buckley [5]; Jagdish Joshi [3]; Joleen Barnard [4]; Justin Cooper [4]; Kuntal Misra [3]; Naveen Dukiya [3]; Nikita Rawat [5]; O. I. Spiridonova [2]; Resmi Lekshmi [6]; Soebur Razzaque [1]

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Gamma-Ray Burst (GRB) afterglows arise from the interaction of relativistic ejecta with the circumburst medium and are observed across the electromagnetic spectrum. Polarisation is expected during the early and late phases of the afterglow depending on the presence of reverse shocks and the viewing geometry of the jet. Polarimetric observations of GRB afterglows serve as a unique diagnostic tool to investigate the geometry and structure of magnetic fields in the emitting region, which cannot be directly inferred from photometric or spectroscopic data alone. We present late-time spectropolarimetric observations of GRB 250129A using the Robert Stobie Spectrograph on the Southern African Large Telescope (SALT), obtained $\sim$19 hours post-burst. We detect a remarkably high linear polarisation of 5–10 % and a $> 90^\circ$ rotation in polarisation angle across wavelength—an unprecedented result for this late afterglow phase. This indicates turbulence with large-scale toroidal and radially stretched magnetic-field structures in the late-time forward shock regime. Such high polarisation levels are typically expected during the early afterglow ($\sim$100 s) when reverse shocks dominate. However, multi-wavelength observations from LCO, DOT, ZEISS, and Swift-XRT show no indication of reverse shock contribution at this epoch. XRT data reveals high-latitude emission and the flaring activity between 5.5 and 11 hours since the explosion. Afterglow modeling incorporating both forward and reverse shocks confirms that the reverse shock component fades rapidly after $\sim$100 s. The multi-wavelength afterglow is best explained by an off-axis viewing geometry ($\sim 11^\circ$ from the jet axis) of a Gaussian jet in a uniform density ISM environment. GRB 250129A thus provides rare observational evidence linking late-time polarisation to geometric and jet-structure effects.

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None

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Yes, I ACCEPT

Poster Session / 274

Growth Kinetics and Structural Evolution of Apatite Coatings on Titanium Alloy in Simulated Body Fluid.

Author: Tshegofatso Mashabela[1]

Co-authors: Eric Njoroge [1]; Thabiso Mathews [1]; Thabsile Thabethe [1]; Tshepo Ntsoane [2]; Unaisa Dockrat [1]

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Abstract:
Apatite coatings formed on metallic substrates such as Ti-6Al-4V (Ti64) can promote osseointegration and are of significant interest for orthopaedic and dental implant applications. However, the slow formation of apatite layers in conventional simulated body fluid (SBF). In this study, we investigate the growth kinetics of apatite layers formed on Ti64 substrates using an enhanced biomimetic approach. A modified version of Kokubo's SBF, referred to as 3×SBF, is employed to accelerate the nucleation and growth of the apatite coating. Ti64 samples are immersed in 3×SBF for varying durations 7, 14, and 21 days to systematically assess the evolution of the coating layer.
A multi-technique characterisation approach implemented to determine the growth kinetics and coating properties. Energy Dispersive X-ray Spectroscopy (EDS) was used to determine the elemental composition and monitor the Ca:P ratio over time, allowing comparison to the stoichiometry of natural bone mineral. X-ray Diffraction (XRD) was employed for phase identification and to track changes in crystallinity and crystal structure associated with apatite maturation. A fluorescent confocal microscope was utilized to investigate the spatial dynamics of mineral deposition, quantify porosity, assess coating thickness, and conduct depth profiling. Together, these techniques provide a comprehensive understanding of the temporal and structural evolution of the apatite layer on Ti64, providing insight into the mechanisms involved in biomimetic coating growth. The results aim to inform strategies for a faster and more effective biomimetics coating for bioactive implant surfaces.
Key words: Apatite, Titanium alloy (Ti64), Biomimetic coatings, In vitro, Calcium phosphate (CaP), Biocompatibility.

Apply for student award at which level::

PhD

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Yes, I ACCEPT

Poster Session / 275

Investigating the Correlation between Magnetic and Photoluminescent Properties of Fe3+ doped ZnAl2O4: A Multifunctional Material for Emerging Applications.

Author: Emmanuel Diutlwetse Magasi[1]

Co-authors: Buyisiwe Sondezi [2]; Machaba Leanyatsa Abraham Letswalo [2]; Odireleng Ntwaeaborwa [3]

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Zinc aluminate (ZnAl₂O₄) is a member of the spinel family which has attracted great research interest due to its diverse properties such as high fluorescence efficiency, hydrophobicity, high chemical, and thermal stability. These properties make it a suitable candidate for application such as in displays, magnetic refrigerators, catalysis, and light emitting diodes (LED). In this study, a well separated ZnAl₂O₄ doped with various Fe³⁺ ions were prepared using Pechini synthesis method. The particle and structural morphology of the phosphors were studied using X-ray diffractometer (XRD) and scanning electron microscope (SEM). The XRD spectra confirmed the crystallinity and formation of a pure ZnAl₂O₄ material which formed in single-phase cubic symmetry and Fd3m space group of ZnAl₂O₄. This crystal structure was maintained even after the substitution with Fe³⁺ ions, indicating a successful substitution of Fe³⁺ ions into the ZnAl₂O₄ structure. Energy dispersive spectroscopy was used for elemental composition investigations which confirmed the presence of Zn, Al, and O in pristine sample and also confirmed the presence of Zn, Al, O, and Fe in doped ZnAl₂O₄ samples. Diffuse reflectance spectra analysis was used for in-depth investigation of the effects of Fe³⁺ doping on the band gap of ZnAl₂O₄. Photoluminescence (PL) spectroscopy, excited using a xenon lamp, revealed two broad emission bands at approximately 470 nm and 730 nm. These emissions are attributed to the ⁴T₁⟶⁶A₁ and ⁴T₂⟶⁶A₁ transitions of Fe³⁺ ions, which occupy the tetrahedral (Tet) and the octahedral (Oct) coordination sites, respectively, within the ZnAl₂O₄ lattice. The CIE (Commission Internationale de I'Eclairage) confirmed that pure ZnAl₂O₄ color emission was lying in the blue region with color purity of 89% and CCT of 3384 K and upon doping with varying concentrations of Fe³⁺, the coordinates were tuned towards the white color region, indicating a potential for tunable white emission. Of particular interest is the 0.01 mol% Fe³⁺ doping which shifted the CIE coordinates to (0.33:0.31) with CCT of 5628K from (0.16:0.11) of the pristine ZnAl₂O₄. The vibrating Sample Magnetometer (VSM) studies revealed that the undoped ZnAl₂O₄ host material exhibits diamagnetic behavior, characterized by a weak repulsion to the magnetic field. In contrast, Fe-doped ZnAl₂O₄ displayed distinct magnetic properties and as varying Fe concentrations. These synthesized materials demonstrate great potential for various applications, such as light displays, magnetic refrigeration, catalysis, and light-emitting diodes (LEDs), due to their unique optical, luminescent, magnetic, and structural properties

Keywords
Luminescence, band gap, diamagnetic, color purity, color coordinate temperature

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Astrophysics & Space Science / 276

Nuggets at the heart of nearby galaxies - -NGC2865

Author: Adebusola Alabi[1]

Co-author: Ilani Loubser [1]

[1] *North-West University*

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In this talk, I will show recent results from the deep optical imaging and spectroscopic study of the spectacular nearby galaxy NGC2865.
NGC2865 is well-known for its system of relatively bright stellar shells in the galaxy's outskirts believed to be remnants of a recent merger event. I will, however, unveil a remarkable but hidden stellar feature at the centre of this galaxy which is directly related to this merger event.
I will show how the combined data from HST imaging, SALT/RSS and VLT/MUSE spectral data help us to unambiguously constrain the nature of the merger event that produced these spectacular stellar features as well as the nature of the disrupted progenitor. I will also discuss the implications of our results, i.e., the decoupled kinematics of the central 'nugget' in NGC 2865 and its stellar population properties (age, metallicity, star-formation histories), in the context of expectations from recent cosmological simulations.

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Yes, I ACCEPT

Astrophysics & Space Science / 277

In Search of Dark Matter with MeerKAT Radio Telescope in Dwarf Spheroidal Galaxies

Author: Shibre Semane[1]

Co-authors: Geoff Beck [1]; Sphesihle Makhathini [1]

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MeerKAT's combination of high-sensitivity and angular resolution makes it a particularly well suited radio interferometer for detecting faint cosmic radio emissions that would otherwise remain inaccessible by other instruments.
This capability is especially important in identifying weak, diffuse radio signals that could be associated with dark matter interactions.

Our research focuses on searching for dark matter signals from dwarf spheroidal galaxies (dSphs), which are promising targets due to their high mass to light ratios, well characterized stellar kinematics and established dark matter density.

We present results from MeerKAT observations of the Milky Way satellite Reticulum II.
We aim to constrain the dark matter parameter space-particularly the Weakly Interacting Massive Particles (WIMPs), by analyzing potential radio signals resulting from their annihilation or decay.
This involves probing two key parameters: the particle mass and the annihilation cross section.
If no significant signal is detected, we set upper limits on these parameters, helping to rule out theoretical models that predict stronger signals than observed.
As sensitivity improves, more theoretical models can be excluded, refining the landscape for future dark matter searches.

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Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 278

Indirect experimental technique for constraining the 193,194Ir(n,γ) cross sections

Author: Sebenzile Magagula[1]

Co-authors: Andreas Görgen [2]; Ann-Cecilie Larsen [2]; Eda Sahin [2]; Fabio Zeiser [2]; Frank Leonel Bello Garote [2]; Gry Merete Teveten [2]; Ina Kullmann [2]; Kgashane Malatji ; Kristine S Beckmann [2]; Lucia Crespo Campo [2]; Luna Pellegri [3]; Magne Guttormsen [2]; Mathis Wiedeking [4]; Sunniva Siem [2]; Therese Renstrøm [2]; To Jørgen E Midtbø [2]; Victor Modamio [2]; Vincent. B Kheswa [5]

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The formation of elements, particularly those heavier than iron, predominantly occurs through two neutron capture processes: slow neutron capture process and rapid neutron capture process, each contributing approximately 50%. These are known as the s- and r-processes, respectively 1.
The neutron capture reactions 192Ir(n,γ)193Ir and 193Ir(n,γ)194Ir were indirectly studied by analyzing data obtained from the Oslo Cyclotron Laboratory (OCL). These data enabled the study of the 193,194Ir isotopes, originating from the 192Os(α,tγ) and 192Os(α,dγ) reactions, respectively. The 193Ir(n,γ)194Ir cross sections constrained by our measurements provided a comparison to existing (n,γ) measurement data [2]. Additionally, the 192Ir(n,γ)193Ir reaction maps a branching point in the s-process, making it highly significant. However, directly measuring the (n,γ) cross section is challenging due to the instability of 192Ir. Therefore, the OCL data provided valuable information on the 192Ir(n,γ)193Ir cross section by indirectly constraining it using the experimental nuclear level density (NLD) and γ-strength function (γSF).
An array of Sodium Iodine (NaI)Tl detectors, called CACTUS, detected γ-rays, while the silicon particle telescope array, called SiRi, was used to detect charged particles in coincidence. The NLDs and γSFs were extracted below the neutron separation energy, Sn, using the Oslo Method [3]. Furthermore, the NLDs and γSFs were used as inputs in the open-source code TALYS to calculate the neutron capture cross-sections and Maxwellian averaged neutron capture cross sections (MACS) for 193,194Ir. Final results of this study will be presented in comparison to existing data.

1 Arnould, M., Goriely, S., and Takahashi, K. (2007). Physics Reports, 450(4-6), 97-213.
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[3] Schiller, A., Bergholt, L., Guttormsen, M., Melby, E., Rekstad, J., and Siem, S. (2000). Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 447(3), 498-511.

This work is based on research supported in part by the National Research Foundation of South Africa (Grant Number:PMDS22070734847), SAINTS Prestigious Doctoral Scholarship, U.S. Department of Energy, Office of Science, Office of Nuclear Physics under Contract No. DE-AC02-05CH11231 and the SARChI under grant No REP-SARC180529336567. The experiment was financed through ERC-STG-2014 under Grant Agreement No. 637686

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / **279**

LGAD technology for beam monitoring and medical applications

Author: Rachid Mazini[1]

Co-author: Karabo Tau [2]

[1] *School of Physics, The University of the Witwatersrand*

[2] *University of the Witwatersrand (ZA)*

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Sensors based on Low Gain Avalanche Diode (LGAD) technology enable high precision timing and position measurements. Paired with a high radiation hardness as well as low production costs, LGAD sensors represent excellent candidates for in-beam detectors, such as beam structure monitoring, but also for various tracking applications. They are currently used for both ATLAS and CMS experiments for their future timing detectors towards the high luminosity LHC upgrade program. Using highly segmented LGADs, timing precision below 50 ps were demonstrated, proving their aptness for these purposes. These properties make LGADs an excellent candidate for medical applications such as radiotherapy monitoring or imaging for particle therapy. We will discuss a new project using LGAD sensors for monitoring, diagnostic and energy measurement of high rate proton beams delivered by the Accelerator Facilities at iThemba LABS. A test bench involving multiple configurations of LGAD sensors is used for real-time monitoring to mimic realistic conditions of Flash radiotherapy. The outcome would help designing an integrated LGAD+ASIC prototype involving multiple disciplinary expertise for medical applications.

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Yes, I ACCEPT

Poster Session / 280

Examining the structural, mechanical and electronic properties of Si-C composite for next-generation anode material

Author: Samson Singo[1]

Co-authors: Katlego Phoshoko [2]; Phuti Ngoepe [1]; Raesibe Ledwaba [1]; Tshidi Mogashoa [1]

[1] *University of Limpopo*

[2] *CSIR*

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Anode materials used in lithium-ion batteries have gained enormous interest in research due to their high Coulombic efficiency and cost-effectiveness. Commercially, graphite is used as the anode material due to its stability but exhibits a low capacity of 372 mAh/g (LiC6). Silicon has attracted attention because of its high theoretical capacity of 4200 mAh/g (in Li4.4Si), making it a promising candidate for next-generation batteries. However, its volume expansion during the lithiation and delithiation processes is a major drawback since it causes loss of electrical contact and low coulombic efficiency. To enhance silicon structural stability and remedy the issues of electrochemical performance, designing silicon composites could work. In this study, the cluster expansion technique is used to determine new and stable variants of Si-C alloy of space group Fd-3m. The cluster expansion simulation produced 25 new structures, with a cross-validation score (CVS) of 6.1 meV/pos. The SiC structure appears on the DFT ground state line which indicates that the structure is thermodynamically stable and has the lowest heat of formation. The structure was found to be cubic in symmetry and mechanically stable. The density of states and band structure of SiC shows an indirect band gap of 1.37 eV which suggests semi-conductor behavior. The findings of this research will contribute to determining a new stable Si-based composite, which will advance the anode materials for next-generation rechargeable batteries.

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Honours

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Poster Session / 281

Ab initio density functional theory of Fe5Ni4S8 (P4_2/nmc) (311) and (111) surfaces : Computational study

Author: Barnard Molala[1]

Co-authors: Phuti Esrom Ngoepe [2]; Peace Mkhonto [1]; Mofuti Mehlape [1]

[1] *University of Limpopo*

[2] *University of LImpopo*

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The properties of the surfaces of materials play a crucial role in determining the behaviour and functionality of materials as the bulk properties, since they control the interaction between the substance and the external environment. They dictate how the material interacts with other substances, such as gases, liquids, or other solids. Many chemical reactions, especially heterogeneous catalysis, occur predominantly at the surface of materials. Pentlandite [(Fe,Ni)9S8] is the principal BMS host of the majority of PGEs and also primary source of Nickel. Pentlandite (Pn) is recovered by milling and flotation. The difficulty in recovering pentlandite is mostly associated with oxidation and the brittle nature of pentlandite. Understanding the surface chemistry of Pn minerals is very crucial as it will improve the recovery of this precious mineral and its hosts. This understanding helps in optimizing processes such as flotation, leaching, and milling, which are commonly used in mineral processing. In the present study we used density functional theory (DFT) technique to study and compare stability of Fe5Ni4S8 (P4_2/nmc) (111) and (311) surfaces. The XRD of Fe5Ni4S8 (P42/nmc), shown in Figure 5.2a, revealed that the (311) plane exhibited the highest intensity, followed by the (111) plane. Structural optimization for possible terminations of both (111) and (311) surfaces was performed. Additionally, the calculated surface energy for (311) was less than that of (111) suggesting (311) was the most stable surface and thus the Pn mineral is likely to cleave through (311) during crushing of these mineral.

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PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Astrophysics & Space Science / 283

Modelling and observation results for the 23-25 March 2023 geomagnetic storm

Author: John Bosco Habarulema[1]

Co-author: Zama Katamzi-Joseph

[1] *South African National Space Agency*

Corresponding Authors: jhabarulema@sansa.org.za, zkatamzi@sansa.org.za

This talk will present results of ionospheric changes during the 23-25 March 2023 geomagnetic storm using observational and modeling data over the African-European sector. Both ionosonde and Swarm observational results show that mid latitudes experienced negative storm effects which have been attributed to thermospheric composition changes. We use models to simulate the ionospheric behavior during this storm period. Considered models were Thermosphere Ionosphere Electrodynamics General Circulation Model (TIE-GCM) and the three-dimensional storm time empirical model (3D-NNstorm) constructed based on radio occultation and ionosonde data. For the maximum electron density of the F2 layer, TIE-GCM and 3D-NNstorm models provide correlation values ranging between 0.48-0.64 and 0.64-0.88, respectively, with lower performance observed at low latitudes.

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None

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Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-2 / 284

Exploring toponium formation at the LHC

Author: Aminul Hossain[1]

Co-author: James Keaveney [1]

[1] *University of Cape Town*

Corresponding Author: hssami005@myuct.ac.za

The top quark, the heaviest known elementary particle ($m_t \approx 172.52\,\text{GeV}$), plays a crucial role in probing the Standard Model (SM) at high energies. At the Large Hadron Collider (LHC), top quark pair production ($t\bar{t}$) is the dominant mechanism for top production. The top quark predominantly decays to a b-quark and a W^+ boson, the latter of which decays either leptonically or hadronically. The dileptonic decay channel ($pp \to t\bar{t} \to b\bar{b}W^+W^- \to b\bar{b}l^+\nu_l l^-\bar{\nu}_l$, with $l = e, \mu$) provides a clean and sensitive probe of the near-threshold region of $t\bar{t}$ production, where the center-of-mass energy is just sufficient to produce the top pair. This threshold region is especially sensitive to key SM parameters such as the top mass, width, and Yukawa coupling. It also offers a unique opportunity to explore the formation of toponium, a relatively unexplored bound state of a top and anti-top quark. Earlier studies indicated discrepancies between theoretical predictions and experimental data in this region, partly due to the absence of toponium effects in standard perturbative calculations. We present an updated and comprehensive study of toponium-induced corrections to various kinematic distributions, including $m_{t\bar{t}}$ and $\Delta\phi(l\bar{l})$ at next-to-next-to-leading order (NNLO) in QCD. Additionally, we incorporate toponium corrections into 2-D differential observables such as $|\Delta\phi^{e\mu}| : m^{e\mu}$, at next-to-leading order (NLO). This analysis compares the improved predictions, now incorporating toponium effects, to LHC data and includes a systematic assessment of theoretical uncertainties.

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MSc

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Yes, I ACCEPT

Astrophysics & Space Science / 285

Neutrino Emission from Bright Blazar Flares

Author: Joshua Robinson[1]

[1] *North-West University*

Corresponding Author: 28804716@mynwu.ac.za

Blazars, a subclass of active galactic nuclei, have emerged as candidates for the sources of very-high-energy astrophysical neutrinos observed by the IceCube Neutrino Observatory. Notable temporal and spatial coincidences, particularly the event IceCube-170922A coinciding with a flare from TXS 0506+056, have sparked interest in the connection between these objects and neutrino production. In this study, we utilize the time-dependent lepto-hadronic code OneHaLe to fit the spectral energy distributions and light curves of bright gamma-ray flares from a sample of blazars detected by Fermi-LAT. In comparison to the calorimetric estimates of neutrino detection rates provided by Kreter et al. (2020), we model the flares with variations in proton injection spectra, allowing for a full assessment of neutrino production. Our findings reveal an overestimation in neutrino production rates using the calorimetric approach, typically by a factor of approximately 10, in cases where gamma-ray emissions are dominated by proton-synchrotron radiation. We also show that the non-detection of neutrinos during these flares does not necessarily imply a lack of relativistic protons within the jet, and shows that future-generation observatories may be able to detect the presence of said protons. The work to be presented has been published in *Robinson & Böttcher* 2024 ApJ 977 42 (DOI 10.3847/1538-4357/ad8dce).

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PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 286

Investigation of samarium-doped hematite nanostructure prepared by hydrothermal method: characterization and application

Author: NTOKOZO CEBEKHULU[None]

Co-authors: Ceboliyazakha .L Ndlangamandla [1]; Sipho E Mavundla [1]

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The hydrothermal method was used to synthesize the hematite phase in this study. To investigate the effect of doping with rare earth metal on the metal oxide semiconductor (MOS) and also to explore the structural, morphology, and optical properties of the hematite phase, four samples with different doping percentages of the samarium (sm) were prepared (0%, 2%,4% and 6%). As-prepared samples underwent different characterizations. X-ray diffraction (XRD) was used to study the crystalline structure and also to confine the rhombohedral of hematite, Scanning electron microscopy (SEM) was used to study the surface morphology of the material while (TEM) Transmission electron microscopy was used to study structural properties of the material. UV-Vis spectroscopy to study the band gap of the material, the thermal stability, and the composition of the material were studied by using the thermogravimetric analysis (TGA). Finally, the overall result suggests that this material has the potential to be used in different applications such as in water treatment, and environmental applications such as in gas sensors.To further study the properties of the material the crystalline size (D), was calculated by using the Scherrer equation, the dislocation density was by using this equation,(2) and the band gap of the material was calculated by using the tau plot equation.

D = kλ/(βcos(θ))

⊠ = 1/ 〖(D)〗 ^2
Where D representing the crystal size in nm, k is the constant, β is the full width half maximum of the intensity (radian), λ is the X-ray wavelength, θ is the Bragg's diffraction angles and ⊠ is the dislocation density 1.

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PhD

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Yes, I ACCEPT

Poster Session / 289

Adopting the ab-initio method to unravel the antiferromagnetic hematite bulk and surface properties

Author: Mariah Madie[1]

Co-authors: Peace Prince Mkhonto [1]; Phuti Ngoepe [1]

[1] *University Of Limpopo*

Corresponding Author: 201945017@keyaka.ul.ac.za

This study employed ab-initio density functional theory (DFT) with Grimme's D3 dispersion correction to investigate the bulk and surface properties of hematite. The Hubbard U parameters 5.0 eV was adopted which gave a band gap of 2.55 eV and lattice parameters of a = b = 5.045 Å and c = 13.774 Å, which were in good agreement with experimental values (band gap: 1.9–2.6 eV; lattice parameters: a = b = 5.035 Å, c = 13.75 Å). The computed electronic properties confirmed the antiferromagnetic nature of bulk hematite, arising from alternating spin-states (spin-up and spin-down) on the Fe atom layers. Various surface orientations including (012), (104), (110), and (116) were modelled to assess surface geometry, relaxation, and energetics to unravel the most stable surface. Among these surfaces, the (104) and (110) surfaces were found to be the most stable based on their relaxations which exhibited the surface energies of 5.61 J/m2 and 5.22 J/m2, respectively. These were in agreement with the computed X-ray diffraction (XRD). These findings revealed the effectiveness of DFT+D3 methods in predicting the bulk and surface of hematite mineral. Furthermore, these form a base for adsorption of collectors to unravel the recovery separation of hematite from other minerals.

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Honours

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Yes, I ACCEPT

Poster Session / 290

EFFECT OF NICKEL DOPING ON THE MAGNETIC AND MECHANICAL PROPERTIES OF B2 FeCo ALLOY

Author: Dineo Maepa[1]

Co-authors: Hasani Richard Chauke [1]; Phuti Esrom Ngoepe [2]; Ramogohlo Diale [3]; Tshegofatso Michael Phaahla [2]

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[2] *University of LImpopo*

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FeCo alloy belongs to the category of intermetallic soft magnetic material. It exhibits the highest saturation magnetisation (~2.4 Tesla) among commercially available soft magnetic materials, along with high Curie temperatures (920–985 ⁰C) and good mechanical strength which make it suitable for various applications. However, this alloy ‘s widespread applications are restricted because of the high cost of Co and low ductility at low temperatures. The aim is to determine how Ni enhances ductility while maintaining the magnetic strength and stability. This study employs the Density Functional Theory (DFT) approach to investigate the effect of Ni on the structural, magnetic, and mechanical properties of B2 Fe₅₀Co_{50-x}-xNi_x alloys (0 ≤ x ≤ 50). Formation enthalpies, elastic constants, and phonon dispersion curves will be analysed to assess thermodynamic, mechanical and vibrational stability, respectively. Building on previous findings for Fe-Co-V alloys, Ni is expected to further improve ductility by lowering the shear modulus-to-bulk modulus ratio. These insights will help evaluate Fe₅₀Co_{50-x}-xNi_x alloys as potential candidates for high-ductility applications.

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MSc

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Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 291

LEAD ISOTOPIC RATIOS AS A NUCLEAR FORENSIC SIGNATURE FOR AGE DATING OF URANIUM ORES

Authors: Manny Mathuthu[1]; Samuel Odumu Ogana JOHN[2]; Stephen Friday OLUKOTUN[3]; Tebogo Gilbert KUPI[3]

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[3] *Center for Applied Radiation Science and Technology (CARST), North-West University, (Mahikeng Campus), South Africa.*

Corresponding Author: manny.mathuthu@nwu.ac.za

South Africa has four uranium "ore provinces", and largely based
on the ages of the provinces, they have distinct nuclear forensics signatures. The International Atomic Energy Agency has mandated all its Member States to develop National Nuclear Forensics Libraries in response to the nuclear security threat posed by nuclear material trafficking. South Africa is thus enhancing their capabilities to interdict and attribute any nuclear material out of regulatory control within its borders, by undertaking this project to document the age and origin of uranium ore materials. In this project, we have determined lead (Pb) isotopic ratios of uranium ore sourced from South Africa and evaluated the Concordia Ages of the two uranium ores. Results show that Variations in the Pb isotopic ratios of different geologic deposits provides a unique nuclear forensic signature for dating the ores. Top ore had an age of 1.8 Ga while the deeper ore had an age of 3.8 Ga. This provides a new nuclear security tool for South Africa's nuclear materials.

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None

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Yes, I ACCEPT

Physics of Condensed Matter and Materials / 292

The electrical and magnetotransport behaviour of layered tetragonal $SrMn_2Ge_2$

Author: Arthur Van der Spuy[1]

Co-authors: Abhishek Pandey [2]; André Strydom [3]; Robert Warmbier [4]

[1] *University of the Witswatersrand*

[2] *School of Physics, University of the Witwatersrand*

[3] *University of Johannesburg*

[4] *University of the Witwatersrand*

Corresponding Author: 1533169@students.wits.ac.za

$ThCr_2Si_2$-type (space group: $I4/mmm$) materials have attracted a significant amount of interest in recent years because of the intriguing ground states and structure-property relationships exhibited by them. In particular, the $A$$Mn_2Ge_2$ (A = alkaline earth metal or rare-earth metal) compounds have been shown to exhibit a wide variety of complex magnetic structures and unusual magnetotransport behaviours. In this work, we present the structural and physical properties of the unexplored compound $SrMn_2Ge_2$ using data obtained from x-ray diffraction, electronic and magnetotransport, thermal, and magnetic measurements. The Sommerfeld coefficient obtained from low-temperature heat capacity data shows a moderately enhanced density of states of 2.9(8) states/(eV f.u.) at the Fermi level in comparison to the values estimated from the band structure calculations. Furthermore, this compound exhibits an anomalously large positive magnetoresistance that approaches ~ 50 % at 2 K and deviates from Kohler's law, instead obeying a power law with an exponent of n = 1.50(8). We discuss and compare our results with those reported for isostructural compound $LaMn_2Ge_2$ which shows similar magnetotransport behaviour.

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PhD

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Yes, I ACCEPT

Poster Session / 293

Strain effects on alkali metal ion adsorption mechanisms on ZrS_2 monolayer for efficient sodium and potassium-ion batteries: A DFT study

Author: David Mahapane[1]

Co-authors: Chewe Fwalo [2]; Edwin Mapasha [2]

[1] *University of Pretoria*

[2] *University of Pretoria*

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In the pursuit of advanced energy storage systems with high energy and power densities, two-dimensional materials like zirconium disulfide (ZrS_2) are being investigated as potential anode candidates for alkali metal-ion batteries due to their exceptional properties. However, there is limited information regarding the application of ZrS_2 monolayers as electrode materials specifically in sodium and potassium-ion
batteries.
In this work, density functional theory with Hubbard (U) parameter implemented in Quantum ESPRESSO, was used to investigate the effects of strain on sodium and potassium-ion adsorption mechanisms on ZrS_2 monolayer. Our results revealed that when sodium is present on a ZrS_2 surface at low coverage, it favors a more tightly bound structure, with sodium ions strongly adsorbing at −1.213 eV under compression
and −0.848 eV under stretching, compared to an energy of −1.055 eV at normal distances. For potassium ions, the corresponding energies are −1.113 eV (compressed) and −0.748 eV (stretched), with an unstrained value of −0.940 eV.
Although both ions exhibit attraction to adatoms, the repulsion between them intensifies as additional adatoms are incorporated, resulting in energy levels that stabilize at approximately −0.5 eV across various strains. Furthermore, the inclusion of
Na and K adatoms introduces additional energy levels within the band gap, enhancing electronic conductivity. When the material is compressed, the band gap reduces to 1.071 eV, whereas stretching increases it to as much as 2.002 eV, also influencing the spin orientation. In terms of the diffusion behavior of adatoms on the ZrS_2 surface, we found that the hollow site serves as the preferred location for adatom diffusion. The
energy barriers for hopping to adjacent sites were found to be between 0.256 to 0.270 eV (path-1) and 0.920 to 0.950 eV (path-2) for sodium, while for potassium, they ranged from 0.312 to 0.330 eV (path-1) and 1.020 to 1.045 eV (path-2). Notably, these low energy barriers signify rapid ionic diffusion, which is crucial for the electrochemical

processes in energy storage systems. Ultimately, this study reveals the significant impact of strain on the structural and electronic properties of monolayer ZrS_2, positioning it as a promising electrode material for next-generation sodium and potassium-ion batteries.

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None

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Yes, I ACCEPT

Poster Session / 295

Identification of Cosmic Filaments using the Simba-C simulation and DisPerSE Filament Finder

Author: Jaydon Durow[None]

Co-authors: Amare Gidelew [1]; Renier Hough [1]; Yin-Zhe Ma [2]

[1] *North-West University*

[2] *Stellenbosch University*

Corresponding Author: jaydondurow@gmail.com

In this study, we combine simulation and topological analysis techniques to identify and study cosmic filaments. We employ the Simba-C simulation, a large-volume hydrodynamic cosmological simulation that incorporates dark matter, baryonic matter, and chemical enrichment, to produce a representative slice of the Universe. To detect filamentary structures within this simulated data, we utilize the DisPerSE (Discrete Persistent Structures Extractor) algorithm, which applies Discrete Morse Theory and Persistence Theory to extract topologically meaningful features from noisy cosmological data.

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Honours

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Yes, I ACCEPT

Theoretical and Computational Physics / 296

Solving the one-dimensional Schrodinger equation using a set of Daubechies wavelet scaling functions.

Author: Obiageli Ezenwachukwu[None]

Co-author: Morotz Braun [1]

[1] *University of South Africa*

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In this contribution basis sets derived from Daubechies wavelets scaling functions1 are used to solve the one-dimensional Schrödinger equation on the interval $[-x_{\max} : x_{\max}]$. We present the results for
a) the harmonic oscillator and b) the Morse potential as function of the number N of intervals. Double logarithmic fits of the energy error against N are also shown. Fast convergence is found.
Finally further applications to the three-dimensional Schrödinger equation also with a view to density functional calculations are discussed.

References

1.Daubechies,I.(1988). *Orthonormal bases of compactly supported wavelets*
Communications on Pure and Applied Mathematics, 41(7), 909-996

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Theoretical and Computational Physics / 297

Machine Learning Modular Forms in String Theory

Author: Abinash Swain[1]

Co-authors: Dumisani Nxumalo [1]; Pratik Roy [1]; Suresh Nampuri [2]; Vishnu Jejjala [1]

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[2] *University of Lisbon, Portugal*

Corresponding Author: 2642931@students.wits.ac.za

Over the last two decades, automorphic forms have emerged as encoders of the mathematical principles underlying the organization of information and microstates in quantum gravity. Perhaps their most significant appearance in this context lies in the counting of black hole microscopic states. The detection and classification of modular forms—and the analysis of their modular properties—thus offer promising pathways to a deeper understanding of quantum black holes.

In this talk, I will demonstrate how the search for modular symmetries relevant to quantum gravity is highly amenable to ML techniques. I will present preliminary results in this direction by developing ML protocols for classifying modular and Jacobi forms and report on the efficacy of the neural nets employed. I will conclude with remarks on potential applications to black hole microstate counting.

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PhD

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Yes, I ACCEPT

Poster Session / 298

Phase Stability and Electro-Mechanical Properties of LiMn1.5Ni0.5O4 via Cluster Expansion and DFT

Author: kemeridge Malatji[1]

Co-author: Phuti Esrom Ngoepe [2]

[1] *University of Limpopo (Materials Modelling Centre)*

[2] *University of LImpopo*

Corresponding Author: kemeridge.malatji@ul.ac.za

High-voltage spinel LiMn1.5Ni0.5O4 (LMNO) is a promising material for next-generation lithium batteries. It has attracted interest as a high-voltage cathode due to its theoretical operating potential of 4.7-4.8 V versus Li^+/Li. However, its practical implementation faces substantial challenges from structural degradation and capacity fade during cycling, originating from complex phase transformations and electronic structure changes during de-lithiation. The fundamental mechanisms governing these degradation processes remain incompletely understood, particularly regarding the interplay between Li/vacancy ordering, transition metal redox chemistry, and lattice stability. This computational study employs cluster expansion and density functional theory (PBEsol+U/HSE06) to systematically investigate the de-lithiation pathway in LiMn1.5Ni0.5O4 (x = 1⟶0). We aim to establish structure-property relationships by examining: (1) phase stability evolution, (2) redox behaviour of Ni and Mn cations, (3) mechanical response to lithium extraction, and (4) thermodynamic voltage profiles of the bulk material. Our calculations reveal sequential oxidation processes (Ni^{2+}⟶Ni^{4+} preceding Mn^{3+}⟶Mn^{4+}) accompanied by Jahn-Teller distortions and identify critical de-lithiation thresholds ($x < 0.25$) where oxygen lattice destabilization occurs. The material maintains remarkable mechanical stability (bulk modulus >120 GPa throughout de-lithiation), suggesting structural resilience despite electronic structure modifications. These findings provide fundamental insights into LMNO's degradation mechanisms while establishing a computational framework for evaluating stabilization strategies.

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None

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Yes, I ACCEPT

Poster Session / 299

H2O adsorption on PtSb2(100) surface

Author: Samuel Mangwejane[1]

Co-author: Phuti Ngoepe [1]

[1] *University of Limpopo*

Corresponding Author: seshupo.mangwejane@ul.ac.za

We performed water adsorptions on the PtSb2 (100) surface, where H2O was adsorbed through oxygen on top of the surface Pt and Sb atoms. The (100) surface was explored by increasing the number of H2O on the surface. The (100) surface was explored by increasing the number of H2O on the surface. Lastly, the full-surface coverage (16/16 H2O/Sb, Pt) was investigated where all Pt and Sb were adsorbed with H2O. We observed that the H2O molecules assemble at an angle on the surface and lie horizontal in particular for multi adsorptions. we found that in all cases the water molecule/s gave larger bond length between Pt/Sb and water O atoms (Pt–OH2 and Sb–OH2). As such, it indicated no bond formation between the surface and water molecules. The H2O bond angle was slightly larger than the isolated H2O molecule. Interestingly, for H2O on Sb atom, we observed a bond formation between the top first surface layer Sb and the fourth surface layer Sb of Sb–Sb = 3.136 Å. This indicated that the top surface Sb relaxed deep into the surface. The calculated adsorption energy of −6.37 kJ/mol was obtained for Pt–OH2 adsorptions, while the adsorption on Sb–OH2 gave +10.34 kJ/mol. This showed that there was poor interaction of water on Sb atoms compared to the Pt atoms.

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None

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Yes, I ACCEPT

Poster Session / 300

THRMAL ANALYSIS OF AMPREG 21 EPOXY AND Bi COMPOSITE MATERIAL USING THE CONE CALORIMETER

Authors: Joseph Asante[1]; Moses Hlongwane[1]; Vincent Mokoana[1]

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Organic polymers with inorganic reinforced composites are in daily use both domestically and industrially - in coating, adhesives, primers, aeronautic utilities, electro-optical devices and sensors, among others. These polymer-based materials are competing with metallic alloys in terms of cost and functionality (durability, strength, and other physical and chemical properties). However, the effect of heat on some of these polymer-based composites, brings some undesirable changes that affect product functionality. In addition, inorganic additives to organic epoxy resin have shown promising flame-retardant effects and increasing electrical conductivity. One particular epoxy polymer, Ampreg 21TM, with Bi inorganic fillers of different weight percentages (0; 0.46; 0.90; and 1.39 wt%) was the focus of this study. The Dual Cone Calorimeter was set to irradiate the samples with 35 and 50 kW/m2 external heat fluxes, yielding the thermal performances of the binary composites in terms of: the heat release rate (HRR), fire spread index (FIGRA), smoke release rate (SPR), smoke spread index (SMOGRA), time-to-ignition (TTI), and the maximum rate of heat emission (MARHE) of the composite samples.
The results show that increasing Bi content in the epoxy decrease the parametric values linked to the fire performance of the samples. Thus, the Bi powder additives, being good heat conductor, assist in spreading heat in the matrix and as a result also serve as fire retardant in the composite.
For the 35 kW/m2 irradiation, TTI decrease from 89 (neat sample) to 70 s (1.39 wt% Bi); Peak HRR decrease from 818.95 (neat) to 698.9 kW/m2 (1.39 wt% Bi); FIGRA decreases from 2.48 (neat) to 1.49 W/s (1.39 wt% Bi); SMOGRA decrease from 5.08 to 3.83 m2/s2; and MARHE decreases from 416.6 to 393.7 kW/m2.
For the 50 kW/m2 irradiation, TTI decrease from 38 (neat sample) to 31 s (1.39 wt% Bi); Peak HRR decrease from 1361.73 (neat) to 675.03 kW/m2 (1.39 wt% Bi); FIGRA decreases from 4.78 (neat) to 2.25 W/s (1.39 wt% Bi); SMOGRA decrease from 9.39 to 6.27 m2/s2; and MARHE decreases from 632.3 to 425.7 kW/m2.

Clearly, increasing Bi additives in the range used, decrease TTI, pHRR, FIGRA, SMOGRA, and MARHE values. Thus, good thermal performance of the composites are achieved with increasing wt% of the Bi additives.

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MSc

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Photonics / 301

Synergistic Effect of Photobiomodulation and Vanillin on Energy Metabolism in Diabetic Wounded Cells In Vitro

Author: Ochuko Erukainure[1]

Co-author: Nicolette Houreld [1]

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Corresponding Author: eochuko@uj.ac.za

Delayed wound healing is among the major peripheral complications of diabetes. Synergistic treatment of diabetic wounds with phytochemicals and non-invasive techniques such as photobiomodulation (PBM) has shown promising results. Cells rely on glucose metabolism for the generation of adenosine triphosphate (ATP) for energy utilization. However, glucose metabolism is altered in diabetic wounds and contributes to delayed healing. The present study investigated the synergistic effect of vanillin and PBM and their modulatory effect on energy metabolism in diabetic wounded (DW) modeled fibroblast cells (WS1). DW cells were treated with vanillin and vanillin + PBM (at 660 nm with a fluence of 5 J/cm² for an irradiation time of 780 s). Controls consisted of WS1 cells, untreated DW cells, and DW cells treated with PBM. There was an increase in the activities of fructose-1,6-biphosphatase, glucose 6-phosphatase, and E-NTPDase, with concomitant suppressed activities of glutathione reductase and glyoxalase, following induction of DW. Treatment with vanillin (12 ug/mL) and vanillin (6 ug/mL) + PBM significantly reversed these activities and closed the wounds while maintaining the cells'morphology. These results indicate the synergistic therapeutic effect of vanillin + PBM on the management of diabetic wounds, with vanillin (6 ug/mL) + PBM displaying the best effect.

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Consent on use of personal information: Abstract Submission:

Theoretical and Computational Physics / 302

Computing the SU(N) Shur index for N=4 super Yang-Mills

Author: Jarryd Bath[1]

Co-author: Sam van Leuven [2]

[1] *University of Pretoria*

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In this talk, I will discuss a computation of the Schur Index of $\mathcal{N} = 4$ super Yang-Mills theory with $\mathrm{SU}(3)$ gauge group. The Schur index counts the number of 1/8 BPS states of a theory. In order to find the gauge invariant (physical) states one must compute several nested complex contour integrals. Through Cauch's theorem, this reduces to finding the residues of the integrands of these integrals. However, there are an infinite number of these residues. We use the partial ellipticity property of the integrand to find all the residues. This computation is the first step to see if we can find any trends relating the rank of the gauge group to the Schur index. The ultimate goal being able to find the Schur index for $\mathcal{N} = 4$ super Yang-Mills with a $\mathrm{SU}(N)$ gauge group, where N is arbitrary.

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MSc

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Applied Physics / 303

VOLITALIZATION OF FLAME RETARDING COMPOUNDS FROM FIREFIGHTER BUNKER GEAR USED IN SOUTH AFRICA DUE TO THERMAL EXPOSURE

Authors: Jonathan Okonkwo[1]; Joseph Asante[2]; Vincent Mokoana[2]

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Firefighting bunker gear provides the first line protection for firefighters during fire conditions. The protective garment is fabricated from superior performance fibres and enhanced by the addition of flame retardants (FRs), which resist ignition and delay flame spread. Flame retardants have been attributed to 15-fold greater escape time for occupants. However, concerns have been emerging on the potential harmful effects of some flame retardants, particularly the brominated flame retardants (BFRs). The BFRs usage have been banned in many countries and are also listed in international treaties as harmful to human and the environment. This study investigated the presence of BFRs concentration in bunker gear, particularly polybrominated diphenyl ethers (PBDEs) and their congeners in the garment and evaluate their impact on thermal performance.

Five different types of bunker gear were tested for the volatilization of the BFRs due to heat exposure. The cone calorimeter was used to expose samples to heat flux of 3, 5, 6 and 8 kW/m2 and polyurethane-foam (PUF) disks were suspended above the samples to capture evolving flame retardants. The PUF disks were extracted with solvents and analysed for the target compound with the gas chromatography mass spectrometry (GCMS). In the GCMS, samples were analysed for a number of PBDEs namely BDE-28, -47, -99, -100, -153, -154, and -209. Of the seven congeners analysed, PBDE congeners -28, -47, and -99 were detected in all five sample materials with concentrations from 0.02 to 0.1 ng/g, 0.03 to 0.34 ng/g and 0.18 to 0.86 ng/g, respectively. Congeners -100 and -153 were detected in 80% and -209 in 40% of the samples. BDE-99 was the most abundant compound detected, with concentration ranging between 0.183 and 0.866 ng/g, followed by BDE-47, ranging from 0.03 to 0.34 ng/g. BDE-209 was the least detected in the samples with concentration, ranging from 0.02 to 0.0.23 ng/g. The results from this study indicates the volatilization of BFRs from the firefighter bunker gear during heat exposure.

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PhD

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Physics of Condensed Matter and Materials 2 / 304

Defects identification in SnO_2 semiconductor using positron annihilation techniques.

Author: Dineo Motjope[None]

Co-authors: Lumkile Ngwazi ; M Madhuku ; Thulani Jili ; Zipho Ngcobo

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The two-component density functional theory is employed in the modelling of defects in ion implanted SnO_2 using positrons as probes. Since defects are localized, the local density approximation (LDA) is used which is part of DFT. Although LDA gives a good approximation of positron lifetimes and electron-positron annihilation momentum density. LDA does not consider the variational nature of the charge density in constituent atoms of the sample. This has an unintended consequence of having over estimation of annihilation rates or underestimation of positron lifetimes compared to experimental values. This deficiency in LDA is corrected by using the generalized gradient approximation (GGA) which considers the variational nature of electron density. The accumulation of annihilation spectrum using coincidence setup, is utilized to allow for the determination of annihilation parameters, S and W. The spectrum consists of positron annihilations at defect sites as well as annihilations in the bulk (defect-free region). It also consists of annihilations of positrons with core electrons (high momentum electrons). The low and high momentum distribution of electrons will be used to characterize the Doppler broadening which will tell us about the quantity of radiation-induced defects in SnO_2 in terms of calculating S-parameter, which is the ratio of the annihilation centroid area to the total area of the annihilation curve. Calculated S parameters are then compared with the experimentally obtained S parameters. The nature of the defects is theoretically obtained from the annihilation rates or equivalently from the calculated positron lifetimes in SnO_2.

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MSc

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Yes, I ACCEPT

Photonics / 305

Getting to know the elegance of Laguerre-Gauss beams

Author: Vasili Cocotos[1]

Co-authors: Light Mkhumbuza [1]; Kayn Forbes [2]; Robert de Mello Koch [3]; Angela Dudley [1]; Isaac Nape [1]

[1] *University of the Witwatersrand*

[2] *University of East Anglia*

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Laguerre–Gaussian (LG) modes are solutions of the paraxial Helmholtz equation in cylindrical coordinates and are associated with light fields carrying orbital angular momentum (OAM). It is customary to modulate such beams using phase-only vortex profiles, e.g. when increasing (laddering up) or decreasing (laddering down) the OAM content of some given LG mode. However, the resulting beams have been shown to be hypergeometric-Gaussian modes, due to the changing radial amplitudes on propagation. In this work, we show that these beams in fact have the angular spectrum of a set of modes known as elegant Laguerre–Gaussian (eLG) modes, which map back to LG-type modes more intuitively than hypergeometric-Gaussian modes. Accordingly, the fields obtain new OAM and radial quantum numbers that depend on the initial OAM and additional OAM gained during modulation. Identifying the true modal structure of OAM-modulated beams as elegant Laguerre–Gaussian modes improves our understanding of beam evolution and supports more precise control in applications like optical communication, beam shaping, and quantum information processing.

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Photonics / 306

Optical Quadrature Microscopy with a polarization-sensitive camera

Author: Calvin Groenewald[1]

Co-authors: Gurthwin Bosman [1]; Pieter Neethling [1]

[1] *Stellenbosch University*

Corresponding Author: 23851171@sun.ac.za

Quantitative Phase Imaging (QPI) is an imaging technique enabling non-invasive, label-free measurement of optical path length differences within samples, facilitating three-dimensional reconstruction from two-dimensional microscopy data. This is traditionally achieved using interferometric approaches such as Phase Shifting Interferometry (PSI) where interferograms generated by combining reference and object beams with controlled phase shifts, are measured.

In this study we explore Optical Quadrature Microscopy (OQM), a variation of PSI that utilizes a quarter-wave plate combined with a rotatable analyzer to introduce controlled phase shifts in the reference arm of a Mach-Zehnder interferometer. We eliminate the need for an analyzer by integrating a polarization sensitive camera, potentially quadrupling the acquisition rate and enhancing temporal resolution. The details of the optical setup as well as preliminary results which validate the system's capability to perform accurate quantitative phase measurements will be presented. Additionally, the implications of our approach for studying dynamic samples will be discussed.

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MSc

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Yes, I ACCEPT

Applied Physics / 307

Gone with the Wind…or Not? Tracking Light's Twists

Author: Vasili Cocotos[1]

Co-authors: Cade Peters [1]; Andrew Forbes [1]

[1] *University of the Witwatersrand*

Corresponding Author: 2341236@students.wits.ac.za

Optical vortices—phase and polarization singularities—are central to structured light applications, yet their comparative resilience to atmospheric turbulence remains underexplored. This study investigates the robustness of phase versus polarization vortices under Kolmogorov-model turbulence using Laguerre-Gaussian and vector beam superpositions. Vortex dynamics are tracked via phase unwrapping and Stokes parameter analysis to quantify spatial drift and topological stability. Understanding the resilience of phase and polarization vortices to atmospheric turbulence can enhance the reliability of structured light in applications such as free-space optical communication, remote sensing, and optical trapping.

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MSc

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Poster Session / 308

Computational framework for light-sheet fluorescence image processing.

Author: Jacques Buÿs[1]

Co-author: Gurthwin Bosman [1]

[1] *Stellenbosch University*

Corresponding Author: 24226238@sun.ac.za

Light-sheet fluorescence microscopy (LSFM) is a technique in which a thin plane of a sample is illuminated with a focused laser beam and the fluorescence signal is collected perpendicular to the optical axis. LSFM provides high quality images of samples, while reducing photodamage and photobleaching. However, the images generated with LSFM still suffer from aberrations and limited resolution.
A computational framework for processing light-sheet fluorescence images was developed to address this problem. An image can be described as the source convolved with a point spread function. This can be reversed by a process called deconvolution whereby a point spread function is separated from an image to estimate the underlying signal. The framework includes noise reduction and deconvolution algorithms. Methods of determining the point spread function, and subsequent deconvolution applied to prepared images and data will be demonstrated.

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MSc

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Yes, I ACCEPT

Poster Session / 310

Simulating the Sky: Digitizing Atmospheric Turbulence

Author: Vasili Cocotos[1]

Co-authors: Cade Peters [1]; Andrew Forbes [1]

[1] *University of the Witwatersrand*

Corresponding Author: 2341236@students.wits.ac.za

It is known that light is an electromagnetic wave and hence, has an intensity and phase profile. In the real world, these properties are distorted by turbulence when light is allowed to propagate through an atmosphere –which it must do for many real-world applications. The need to utilize light in the real world has hence prompted significant studies of atmospheric turbulence. Generating atmospheric turbulence in a lab, however, is difficult for several reasons, and offers limited accuracy in terms of its reproducibility. This prompted us to study the effects that atmospheric turbulence has on light, and to create a system which digitally reproduced these effects, effectively creating turbulence from a purely digital framework! The ability to digitally simulate atmospheric turbulence offers a reliable and reproducible way to study and optimize optical systems for real-world applications such as free-space communication, remote sensing, and imaging through the atmosphere.

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Nuclear, Particle and Radiation Physics-1 / 311

Electromagnetic Properties of the 106Cd Nucleus and Experimental Validation of the Generalized Brink-Axel Hypothesis (gBA)

Author: Ayabulela Tsewu[1]

[1] *University of Johannesburg*

Corresponding Author: ayabulelatsewu606@gmail.com

This study extracts new experimental γ-ray strength function (γSF) and nuclear level density (NLD) data for the ¹⁰⁶Cd isotope using the newly developed Shape Method, coupled with the Oslo Method. These methods are applied to particle-γ coincidence data from the ¹⁰⁶Cd(³He, ³He'γ)¹⁰⁶Cd reaction at the Cyclotron Laboratory of Oslo University (OCL). The functional forms of the γSF and NLD have been normalized using the Shape Method, which enables the extraction of γSF and NLD data even in the absence of experimental neutron resonance spacing. This experimental data is then used to calculate the ¹⁰⁶Cd(n, γ) cross-sections within the Hauser-Feshbach formalism. Moreover, this study experimentally tests the validity of the generalized Brink-Axel hypothesis (gBA) in the mass region A=106 for the first time, which asserts that the γ-ray strength function (γSF) is independent of excitation energy. Additionally, we extend our investigation to ¹⁴⁰La, where the validity of the gBA is tested experimentally using data from the ¹³⁹La(d,p) reaction, also conducted at OCL. Finally, the thermodynamic properties of ¹⁰⁶Cd nucleus are extracted for the first time. Details of our findings will be presented at the upcoming conference.

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PhD

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Poster Session / 312

First-Principles Study of Ni-Doped NaMnPOF Cathodes: Enhancing Electronic Conductivity and Sodium-Ion Mobility for Advanced SIBs

Author: RATSHILUMELA STEVE DIMA[1]

Co-authors: David Tshwane [1]; Eric Nnditshedzeni Maluta ; Lethabo Mogakane [1]; Prettier Maleka [1]; Regina Maphanga [2]; Tshifhiwa Masikhwa [3]

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The development of sodium-ion battery (SIB) technology relies on the development of high-performance cathode materials. Ithis study investigates the structural, electrical, and electrochemical properties of Ni-doped NaMnPO3F cathodes (NaMn1-xNixPO3F, 0 < x < 0.5) through the first-principles calculations based on density functional theory (DFT). The simulations conductedin this study show a slight decrease in the band gap, resulting from the partial substitution of Mn with Ni via doping, indicating enhanced electronic conductivity and improved charge transfer. The Bader charge analysis and partial density of states (PDOS) further suggest a synergistic redox activity between Mn and Ni during sodium de/intercalation.Additionally the calculated formation energies confirm the thermodynamic stability of the doped structures.Overall, the results demonstrate that Ni doping not only stabilizes the olivine-type structure but also enhances the electrochemical performance of $NaMnPO_3F$, positioning $NaMnNiPO_3F$ a promising candidate for high-capacity and high-rate sodium-ion battery cathodes.

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Applied Physics / 313

Warping light into Neural Networks

Authors: Hadrian Bezuidenhout[1]; Cade Peters[1]; Mwezi Koni[1]; Andrew Forbes[1]; Isaac Nape[1]

[1] *University of the Witwatersrand*

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In recent years, Deep Diffractive Neural Networks (D2NNs) have emerged as a powerful tool in optical computing and information processing. These systems utilise consecutive phase modulations to map a set of optical input states defined in one basis, to a new set of target states in an arbitrarily defined basis. Traditionally, the phase masks used to achieve these operations are optimised through randomly generated phase patterns or by finetuning individual pixel values using various search algorithms. In this work, we introduce a novel approach to the construction of these phase screens using Zernike polynomials. Switching from the pixel basis to this modal basis allows us to train the coefficients of the polynomials contained in each phase screen analogously to the weightings found within a traditional neural network - fewer training parameters lead to reduced computing cost and results in faster convergence during training. We demonstrate the computational abilities of this approach by characterising Laguerre Gaussian modes into predefined channels, as well as by emulating a quantum gate operation using vectors defined as a lattice of Gaussian modes. This work advances high-dimensional free-space information processing and has the potential to be adapted to real-time processing tasks.

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MSc

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Physics of Condensed Matter and Materials 2 / 314

Electrical and structural properties in Mo-Re alloys; a study on their superconductivity.

Author: Treatwell Pamhidzayi[1]

Co-authors: Aletta Prinsloo [1]; Charles Sheppard [1]

[1] *University of Johannesburg*

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Previous studies [1,2] reported on superconductivity (SC) observed for alloy systems with the general formula $\mathrm{Mo}_{1-x}\mathrm{Re}_x$. In order to probe this behaviour further, three samples $\mathrm{Mo}_{73.5}\mathrm{Re}_{26.5}$, $\mathrm{Mo}_{67.1}\mathrm{Re}_{32.9}$, and $\mathrm{Mo}_{79.5}\mathrm{Re}_{20.5}$ were prepared and characterized. Pure elements, 99.99 % in purity, of Mo and Re were used to synthesize the three samples utilizing the arc-melting technique. Analysis of x-ray diffraction results show that these alloys exhibit both body-centred cubic (BCC) and the A15 phases. The A15 phase, with a β-W crystal structure, is typically observed in intermetallic compounds of the form Y_3Z, where Y is a transition metal, and Z is any element and is associated with superconducting behaviour [3]. The four-probe method was used for resistivity as a function of temperature, $\rho(T)$, measurements. All the samples showed normal metallic behaviour on cooling down from 300 K to the temperature associated with the onset of SC, T_{sc}, where a clear anomaly in the form of a step in the $\rho(T)$ curve is observed. As the applied magnetic fields are increased, the T_{sc} values shift to lower temperatures. Alternating current heat capacity measurements as a function of temperature, $C_p(T)$, were performed. Clear transitions, in the form of humps, are observed in the $C_p(T)$ curves of the $\mathrm{Mo}_{67.1}\mathrm{Re}_{32.9}$ and $\mathrm{Mo}_{79.5}\mathrm{Re}_{20.5}$ samples, corresponding to T_{sc} values of (9.53 ± 0.02) K and (9.98 ± 0.05) K, respectively.

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MSc

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Poster Session / 315

Development and Evaluation of a Poly(2,5-benzimidazole)-Graphene Oxide Composite for LEO Coating Applications: A Comparative Experimental and Computational Study

Author: Nicholas Snyman[1]

Co-authors: Kingsley Obodo [2]; Lynndle Square [3]

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[2] *North-West University & NITheCS & University of KwaZulu-Natal*

[3] *North-West University & NITheCS*

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The longevity of spacecraft materials is severely impacted by the radiation-rich environment of Low Earth Orbit (LEO), which has led to the development of lightweight, radiation-tolerant coatings. In this work, a composite material consisting of graphene oxide the (GO) and poly(2,5-benzimidazole) (ABPBI) was synthesised by in situ polymerisation and characterized by X-ray diffraction (XRD) and UV-visible spectroscopy (UV-Vis). The electrical and optical properties of the composite and its components were investigated computationally using Density Functional Theory (DFT).
In agreement with DFT results and much like investigations of ABPBI carbon nanotube (CNT), the ABPBI/GO samples UV-Vis data indicated significant absorption in the UV region. The electronic properties of ABPBI/GO are shown by the band structure and density of states (DOS, characteristic an indicative of a semiconducting nature.
ABPBI/CNTs have been successful in its resilience against atomic oxygen, proton and secondary neutron generation (Square et al., 2023a; Fourie et al., 2023). To evaluate ABPBI/GO, this work considers the plausibility of GO as an alternative nanofiller. The optical absorption, and electronic characteristics of the ABPBI/GO composite is compared to previously researched ABPBI/CNT systems. Recent results suggest enhanced structural flexibility under microgravity conditions (Swanepoel, unpublished manuscript). A large bandgap of ~4.12 eV was obtained for the pristine ABPBI, consistent with insulating behaviour, while the ABPBI/GO composite showed a reduced bandgap of ~2.01 eV. Both ABPBI/CNT and ABPBI/GO composites exhibit semiconducting behavior with DOS indicating bandgap narrowing and interfacial charge transfer. Optical absorption is strong in the deep-UV (~100–250 nm) for the GO composite and tunable between ~200–400 nm for the single-walled carbon nanotube (SWCNT) system, depending on nanotube loading.

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Honours

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Applied Physics / 316

Combining spheres and spirals of light for noise free communication through optical fibre

Authors: Cade Peters[1]; Vineetha Ashok[2]; Siddharth Ramachandran[2]; Andrew Forbes[3]

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[2] *Boston University*

[3] *University of the Witwatersrand*

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Topology has played a significant role many areas in Physics, ranging from cosmology and condensed matter to high-energy physics and waves. In electromagnetism, one can create an optical Skyrmion through correlations between position and polarization which map from real space to the Poincaré sphere. These topological states of light can be realised in classical laser beams and biphoton entangled states, demonstrating remarkable resilience in both regimes to a wide range of perturbations and noise. This makes them a viable candidate for information encoding and transport, promising inherent robustness and a higher dimensional encoding alphabet. However, optical Skyrmions are not resilient to modal noise, currently hindering their implementation in multimode optical fibres which are necessary for the long range and high-speed transmission of information. In this work we leverage the recently discovered phenomenon of topological confinement in optical fibres for light with spiral wavefronts to greatly diminish the effects of modal noise. Our findings demonstrate the potential for Skyrmions to be transported over large, previously unreachable distances by leveraging two topological phenomena. This opens the doorway for the use of optical Skyrmions in communication networks as a means for encoding and transporting information in a manner that is robust to virtually all forms of noise.

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PhD

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Physics of Condensed Matter and Materials / 317

Microstructure and Phase Composition of CrNiX (X = Co, Al, Mn) Low-Entropy Alloys

Author: Nozipho Prudence Botsho[1]

Co-authors: Charles Sheppard [1]; Aletta Prinsloo [1]

[1] *University of Johannesburg*

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Alloying chromium-nickel with cobalt (Co), and manganese (Mn) offers the possibility of creating alloys with high yield strength and fracture toughness, while alloying chromium-nickel with aluminum (Al) also contributes yield strength and fracture toughness, along with low density. This study probed the phase composition and microstructure of the low entropy CrNiX system by considering X = Co, Al, Mn. The phase formation rules of low-entropy alloys are explored using empirical formation rules of simple solid solutions. A single phase is likely to form when the mixing enthalpy (H_mix) is within the range -20≤H_mix≤5 kJ.mol^(-1), configurational entropy (ΔS_conf) values 12≤ΔS_conf≤17.5 J.K^(-1).mol^(-1), and atom-size difference (δ)≤6.6%. CrNiCo, CrNiAl, and CrNiMn all fall within the ΔS_conf range at 13 J.K^(-1).mol^(-1), although CrNiAl is outside the H_mix range, with H_mix=-51.485 kJ.mol^(-1). In contrast, CrNiCo and CrNiMn fall within the H_mix range with values of -14.52 kJ.mol^(-1) and -17.16 kJ.mol^(-1), respectively. CrNiCo, CrNiAl, and CrNiMn alloys meet the atomic size misfit criterion with δ values of 0.17%,3.44%, and 3.75 %, respectively. Multicomponent alloys CrNiX (X = Co, Al, Mn), in equal atomic proportions, were then synthesized by arc melting. The chemical composition and elemental segregation were analysed using scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), and electron probe microanalysis. The crystal structure was identified using X-ray diffraction (XRD) analysis. CrNiCo exhibited a face-centered cubic structure (FCC), spacegroup Fm-3m, with a lattice parameter of 3.57±0.54 Å, CrNiAl showed a body-centered cubic (BCC) structure, space group Pm-3m, with a lattice parameter of 4.07±0.36 Å and CrNiMn demonstrated both FCC (spacegroup Fm-3m) and BCC (spacegroup Im-3m) with an average lattice parameter of 3.35 ±0.23 Å. Resistivity measurements were done over a temperature range of 0-300 K. For both CrNiCo and CrNiAl, resistivity increases with temperature, which is typical for metals due to increased phonon scattering. Between 0-50 K, the resistivity levels off, indicating residual resistivity from impurities or defects, which were observed in both electron probe microanalysis and EDS. Furthermore, the resistivity of both CrNiCo and CrNiAl follows a linear trend between 50-213 K and 50 -240 K, respectively. Magnetic transitions were observed at 213 K for CrNiCo and 240 K for CrNiAl.

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PhD

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Yes, I ACCEPT

Photonics / 318

Compensating and keeping up with atmospheric chaos by tailoring beams of light

Authors: Cade Peters[1]; Giacomo Sorelli[2]; Raphael Bellosi[2]; Szymon Gladysz[2]; Andrew Forbes[3]

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The ability to tailor light in all of its degrees of freedom has seen significant improvements in the fields of optical imaging and communications. It has allowed for the straightforward implementation of spatial modes of light which can be used to form higher dimensional encoding alphabets to increase the bandwidths of free space and optical fibre channels. The orthogonality and completeness of the mode sets allow them to perfectly describe any 2D complex (amplitude and phase) image. However, the promise of structured light is hindered by the distortions induced by the various complex media through which it often needs to propagate. This has many deleterious effects such as limiting imaging resolution, reducing the range over which we can communicate and increasing modal crosstalk. Many of the proposed solutions to combat the degradation of structured light involve determination of a transmission matrix (TM) which describes the manner in which the channel distorts incident light fields. However, The TM is time consuming and difficult to measure making these techniques challenging to implement. Here, we propose a method for estimating the TM in parallel with sending or receiving data through the channel. This allows for a more realistic implementation of these methods and allows us to update our transmission matrix as the medium evolves in time. We demonstrate this both numerically and experimentally, using atmospheric turbulence as an example. This work has applications in the fields of both quantum and classical imaging and optical communications.

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PhD

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Yes, I ACCEPT

Physics of Condensed Matter and Materials / 319

The Effect of Chlorine on the Morphology and Crystal Structure of Tin-doped Mixed Halide Perovskites

Author: Siphesihle Magubane[1]

Co-authors: Chrirstopher Mtshali [1]; Christopher Arendse [2]

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In this work, we use Rutherford Backscattering Spectrometry (RBS) to investigate the effect of chlorine (Cl) content on the morphology and the crystal structure of tin-doped mixed halide perovskite films. A chemical vapor deposition (CVD) system was used to grow lead-tin (Pb-Sn) halide films using lead chloride (PbCl2) and tin chloride (SnCl2) precursor materials. These films were subsequently exposed to CH3NH3I (MAI) vapor to form MAPb1-xSnxI3-yCly for $0 < x \leq 0.5$. The quantitative analysis and the depth profile of Sn-doped perovskite films show no evidence of a backscattered peak from chlorine anions (Cl-) which was expected at about 1920 keV. However, its effect is observed in the morphology and crystal structure of the films. The absence of the Cl peak in the RBS spectra of perovskite films is attributed to a complete replacement of Cl- by the iodine anions (I-) during the conversion process. This affirms the high quality of CVD-grown perovskite films over their spin-coated counterparts, which usually depict a Cl peak as a manifestation of an incomplete conversion process.

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None

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Yes, I ACCEPT

Poster Session / 320

The behaviour of vectorial structured light through real-world atmospheric turbulence

Authors: Cade Peters[1]; Mitchell Arij Cox[2]; Alice Drozdov[3]; Andrew Forbes[3]

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Vectorial structured light has demonstrated numerous advantages of scalar light fields in various contexts, including communications, imaging and sensing. Their analogous mathematical structure to entangled biphoton states has allowed for the investigation of new physics in a more accessible manner. Recent work, inspired by the quantum metric commonly called the concurrence, has shown that the non-separability and homogeneity of vectorial structured light can be quantified using this metric. Furthermore, because this measure is defined in terms of inner products, it has been shown to be invariant through any unitary channel. Such findings have substantial implications for free-space optical communication (FSOC), where even the many advantages of structured light have reached their limits due to the deleterious effects of atmospheric turbulence. The concurrence of vectorial structured light, - how "vector"it is - will remain unchanged –including through atmospheric turbulent channels. This is despite distortions to its amplitude, phase and polarization structured which would normally be detrimental to the use of structured modes for communication. Here we report the first demonstration of this phenomenon through real-world atmospheric turbulence. We see that the non-separability remains invariant through a 270 m real-world turbulent channel over a period of 2 hours for encoded concurrence values of 0.25, 0.5, 0.75 and 1. Such a result demonstrates the potential to use this quantity as an encoding scheme in free space optical links. It cares solely about the unitary nature of the channel, thus providing a reliable, distortion-free basis with which to communicate. Consequently, we have also shown strong evidence that atmospheric turbulence is unitary, encouraging the exploitation of this property for exotic, invariant forms of structured light.

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PhD

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Poster Session / 321

Matrix Optimisation with Light-speed Multiplication

Authors: Hadrian Bezuidenhout[1]; Mwezi Koni[1]; Paola Concha Obando[1]; Jonathan Leach[2]; Andrew Forbes[1]; Isaac Nape[1]

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Structured light, which involves the precise manipulation of an optical fields the internal degrees of freedom, has emerged as a key tool in both quantum and classical information processing protocols. Its benefit in the realm of photonic computing lies in its ability for high-dimensional, light-speed information processing. In this work, the high dimensional nature of light is leveraged by modulating its transverse spatial degree of freedom to develop a flexible approach for learning unitary operations. Using optical vector-matrix multiplication together with methods found in variational quantum computing, we transfer the task of solving for a parametrised unitary onto that of solving the minimum ground energy of a specified cost function. The operations themselves are performed using arrays of Gaussian modes, representing the corresponding matrices and vectors being multiplied while the parameter space of the unitary operation is searched through using a guided random walk procedure. For the measurement, we take advantage of the partial Fourier transformation that is applied by a cylindrical lens and capture the resultant output vector using a CCD camera. We cover both the theoretical framework and the experimental implementation to demonstrate that we are able to learn optical unitary matrices up to 16-dimensions, achieving fidelities greater than 90% in all cases. Our work contributes to the advancement of high dimensional information processing and can be applied to both process and quantum state tomography of unknown states and channels.

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MSc

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Poster Session / 323

Protecting quantum information using topological armour

Authors: PEDRO DINIS ORNELAS[1]; Isaac Nape[1]; Robert de Mello Koch[2]; Andrew Forbes[1]

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An open challenge in quantum information processing and communication is enhancing the robustness of quantum information against environmental noise, a major obstacle in real-world applications. In this work, we study the decay of quantum states under generic noise, as measured by the decline of conventional entanglement witnesses, typically used as resources for quantum information encoding. Instead of the conventional approach of encoding information into these witnesses, we propose leveraging the topology of recently discovered quantum Skyrmions. Through a comprehensive theoretical framework and experimental evidence, we demonstrate that the topological observables of the state remain invariant under noise, revealing a robust mechanism for protecting quantum information through this encoding scheme. This method offers a promising pathway for intrinsic quantum information resilience through topology, with strong implications for real-world applications, including global quantum networks and noisy quantum computing.

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PhD

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Photonics / 324

Invariance to Randomness Using the Topology of Light

Authors: Tatjana Kleine[1]; Kelsey Everts[2]; Pedro Ornelas[1]; Cade Peters[1]; Andrew Forbes[1]

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The topology of light and its robustness to noise has garnered significant interest over the last few years as a promising means of information transfer. Light's topology, more specifically the Skyrmion topology, describes the correlation between light's position and polarization. Skyrmions have been shown to be invariant to isotropic noise; whether topology is invariant to random media is investigated. In this work, we investigate classical vector beams and spatially and polarisation entangled photons' reaction to random media. We used digital phase screens to simulate the random media before using real and biological cell samples. We successfully showed that light's Skyrme number was invariant to all three kinds of random media investigated. For classical vector beams topology was conserved for random media varying in scattering strength. Our work demonstrates topologies robustness to random media and shows exciting promise for its use in real-world information transfer.

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Poster Session / 325

Fe-Doped $NaVS_2$: A Study on the Structural, Electronic, and Electrochemical Properties for Enhanced Energy Storage Applications

Author: Lethabo Mogakane[1]

Co-authors: David Tshwane ; Prettier Maleka ; Regina Maphanga ; Steve Dima

[1] *Researcher*

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Abstract
The transition metal dichalcogenide (TMD) $NaVS_2$ has attracted considerable attention as a candidate for energy storage systems, particularly sodium-ion batteries (SIBs), owing to its excellent electrical conductivity, advantageous electronic properties, and catalytic versatility. Nevertheless, its practical application is hindered by limited ionic conductivity and suboptimal cycling stability. In this work, we explore how iron (Fe) doping influences the structural, electronic, and electrochemical characteristics of $NaVS_2$ to enhance its performance as an energy storage material. First-principles calculations based on density functional theory (DFT) were used to analyse the electronic band structure, density of states (DOS), and formation energies. The findings reveal that incorporating Fe significantly alters the electronic behavior, resulting in a reduced band gap and increased DOS at the Fermi level, both beneficial for facilitating rapid charge transport. The negative formation energies further indicate the thermodynamic feasibility of Fe substitution in the $NaVS_2$ lattice. These structural and electronic enhancements are likely to improve ion mobility and electrode longevity under repeated cycling. Furthermore, the study sheds light on how dopant type and concentration can be strategically utilized to optimize TMD materials for energy-related applications. In conclusion, Fe-doped $NaVS_2$ shows strong promise as an advanced electrode material for SIBs, and the findings reinforce the broader potential of transition metal doping in fine-tuning TMD properties for battery technologies.
Keywords: sodium-ion batteries, transition metal dichalcogenides, density functional theory, electronic structure.

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Honours

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Yes, I ACCEPT

Physics of Condensed Matter and Materials / 326

High-resolution X-ray diffraction and Photoluminescence study of GaAsN epilayers

Author: ANDI ISNI PUJIRANA[1]

Co-authors: Andre Venter [1]; Assane Talla [2]; JR Botha [1]; Ngcali Tile [1]; Zelalem Urgessa [2]

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Abstract
Incorporating nitrogen atoms into gallium arsenide (GaAs) significantly reduces the band gap, primarily due to a downward shift in the conduction band edge. This distinctive characteristic of gallium arsenide nitride (GaAsN) and other III-V-N alloys makes them promising candidates for various applications in semiconductor electronics, such as solar cells and telecommunication laser diodes based on GaAs.
In this study, GaAsN/GaAs layers were fabricated using metal-organic vapour phase epitaxy (MOVPE) on semi-insulating GaAs (100) substrates that were off-cut by 2° (±0.05) towards [100]. Before the growth of the GaAsN epilayer, a GaAs buffer layer with a thickness of 0.5 µm was deposited at a temperature of 600℃. GaAs1-xN$_x$ was grown using a novel combination of precursors: triethylgallium (TEGa), tertiary-butyl arsine (TBAs), and tertiary-butylhydrazine (TBHy), as sources for gallium (Ga), arsenic (As, and nitrogen (N), respectively. The structural and optical properties of GaAs1-xNx/GaAs were characterised through high-resolution X-ray diffraction (HRXRD) and photoluminescence (PL), performed over a temperature range of around 5–200 K.
HRXRD showed that the GaAsN and GaAs buffer layer peaks dominate for all samples. A noticeable shift to lower angles was seen for samples with higher nitrogen content, suggesting a significant lattice expansion due to increased nitrogen incorporation. PL of the GaAsN/GaAs epilayers reveals a reduction in peak emission energy as the nitrogen concentration increases. The redshift observed is approximately 18 meV and 240 meV for nitrogen contents of x=0.006 (Fig. 1) and x=0.012 (Fig. 2), respectively. These results show that the significant shift is attributed to the variation of the band gap with nitrogen incorporation and suggest that the band gap bowing parameter is not constant but varies depending on the nitrogen content of GaAs1-xNx. In addition, the PL spectral line (1.438 eV) shape indicates that the photogenerated carriers are trapped in localised states within the GaAsN matrix.

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PhD

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Poster Session / 327

Nonlinear control of structured light

Authors: Sachleen Singh[None]; Andrew Forbes[1]

[1] *University of the Witwatersrand*

Corresponding Author: 2661774@students.wits.ac.za

Structured light, where complex optical fields are engineered across all degrees of freedom, has recently become a highly topical area of research. This rise is fueled by the development of sophisticated toolkits for the creation, control, and detection of light. Traditionally, both the creation and detection of structured light have assumed a fixed wavelength, relying on linear superpositions of light patterns. In this work, we introduce a nonlinear approach to control structured light, enabling the transfer and retrieval of information independent of wavelength, all while preserving the light's spatial structure. This is achieved by integrating digital holography with nonlinear optics, demanding precise spatial overlap of interacting beams within the nonlinear medium. To meet this challenge, we developed a light-by-light alignment technique within the nonlinear crystal, enhancing frequency conversion fidelity to beyond 90%. This enabled the design of custom light patterns tailored to specific signals, improving the frequency conversion efficiency of structured light by more than 40%. While frequency conversion enables pattern creation across a range of wavelengths, high-fidelity detection is essential to extract the encoded information. We address this by introducing a nonlinear version of modal decomposition, allowing us to unravel information in the near-infrared using a basis encoded in the visible wavelength. With full control over both the creation and detection of structured light, we further deployed our system in a prepare-and-measure configuration over a highly aberrated optical channel. Remarkably, the phase conjugation inherent to the nonlinear process allowed us to naturally correct for distortions at the speed of light, without the need for active measurements. We believe that our nonlinear framework for structured light unlocks powerful new capabilities, paving the way for future breakthroughs in optical communication, imaging, and spectroscopy.

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PhD

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Astrophysics & Space Science / 328

Probing Gas Sloshing in the Core of Galaxy Cluster ZwCl 3146: Insights from Chandra and GMRT Observations

Author: Satish Sonkamble[None]

Co-author: Ilani Loubser [1]

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We present an analysis of the X-ray bright galaxy cluster ZwCl 3146 (redshift z = 0.291) using archival 90 ks Chandra observations, along with our 1.4 GHz GMRT observations. Beta model subtracted residual and unsharp X-ray images reveal spiral-like features within the central 230 kpc, indicative of gas sloshing in the intracluster medium (ICM). We also detect an offset of about 11 kpc between the brightest cluster galaxy (BCG) and the X-ray peak, as well as signs of interaction between the BCG and a substructure in the cluster core. These features suggest that the observed sloshing was triggered by a minor merger event. Furthermore, we identify three sharp surface brightness edges to the North-East, South-East, and South-West of the X-ray peak, located at projected distances of 232 kpc, 172 kpc and 119 kpc, respectively. X-ray spectral analysis across these edges reveals temperature jumps, accompanied by electron density discontinuities with an average density compression factor C = 1.46. The pressure profiles remain continuous across these edges, consistent with their interpretation as cold fronts generated by gas sloshing. The GMRT 1.4 GHz image reveals the presence of a central radio source, along with diffuse radio emission co-spatial with the central spiral structure. The radio emission partially fills some of the previously reported X-ray cavities.

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Physics of Condensed Matter and Materials / 329

Effect of Cr doping on the electronic, thermal and magnetic properties of $SrCo_2As_2$

Author: Sampad Mondal[1]

Co-authors: Abhishek Pandey [2]; Daniel Wamwangi [2]; Mahlogonolo Morena [2]

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The layered $ThCr_2Si_2$-type tetragonal compound, $SrCo_2As_2$ shows antiferromagnetic fluctuations, which are believed to be a precursor for superconductivity in the iron-arsenide family. However, the co-existence of ferromagnetic (FM) fluctuations likely precludes a superconducting ground state in this compound. Hence, it is important to investigate whether chemical doping suppresses FM fluctuations in order to reach a superconducting phase. We report here the effect of hole doping on structural, magnetic, and transport properties of high-quality single crystals of $SrCo_2As_2$ via partial substitution of Co by Cr. All the doped compositions crystallize remain in $ThCr_2Si_2$-type structure. The basal plane electrical resistivity ρab shows metallic behavior for all the doped compositions. The heat capacity $C_{\rm p}(T)$ and magnetic susceptibility $\chi(T)$ of the doped compositions infer the absence of long-range magnetic ordering down to 1.8 K . Sommerfeld coefficient obtained from low-temperature $C_{\rm p}(T)$ data decreases with an increase in Cr concentration, indicating the reduction of the density of states at the Fermi level $E_{\rm F}$. The $\chi_{ab}(T)$ ($H \parallel ab$-plane) and $\chi_c(T)$ ($H \parallel c$-axis) are anisotropic and the isothermal magnetization M is proportional to H for both orientations of the applied field. We provide a detailed overview of the dependence of physical properties and electronic states with changes in carrier concentration.

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None

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Physics for Development, Education and Outreach / 330

Assessing First Year Students'Epistemological Beliefs about Learning Physical Science

Author: Paul Molefe[1]

Co-authors: Buyi Sondezi [1]; Mphiriseni Khwanda [2]

[1] *University of Johannesburg*

[2] *University of johannesburg*

Corresponding Author: pmolefe@uj.ac.za

Epistemological beliefs individuals hold about the nature of knowledge and learning play a crucial role in understanding and engaging in the physical sciences. These beliefs influence how students, educators, and researchers perceive scientific concepts, theories, and methodologies. In the context of physical sciences, epistemological beliefs encompass views on the certainty and structure of scientific knowledge, the role of empirical evidence, the nature of scientific inquiry, and the evolution of theories over time. While some individuals may see scientific knowledge as absolute and unchanging, others recognize its dynamic and tentative nature, shaped by ongoing experimentation and revision. Research suggests that sophisticated epistemological beliefs, which acknowledge the complexity and evolving nature of scientific understanding, enhance critical thinking, problem-solving, and engagement in scientific discourse. The study shows a slight improvement in the sophistication of epistemological beliefs after intervention using inquiry-based approaches.

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None

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Poster Session / 331

Integration of grid-scale battery energy storage in solar micro-grids for rural communities in Limpopo province

Author: Pfesesani Netshilonwe[1]

Co-authors: Fhulufhelo Nemangwele [1]; Mukovhe Ratshitanga [2]

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Abstract

The ongoing issue of community blackouts due to load reduction and shedding needs urgent solutions. These power interruptions disrupt daily life and affect supply and demand dynamics. The root of the problem is the high cost of electricity and annual tariff increases. As a result, some customers resort to illegal connections, theft, and meter tampering to reduce their expenses, further contributing to load reduction. This paper investigates the integration of grid-scale battery energy storage with solar photovoltaic plants to support rural communities in Limpopo. The Herman-beta method was used to estimate the electrical loads using 2022 census data from Statistics South Africa. Homer software was used to Analyse the technical and economic metrics of the communities of Ka-Dzingidzingi, Duthuni, and Mookgopong NU in terms of integrating them with solar-powered grid-scale battery energy storage systems. Solar panel capacities of 250W, 375W, and 500W were compared for their economic metrics, with a 48V, 14.4kWh lithium-ion battery selected for the grid-scale component. The results show that the 250W solar module has the lowest capital expenditure and the best Net Present Cost and Levelized Cost of Energy in Duthuni and Mookgopong NU, with Net Present Cost values of 79.7 million and 199 million and Levelized Cost of Energy of around 0.250 R/kWh and 0.5 R/kWh, respectively. In Ka-Dzingidzingi, however, the 375W module offers the most favourable Net Present Cost and Levelized Cost of Energy. The return on investment indicates that the system may not be beneficial for larger communities with more than 1,000 households. However, in suitable communities, electrical power delivery in the province can significantly improve.

Keywords: microgrids, battery energy storage, net present cost, levelized cost of energy, Herman beta method, Homer pro

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MSc

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Yes, I ACCEPT

Physics for Development, Education and Outreach / 332

Pre-service students'misconceptions about simple electric circuits.

Authors: Buyi Sondezi[1]; Mphiriseni Khwanda[2]; Paul Molefe[None]

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Despite all the efforts made by Physics Education Researchers in terms of strategies to enhance students'conceptual understanding of electric circuit phenomena, students still have conceptual difficulties related to solving problems related to electric circuits. The difficulty is worsened by the presence of misconceptions about electric circuit phenomena. In terms of constructivism, the preparation for teaching should start with identifying what students know prior to instruction. In line with this pedagogy, the research reports on the identified misconceptions as studied from the pre-service students. A report on how these challenges were addressed during the intervention will also be highlighted

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None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Photonics / 333

Nonlinear modal decomposition of structured light

Authors: Sachleen Singh[None]; Adriana Rosalia Sánchez-Montes[1]; Angela Dudley[2]; Andrew Forbes[2]

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Structured light, tailored in its degrees of freedom for specific applications, has recently emerged as a highly topical field driven by advancements in both linear and nonlinear optical techniques. This has led to significant progress in nonlinear structured light, with applications spanning holography, spectroscopy, imaging, and even quantum teleportation. These breakthroughs rely on the ability to create structured light at one wavelength while achieving high-fidelity detection at another. While wavelength conversion techniques for generating structured light are well established, detection tools remain in their infancy. Here, we introduce a modal decomposition technique for structured light using nonlinear crystals, enabling full-field reconstruction at one wavelength by using a basis encoded at a different wavelength. In addition, we propose a faster, single-shot reconstruction approach through a nonlinear extension of off-axis holography. We demonstrate both techniques using representative examples of structured light, including orbital angular momentum (OAM) and Hermite-Gaussian (HG) beams. Our nonlinear approach to modal analysis offers the flexibility to choose efficient detectors, effectively removing wavelength constraints in structured light applications. This technique opens up new possibilities for nonlinear structured light, paving the way for future advancements in communication, imaging, and spectroscopy.

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PhD

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Yes, I ACCEPT

Poster Session / 334

Deconstructing a high dimensional mug into 2 dimensional donuts

Authors: Andrew Forbes[1]; Bo-Qiang Lu[2]; Isaac Nape[1]; Neelan Gounden[1]; PEDRO DINIS ORNELAS[1]; Robert de Mello Koch[2]

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From hybrid (spin and orbital angular momentum) entangled states, topological structures emerge when one investigates the mapping of the spatial profile (orbital angular momentum) possessed by one photon to the spin angular momentum on the Poincarè sphere of the other photon. The extraction of topological invariants (in the field of photonics) has been primarily limited to 2-dimensional states, however the extraction of topological invariants for high-dimensional states has seldomly been explored. In this work we will follow a method which can be utilized to extract topological invariants from high-dimensional bi-photon states with the help of the OAM degree of freedom. Experimentally, this technique leverages the capability of a topological structure in a high-dimensional vector space to be decomposed into multiple submanifolds, over which a topological invariant can be extracted for each. This decomposition technique allows for the retrieval of topological invariants present in a high- dimensional vector space.

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PhD

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Poster Session / 335

The hidden interference pattern

Authors: Cathy Maako[1]; Andrew Forbes[1]

[1] *University of the Witwatersrand*

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Young's double slit experiment is often referenced when studying the concept of interference of light. To see an interference pattern in the intensity distribution, the two interfering beams must be coherent, that is they must have the same polarization. Polarisation describes the time variation of the electric field in the plane orthogonal to the plane of propagation of the beam. Polarisation maps are often used to characterize the polarisation state of a field. When beams that have different polarisations are interfered, the resulting field has a polarisation map that varies spatially across the field. In this work we investigate the concept of interference more closely and show that interference can be observed in other degrees of freedom of light. We illustrate that when beams with orthogonal polarisations are interfered, a fringe pattern can be observed in the polarisation map of the resulting field. We provide a simple and easily replicable experiment to be conducted in undergraduate laboratories to assist the study of light and its different degrees of freedom.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-2 / 336

Early Failures Detection with Machine Learning for ATLAS TileCal LVPS: The Impact of Burn-in Assessed with Test Bench Datasets

Author: Chuene Mosomane[1]

Co-author: Vongani Chabalala [2]

[1] *iThemba Labs*

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The Large Hadron Collider (LHC) is undergoing a high-luminosity upgrade to increase its luminosity, affecting the ATLAS detector and, consequently, its hadronic Tile-Calorimeter (TileCal). As part of the ATLAS Phase-II Upgrade to adapt to the new high-luminosity environment, the TileCal is upgrading its low-voltage power supplies (LVPS) that power its on-detector front-end (FE) electronics. Over 1000 boards (Transformer-coupled buck converters) housed within the LVPS will be manufactured in South Africa. Quality control is crucial due to the limited access to the boards once installed in the inner-barrel of the TileCal. A board failure would result in offline FE electronics, degrading detector performance. This study aims to improve the current quality control procedure by integrating machine learning techniques as anomaly detection models. The analysis is based on production data collected from 1032 LVPS boards, functional parameters are measured using two test bench stations to ensure that the boards operate within the specified design limits. By comparing the measurements obtained from the two test bench stations, both with and without the inclusion of a burn-in step, valuable insights can be gained into the impact of burn-in on the quality control process. This comparative analysis aims to identify the critical functional parameters that contribute to high accuracy in detecting anomalies and identify potential defects in the LVPS boards and ultimately minimizing the risk of deploying faulty boards in the TileCal at CERN.

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Poster Session / 338

Structural and Morphological properties of a Novel Double Perovskite Sm2MgRuO6

Author: Irénée Brice Mouadje Mouadje[1]

Co-authors: Buyisiwe Sondezi [1]; Redrisse Djoumessi Fobasso [1]

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Corresponding Author: 224221523@student.uj.ac.za

Double perovskite oxides (A2B′B′′O6) with A-site being Rare Earth, B′ and B′′ the magnetic ions at the six-coordinate B-sites have been studied in the search for materials with enhanced magnetoresistive properties and for spintronics applications. The Sm2MgRuO6 polycrystalline compound was synthesized by conventional high-temperature solid-state reaction under controlled temperature and time conditions. Stoichiometric proportions of high purity (99.99 %) samarium (III) oxide (Sm2O3),ruthenium (IV) oxide, (RuO2) and magnesium oxide (MgO) were mixed thoroughly and heated at 800 ℃ for 12h. The pre-heated powders were sintered again at 1250℃ for 36h with intermediate grinding before any characterization processes could be employed. The Rietveld crystal structure refinement of powder X-Ray diffraction patterns with a full-profile refinement indicated that Sm2MgRuO6 crystallizes in the monoclinic space group P21/n allows for a combination of rock-salt-like ordering of the two B-sites. SEM micrograph shows spherical particles of Sm2MgRuO6, which appear to be agglomerated in some areas. EDS mapping was used to study the uniformity of the element distribution, and it is seen that all the elements are distributed homogeneously. Physical properties measurements, that is, heat capacity (Cp(T) and magnetic properties M(B,T), will also be reported in this presentation.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics for Development, Education and Outreach / 339

An optical approach to quantum education

Authors: Cathy Maako[1]; Andrew Forbes[1]

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Quantum mechanics is an inherently challenging subject to learn and is sometimes counterintuitive. For example, concepts like entanglement, and the wave-particle duality theory oppose classical physics. However, conceptual parallels between quantum systems and classical systems can be exploited to bring intuition and advance the learning process. Classical light fields are one such states that can exhibit properties that are analogous to some properties of quantum states, for example, they also satisfy the wave-particle duality theory. Vector fields are a form of classical light whose spatial mode is coupled to its polarisation state and are said to be non-separable. Mathematically, they are similar to quantum entangled states, that is when two spatially separated particles are correlated, thus, performing a measurement on one particle will affect the outcome of a measurement on the other particle. In this work, the use of quantum tools, like quantum state tomography and Bell-type measurements, is demonstrated on simple classical experiments to draw an intuition of quantum entangled states. We present a low-cost, easily replicable experiment, based on spatial light modulator technology, for laboratories to assist in the study of quantum mechanics.

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MSc

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Photonics / 340

Revealing the quantum nature of a continuous laser carrying orbital angular momentum

Author: Moslem Mahdavifar[1]

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Revealing the quantum nature of a source that generally is considered classic radiation is significant. In quantum optics and generally in optics we have the scalability problem as the experiment extends. Hence, finding sources that can overcome this challenge is essential. Radiation from a continuous wave (CW) source is described by the dynamics of quasi-classical (coherent) states. Such a source, though abundant with photon rate but fail to represent a single-photon source. Theoretically, the quantum aspect of such states can be observed in the weak limit hinting to the high single-photon rate. Yet, since these states are superposition of different particle-states of radiation, we need post-selection to achieve this result and within the weak limit. However, this high rate has never been observed. In this work, we experimentally demonstrate that the weak limit of quasi-classical states supplemented by orbital angular momentum (OAM) can deliver a high photon rate producing a quantum signature. Through our experiment, we realize two-photon bunching with the projection of OAM from a continuous wave source. We observe that this approach can produce the result from a single photon source with high accuracy after the post selection. In addition, this can be considered as confirmation that OAM is an intrinsic property of light at the quantum level. In fact, since there is no interaction with matter, the post-selected photon rate from this approach can be considered as an upper bound for the single-photon generation based on the input power. This work is a step forward toward a more diverse and practical use of quasi-classical states in the domain of quantum optics and quantum information.

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None

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Yes, I ACCEPT

Physics for Development, Education and Outreach / 341

Quantum computing education availability in South Africa

Author: Coral Featherstone[1]

Co-authors: Laing Lourens [1]; Nyameko Lisa [1]

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Several formal initiatives, universities, and research institutions are working on quantum computing education in South Africa. This study explores the availability of quantum computing courses and educational resources for quantum computing students in South Africa, assessing their target levels, educational prerequisites, structure, and content.
The investigation identifies offerings from universities, online platforms, and research institutions, categorising them by complexity: introductory, intermediate, or advanced.
Prerequisite knowledge in linear algebra, programming, and quantum mechanics is analysed to determine accessibility. Course structures (e.g., lectures, workshops, hands-on projects) and core topics (e.g., qubits, quantum algorithms, error correction) are examined to evaluate pedagogical approaches.
The findings aim to guide prospective learners
and highlight the gaps in South Africa's quantum education landscape.

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None

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Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-2 / 342

A search for tWZ production in the ATLAS experiment Run 2 dataset

Author: Thobani Sangweni[1]

Co-authors: James Keaveney [1]; Kevin Barends [1]

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Corresponding Author: nkosinathi.sangweni@cern.ch

The tWZ production is a rare and unobserved Standard Model process which refers to the production of a single top quark with an associated W boson and Z boson. The tWZ process is sensitive to top-electroweak couplings and thus it will be an important input into global Standard Model Effective Field Theory (SMEFT) fits. Additionally, this process can be used as a background in other top process such as ttZ cross section measurements. A search for tWZ production was performed using 140fb^{-1} proton-proton collision data at center of mass energy of $\sqrt{s} = 13\text{TeV}$ measured with the ATLAS detector at CERN. This search will focus on 4 lepton final states (electrons and muons). The analysis has been re-implemented on Release 25 and on latest ATLAS recommended analysis frameworks, TopCPToolKit and FastFrames. The signal regions (SRs) and control regions (CRs) were defined based on multiplicities of physics objects such as the number of jets, number of b-tagged jets, number of Z boson candidates, etc. A deep neural network is used to discriminate signal and background. The signal parton shower systematic uncertainty will be evaluated for the first time. The expected signal strength of tWZ production μ_{tWZ}, will be extracted using a blinded maximum-likehood fit to multiple SRs and CRs with full systematic uncertainties.

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MSc

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Nuclear, Particle and Radiation Physics-1 / 343

Effect of SrO on radiation attenuation properties of boro-tellurate glass systems at a high energy region.

Author: Sifiso Mthalane[1]

[1] *University of Zululand*

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In this study the effect of radiation ionization of the 40SrO–30B2O_3–10TeO_2–20Bi_2O3, 35SrO–30B_2O_3–10TeO_2–25Bi2O_3, 30SrO–30B_2O_3–10TeO_2–30Bi_2O_3, 25SrO–30B_2O_3–10TeO_2 35Bi_2O_3, 20SrO–30B_2O_3–10$TeOS_2$–40Bi_2O_3 glass was investigated using the Phy-X/PSD, XCOM simulation Software and ratified using the geant4 simulation. Between the high energy region between 1 MeV and 15 MeV, the mass attenuation coefficients (MAC), linear attenuation coefficient (LAC), and Effective atomic number of all the glasses under investigation were calculated. The results show that increasing the concentration of Bi_2O_3 in these glasses improves its radiation shielding ability. The half value layer (HVL), tenth value layer (TVL) and mean free path (MFP) of the glass were investigated and the results show that glasses with a high concentration of Bi_2O_3 attenuated high amount of photons at a smaller thickness. It was also observed 20SrO 30B_2O_3–10$TeOS_2$–40Bi_2O_3 glass has better radiation shielding compared to other radiation shielding materials that have been investigated.

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Nuclear, Particle and Radiation Physics-2 / 344

Real-Time Anomaly Detection in High Energy Physics

Author: Ryan Atkin[1]

Co-authors: Claire David [2]; James Keaveney [1]

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[2] *AIMS*

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While searches for physics beyond the Standard Model (BSM) have yet to yield conclusive discoveries, they continue to motivate the development of more flexible, data-driven strategies. At the ATLAS experiment at the Large Hadron Collider (LHC), trigger systems are used to rapidly select potentially interesting proton–proton collisions for further analysis. Traditional triggers rely on pre-defined criteria, such as high-momentum particles, which may miss more subtle or unconventional signs of new physics. To overcome this limitation, machine learning algorithms are being developed to identify anomalous events in real time based on their overall detector signature, rather than specific features. Using unsupervised learning techniques, these algorithms learn to characterise typical collision patterns directly from the data, without input from Standard Model or BSM theory. Events that diverge significantly from these patterns are flagged as anomalous for further study. Such events are stored for detailed offline analysis. This approach enables a broad and largely model-independent search for unexpected phenomena in the vast datasets of Run-3 and beyond, potentially revealing signals that targeted BSM searches might overlook.

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Theoretical and Computational Physics / 345

Comparative Study of Neutron and Proton Halo Breakup Cross Sections

Author: Lucas Vusi Ndala[1]

Co-author: Mantile Leslie Lekala [1]

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We use the Continuum Discretized Coupled Channels (CDCC) method to study in detail the similarities and differences between neutron and proton halo breakup cross sections including total, nuclear, and
Coulomb contributions in the breakup reactions of 8B⟶7Be+p and 8Be⟶7Be+n on various target nuclei (28Si, 120Sn and 236U). Our preliminary results reveal that the neutron halo breakup cross sections are generally larger than those of the proton halo. Additionally, we find that continuum-continuum couplings are stronger in the neutron halo breakup than in the proton halo breakup.

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None

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Yes, I ACCEPT

Poster Session / 346

3D printed optics achieves broadband structured light

Authors: Andrew Forbes[1]; Jan Korvink[2]; Leerin Perumal[None]; Moslem Mahdavifar[1]; Stefan Hengsbach[2]

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[2] *Karlsruhe Institute of Technology*

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Structured light has gained in popularity of late, fueled by a toolbox for arbitrary control of light's many degrees of freedom. Although this toolbox is very sophisticated and diverse, it is still primarily centered on single wavelength digitally controlled structured light, only recently expanding into broadband structured light modes. Here, tools are combined from Fourier optics with recent advances in grayscale 3D nano-printing of optical materials to design and fabricate micro-optical elements for the creation of broadband structured light beams by phase-only and full complex amplitude modulation. Importantly, this approach allows to fabricate a single device at a design wavelength and later use it for non-design wavelength operation, as well as multiple wavelengths simultaneously, which is demonstrate across ≈200 nm bandwidth. A myriad of optics is created to produce orbital angular momentum, Hermite–Gaussian, and Laguerre–Gaussian beams, with measured purities in the 94% – 100% range, for non-design wavelengths. This work provides a compact, simple and cost-efficient tool for control of the spatial-spectrum of structured light.

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None

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Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-2 / 347

Search for a new spin-0 scalar and a spin-1 boson using Run2 ATLAS detector data

Author: Xola Mapekula[1]

[1] *University of Johannesburg*

Corresponding Author: xola.mapekula@cern.ch

We present a search for a spin-1 boson together with a spin-0 scalar wherer the additional scalar decays into a four lepton final state ($\ell = \mu$~or e) via two intermediate dark vector bosons in the folllowing decay channel $S \rightarrow Z_d Z_d \rightarrow 4\ell$. In this scenario, the targeted additional scalar (S) mass ranges is between 20 GeV and 1 TeV where we exclude the Higgs boson mass window of $115\ GeV < m_S < 130\ GeV$ while the dark vector boson has a mass between 15 and 300 GeV. The search is conducted using $p-p$ collison data collected using the ATLAS detector at the LHC which corresponds to a center of mass energy of $\sqrt{S} = 13TeV$ and an integrated luminosity of 139 fb^{-1}. There were no significant excesses observed. Therefore, a 95\% upper limit was set on the cross-section $\times$ branching ratio as a function of the mass of both particles m_S and m_{Z_d}.

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PhD

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Physics of Condensed Matter and Materials / 348

Optical spectroscopic investigations of antiferromagnetic semiconducting BaMn2P2

Authors: Susan Jacobs[1]; Rudolph Erasmus[2]; Abhishek Pandey[3]

[1] *University of Johannesburg*

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Materials with ThCr₂Si₂-type crystal structure (Space Group: I4/<i>mmm</i>) have sparked scientific interest for several decades now owing to their novel properties and exotic ground states. The ThCr₂Si₂-type compounds have physical properties that are highly tunable, making this family of compounds ideal for investigating the structure-property relationship. Unconventional high <i>T</i>_c superconductivity was observed in iron-based arsenides, Ba_{1−<i>x</i>}K_{<i>x</i>}Fe₂As₂ 1 and BaFe_{2−<i>x</i>}Co_{<i>x</i>}As₂ 2. The quest for higher <i>T</i>_c superconductivity led research into other Ba<i>T</i>₂<i>Pn</i>₂ compounds, where <i>T</i> = transition metal and <i>Pn</i> = P, As, Sb, Bi, revealing a variety of physical properties. BaMn₂P₂ is one such compound that was recently investigated by us [3]. Electrical resistivity and heat capacity measurements on single crystals of BaMn₂P₂ revealed an insulating ground state with a small band gap [3]. Anisotropic magnetic susceptibility measurements confirmed that BaMn₂P₂, like its As-, Sb- and Bi- counterparts, has collinear Néel type antiferromagnetism below <i>T</i>_N = 795(15) K, which is the highest value for the family of 122-pnictide compounds thus far. Moreover, the magnetic susceptibility increases above <i>T</i>_N, like in the As-, Sb-, and Bi-based compounds, suggesting that antiferromagnetic correlations persist above the magnetic ordering temperature. In this contribution, we probe the properties of this interesting compound using Raman spectroscopy, investigating its structure around <i>T</i>_N. We also attempt to probe the effect of tweaking the ground states by changing charge-carrier concentrations.

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3. B. S. Jacobs and Abhishek Pandey, Phys. Rev. Mater.7 044410 (2023).

Apply for student award at which level::

None

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Photonics / 349

Using a synthesised wavelength to non-locally probe the depth of objects

Authors: Akhil Kallepalli[1]; Andrew Forbes[2]; Bienvenu Ndagano[3]; Chané Moodley[2]; Chong Kuong Ng[4]; Fazilah Nothlawala[2]; Isaac Nape[2]; Jiachen Wu[5]; Liangcai Cao[6]; Neelan Gounden[2]; Yungui Ma[4]

[1] *University of Strathclyde*

[2] *University of the Witwatersrand*

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[6] *Tsinghua university*

Corresponding Author: 2097061@students.wits.ac.za

Quantum ghost imaging (QGI) makes use of a pair of quantum entangled photons whereby one interacts with an object while spatial projective measurements are performed on the other. Using the correlated detections of the entangled photons, the transverse spatial profile of the object can be retrieved. QGI has recently been used to retrieve phase information of a field, however the depth profile of objects with heights which are orders of magnitude larger than the wavelength of the photons could not be achieved. In this presentation we will be learning how to probe an object with two diCerent wavelengths to obtain its depth profile using QGI, the depth profile of the object is not resolvable with either of the wavelengths individually.

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PhD

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Physics of Condensed Matter and Materials / 350

Investigating the properties of Li9Al3(PO4)2(P2O7)3 solid electrolyte material for lithium-ion batteries: A computational study

Authors: Donald Hlungwani[1]; Kemeridge Tumelo Malatji[1]; Mamabolo Mashaole Stuart[None]; Phuti Erasmus Ngoepe[1]; Raesibe Sylvia Ledwaba[1]

[1] *University of Limpopo*

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The development of electric vehicles and smart devices has been the primary driver of the rapid growth of the global market for lithium-ion batteries (LIBs). However, they suffer from challenges of safety, narrow electrochemical windows, and long-life cycles, which are ascribed to the usage of liquid electrolytes. The Li9Al3(PO4)2(P2O7)3 material is among the potential replacements for hazardous liquid electrolytes due to their high ionic conductivity (of the order of ~10-3 S/cm) and acceptable chemical stability for next-generation LIBs. However, the electronic structure, electronic, and vibrational properties of this material are not yet fully understood. Hence, in this work, we investigate the electronic structure Li9Al3(PO4)2(P2O7)3 to understand the performance in LIBs, through band structure and density of states calculations (DOS) and vibrational through phonons with the Vienna Ab initio Simulation Package (VASP) code. The calculations were performed using the generalized gradient approximation (GGA) with the Projector-Augmented Wave (PAW) pseudopotentials and Perdew-Burke-Ernzernhof (PBE) exchange-correlation function. The DOS and band structure results of the Li9Al3(PO4)2(P2O7)3 structure are both showing the wide bandgap, and they show that this material is an insulator with an indirect band gap of 5.403 eV. The wide band gaps of the insulator will ensure chemical stability during battery operation. As such, the cyclic performance of LIBs utilizing these solid electrolytes will be enhanced

Apply for student award at which level::

PhD

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Nuclear, Particle and Radiation Physics-2 / 351

Measuring the anomalous ttZ and ttγ couplings at Future e−p colliders.

Author: Katlego Innocent[1]

Co-author: Mukesh Kumar [1]

[1] *University of the Witwatersrand*

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We investigate the anomalous <i>ttx305;X</i> couplings for neutral charged gauge boson <i>X=Z/gamma;</i> in the Standard Model (SM) and measure their precision beyond the SM in future electron-proton collider environments. The <i> ttx305; </i> quark pairs are produced in the neutral currents channel through the process <i> e⁻ p rarr; e⁻ t tx305; </i>, for electron and proton beams of energy E_e = 60 GeV and E_p = 7 TeV respectively, at the center of mass energy of 1.3 TeV as proposed for the LHeC. The <i> ttx305;gamma;</i> interaction is further probed through the photo-production process <i> gamma;prarr;t tx305;</i> with gamma; scattered from the electron. We focus on the semileptonic channel where <i> t rarr; bW⁺, W⁺rarr;l⁺nu;_l </i> and <i> tx305;rarr;bx305;W⁻, W⁻rarr;l⁻nu;_l </i> and investigate sensitive kinematic observables to these couplings. We observe that the azimuthal angular difference, Delta;Phi;, between the scattered electron and the <i>l⁺</i> is the most sensitive observable to <i>ttx305;Z</i> couplings. We further investigate sensitive kinematic observables to <i>ttx305;gamma;</i> couplings in the photo-production process. We perform a chi;² analysis at the inclusive and differential levels in the cross section to constrain the couplings.

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None

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Physics of Condensed Matter and Materials / 352

From Composition to Crystal: Predicting Sodium-Ion Battery Material Symmetries Using Physics-Guided Machine Learning

Author: Keletso Monareng[1]

Co-authors: Petros Ntoahae [1]; Regina Maphanga [2]

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Keletso Monareng1, Petros Ntoahae1, and Rapela Maphanga2,3

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3 National Institute for Theoretical and Computational Sciences, NITheCS, Gauteng, 2000, South Africa

Abstract
Sodium-ion batteries (SIBs) have emerged as a promising alternative to lithium-ion systems due to the abundance of Na in Earth's crust and cost-effectiveness. A critical challenge in advancing SIB technology lies in predicting suitable cathode materials and their crystal structures from chemical compositional space. Predicting the crystallographic symmetry of materials from chemical composition remains a central challenge in condensed matter physics and materials science. Traditional methods require detailed structural data, making the discovery process cumbersome. To address this, machine learning (ML) offers a data-driven pathway for rapid and accurate predictions using only elemental information. This study presents a robust, physics-guided ML framework for classifying crystallographic symmetry groups specifically space groups, crystal systems, point groups, and Bravais lattices from chemical formulas of binary and ternary compounds relevant to sodium-ion battery applications. A minimal, physically meaningful feature set was used, including stoichiometry, ionic radii, ionization energies, and oxidation states. The classification task was treated as a multi-label, multi-class problem, and model training addressed data imbalance using weighted metrics. The trained classifiers achieved weighted balanced accuracies exceeding 90% across all symmetry group types. Despite the reduced feature dimensionality, the models consistently captured underlying physical trends, demonstrating high reliability. Comparative analyses revealed that performance scales with dataset size, with ternary compounds yielding higher prediction accuracy than binary ones due to richer data availability. This work underscores the potential of employing physics-informed ML models to accelerate crystal structure prediction directly from chemical formulas, serving as a foundational step toward full geometry prediction and faster discovery of novel materials.

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PhD

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Yes, I ACCEPT

Theoretical and Computational Physics / 353

HBA-XGBoost: Honey Badger Algorithm with XGBoost Model for Residual Demand Forecasting

Author: Pfano Nemakonde[None]

Co-authors: Fhulufhelo Nemangwele [1]; Mukovhe Ratshitanga [2]

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[2] *Cape Peninsula University of Technology*

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Abstract

Accurate forecasting of residual electricity demand is crucial for enhancing energy planning, grid reliability, and the integration of renewable energy sources. Traditional statistical models often struggle with the complex, nonlinear patterns inherent in electricity demand, giving rise to the need for more robust machine-learning approaches. This paper proposes a novel forecasting framework, HBA-XGBoost, which integrates the Honey Badger Algorithm (HBA) with the Extreme Gradient Boosting (XGBoost) model to optimise forecasting performance. A comprehensive feature engineering pipeline, including temporal decomposition and Fourier analysis, captures the data's daily, weekly, and seasonal variations. The hyperparameters of the XGBoost model are finely tuned using the Honey Badger Algorithm, a swarm intelligence optimisation technique inspired by the foraging behaviour of honey badgers. Experimental evaluation is conducted on historical South African energy demand datasets, divided into training, testing, and out-of-sample validation sets. The results demonstrate that the proposed HBA-XGBoost framework achieves superior predictive accuracy, yielding lower Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE) compared to conventional methods. These findings highlight the potential of synergising metaheuristic optimisation with machine learning models for reliable residual demand forecasting in emerging smart grid infrastructures.

Keywords: residual demand forecasting, XGBoost, honey badger algorithm, machine learning, metaheuristic optimisation, renewable energy integration, smart grids.

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MSc

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Applied Physics / 354

Measurement of fundamental ion-atom interaction parameters for heavy ion beam materials analysis

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The interaction of high-speed ions with target atoms in solid matter continues to be of both fundamental and practical interest. In materials research and development, one of the key ion-atom interactions of interest is the energy loss of the incident ion to target nuclei and the electron cloud. Accurate theoretical description of ion energy loss processes in matter is key to the development of ion beam analytical and materials synthesis/modification techniques. Rutherford Backscattering Spectrometry (RBS), Elastic Recoil Detection Analysis (ERDA and Particle Induced X-ray Emission (PIXE) spectroscopy are now well-stablished ion beam analysis (IBA) techniques in materials research. For IBA using light ions (Z = 1, 2) existing theoretical models for the energy loss per unit depth (i.e. stopping force) for RBS, ERDA, and X-ray production cross section for PIXE fare quite well in the range of beam energies used in analysis. Recent developments in IBA are geared towards using heavy ions (Z>6) for analyses. This, however, has come with analytical challenges in that the predictive accuracy of existing theories and models for both stopping force and X-ray production cross sections is largely inadequate for heavy ion IBA work. There is a therefore a continual need for experimental data to aid further development and validation of theory. This presentation describes the contribution made by our group to the global databases of stopping force and X-ray production cross section data for applications in heavy ion beam analytical techniques

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Poster Session / 355

First-principles study of Hf- and Cu-doped Ti-Ni-Mo shape memory alloys: structural stability and mechanical properties for biomedical applications.

Author: Velile Mnisi[1]

Co-authors: Enoch Sithole ; Rosinah Modiba

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Titanium-based shape memory alloys (SMAs) are valuable for biomedical applications due to their mechanical stability and biocompatibility. However, their clinical performance is limited by ion release, stress shielding effects due to bone-implant stiffness mismatch, toxicity risks, and the need for optimized phase stability. This study aims to improve the Ti-Ni-Mo alloy's performance by investigating how replacing some Ni atoms with small amounts of Hf and Cu affects its properties. DFT first-principle calculations were performed to examine the impact of introducing Hf and Cu into Ti-Ni-Mo on its thermodynamic, mechanical, and electronic properties, aiming to optimize mechanical strength alongside biological compatibility for prolonged implant functionality. These properties include heats of formation, elastic constants via Born criteria, elastic moduli from the Voigt-Reuss-Hill method, and density of states (DOS) analysis. The density of states plots analysis indicated that Hf doping improves Ti-3d orbital hybridization improving phase stability. While Cu doping redistributes electron density around Ni atoms, enhancing ductility. These findings enable systematic development of Ti-based shape memory alloys, where controlled doping achieves the crucial objectives of thermodynamic, mechanical, electronic properties and biocompatibility for medical implants.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics of Condensed Matter and Materials / 356

Mechanical investigation of (Ti2NbPt)2 HTSMAs from binary phase diagram

Author: Mordecai Mashamaite[1]

Co-authors: Hasani Richard Chauke [1]; Phuti Esrom Ngoepe [2]

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[2] *University of LImpopo*

Corresponding Author: mordecai.mashamaite@ul.ac.za

High temperature shape memory alloys (HTSMAs) are smart materials with unique ther-momechanical characteristics that can regain their original shape after deformation. HTSMAs have been used in a wide range of industrial applications, thus include actuators in automobiles, aviation parts in aerospace and biomedical equipment. Ti-based alloys such as NiTiPd, NiTiPd and NiTiFe have lower martensitic transformations (MT) around 700 K, which limits their performance for higher temperature usage. TiPt has a higher MT of about 1300 K, which has the potential to be used for higher temperature applications. Furthermore, TiPt exhibits negative C′ = -32 GPa. The addition of a third element such as Nb is expected to stabilize and improve the mechanical behavior of TiPt alloy. In this study, first principles calculations were used to explore the structural stability and mechanical properties of (Ti₂NbPt)₂ HTSMAs. It was found that the lattice parameters, density and volume decrease with Nb addition, enhancing the structural stability of the alloy. It was also found that (Ti₂NbPt)₂ alloy is thermodynamically stable due to the negative heats of formation (-0.361 eV/atom). The elastic constants (Cij), Bulk (B), Shear (G) and Young (E) moduli were found positive suggesting mechanical stability. Furthermore, the phonon dispersion curves showed vibrational stability due to the absence of soft mode across the Brillion zone direction. The Nb alloy addition can stabilize TiPt for higher temperature applications.

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Physics for Development, Education and Outreach / 358

Exploring Curriculum Considerations to Prepare Future Radiographers for an AI-Assisted Health Care Environment: Protocol for Scoping Review

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Co-authors: Elize Archer [2]; Mariette Volschenk [2]; Penelope Engel-Hills [3]

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The use of artificial intelligence (AI) technologies in radiography practice is increasing. As this advanced technology becomes more embedded in radiography systems and clinical practice, the role of radiographers will evolve. In the context of these anticipated changes, it may be reasonable to expect modifications to the competencies and educational requirements of current and future practitioners to ensure successful AI adoption.

The review aims to explore and synthesize the literature on the adjustments needed in the radiography curriculum to prepare radiography students for the demands of AI-assisted health care environments.

Using the Joanna Briggs Institute methodology, an initial search was run in Scopus to determine whether the search strategy that was developed with a library specialist would capture the relevant literature by screening the title and abstract of the first 50 articles. Additional search terms identified in the articles were added to the search strategy. Next, EBSCOhost, PubMed, and Web of Science databases were searched. In total, 2 reviewers will independently review the title, abstract, and full-text articles according to the predefined inclusion and exclusion criteria, with conflicts resolved by a third reviewer.

The search results will be reported using the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews) checklist. The final scoping review will present the data analysis as findings in tabular form and through narrative descriptions. The final database searches were completed in October 2024 and yielded 2224 records. Title and abstract screening of 1930 articles is underway after removing 294 duplicates. The scoping review is expected to be finalized by the end of May 2025.

A scoping review aims to systematically map the evidence on the adjustments needed in the radiography curriculum to prepare radiography students for the integration of AI technologies in the health care environment. It is relevant to map the evidence because increased integration of AI-based technologies in clinical practice has been noted and changes in practice must be underpinned by appropriate education and training. The findings in this study will provide a better understanding of how the radiography curriculum should adapt to meet the educational needs of current and future radiographers to ensure competent and
safe practice in response to AI technologies.

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PhD

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Theoretical and Computational Physics / 359

Discriminating multiprong jet substructure

Authors: Deepak Kar[1]; Hannah van der Schyf[1]

[1] *University of Witwatersrand*

Corresponding Author: hvanders@cern.ch

A wide array of jet substructure based techniques have been used to discriminate large-radius jets coming from the hadronic decay of top quarks against those from light quark or gluons. However, discriminating jets with more than three-prongs have been much less explored. In this work, a new physics signal of a boosted right handed heavy neutrino decaying to a top-bottom quark along with a charged lepton is investigated. The aim is to see which jet substructure observables can be sensitive to identify this signal over the multijet and top quark pair production background processes.

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PhD

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Physics of Condensed Matter and Materials / 360

Redox properties of VCo₂O₄ (001) surface in zinc air batteries

Author: Percy Ngobeni[None]

Co-authors: Phuti Ngoepe [1]; khomotso Maenetja [1]

[1] *University of Limpopo*

Corresponding Author: khehlapercy0@gmail.com

The evolution and progress of humanity have a significant connection to our energy consumption practices. Reliable energy sources are essential for promoting economic expansion, particularly as modern society becomes ever more energy dependent. The rapid development of zinc-air batteries (ZABs) is leading them to be seen as promising alternatives to traditional lithium-ion batteries for energy storage. However, the kinetics of the air cathode are slow, resulting in a short life cycle and low energy efficiency for zinc-air batteries. First-principles calculations are used to develop the catalyst that promotes the nucleation of Zn-air batteries' most stable discharge products. The density functional theory (DFT) is used to determine the adsorption (Gamma;= +1, +2) and vacancy formation (Gamma;= -1, -2) energies of the oxygen atom on the (001) surface of VCo₂O₄. The Bader charge is used to determine how the system's atoms interact with one another. As oxygen atoms are reduced and adsorbed, it is observed that the V and Co atoms show negligible charge differences upon either reduction/oxidation as compared to the pristine phase. The interplanar distances indicate that when an oxygen atom is added and removed from the pristine state, the system expands and contracts, respectively. The work function aids in determining the level of reactivity within the system. Absorbing oxygen atoms decreases the system's reactivity, whereas the removal of oxygen increases it. The results will give insights into finding the catalyst that will enhance the oxygen reduction reaction (ORR) and oxygen evolution reaction (OER), thereby improving the performance of Zn-air batteries.

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PhD

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Poster Session / 362

The Structural Variations of Li1+xNi0.5Mn1.5O4 Nanoporous Material for Li-ion Battery Cathodes

Author: Beauty Shibiri[1]

Co-authors: Phuti Esrom Ngoepe [2]; Raesibe Ledwaba [1]

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[2] *University of LImpopo*

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The demand for batteries with higher energy density and storage capacity has been increasing over the past three decades. As such, spinel $LiMn_2O_4$ has emerged as one of the most promising cathode materials for Li-ion batteries, owing to its environmental friendliness, inexpensiveness, and structural stability compared to its counterparts, such as $LiCoO_2$. However, $LiMn_2O_4$ suffers from high capacity loss and voltage fade due to factors such as the Jahn-Teller distortion and disproportionation reactions, which cause volume expansion in bulk materials. This results in a material that has reduced symmetry and energy, consequently causing fractures and pulverisation to the material. Studies have shown that Ni doping can mitigate the specific capacity loss and voltage fade in $LiMn_2O_4$ cathodes and improve their structural stability. Furthermore, nanoporous materials as electrodes offer a large surface area and pore volume for better electrolyte interaction and Li^+ diffusion, resulting in enhanced electrochemical performance and mechanical stability. Therefore, in this study, molecular dynamics (MD) simulations using the DL_POLY code are employed to investigate the structural changes on lithiated and Ni-doped $Li_{1+x}Ni_{0.5}Mn_{1.5}O_4$ nanoporous material with 67x67x67 Å cell dimension. The nanoporous material has recrystallised into single and multi-grained structures during lithiation. The pore cavity of the material is reduced or completely closed with the Ni dopant and increasing Li content. Furthermore, the surface areas of the material increased with lithiation except at the abrupt concentration of $Li_{1.75}Ni_{0.5}Mn_{1.5}O_4$; in this Li concentration, the surface areas reduced significantly. In addition, the material expands with increasing Li concentration; however, the structural integrity of the material is maintained upon full lithiation. This is because the material almost regains its porosity and recrystallizes into single-grained structures. This indicates that Ni-doped $Li_xMn_2O_4$ nanoporous materials can potentially stabilise and retain the spinel structure to enhance their cycling stability.

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None

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Poster Session / 363

First-Principles Study on the Role of Ti, V, and Sc Catalysts in Enhancing the Catalytic Effects of Boron Oxide Monolayer for Efficient Lithium-Selenium Batteries

Author: Edwin Mapasha[1]

Co-authors: Chewe Fwalo [1]; Emmanuel Igumbor [2]

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[2] *University of Johannesburg*

Corresponding Author: edwin.mapasha@up.ac.za

Ongoing research on lithium-air batteries aims to overcome setbacks caused by shuttle effects by exploring various cathode materials, with a particular focus on 2D materials such as monolayer boron oxides (MBOs).These materials are gaining popularity due to their unique properties, such as large surface areas, ballistic electronic transport, mechanical strength, and anisotropy, making them promising candidates for cathodes in lithium-air batteries. In this study, density functional theory (DFT) implemented within the quantum espresso code was employed to investigate the interaction of lithium polyselenides (specifically Li_2Se_x, where x = 1, 2, 4, 6, and 8, as well as Se_8) with monolayer boron oxide (MBO). We investigated the influence of lithium polyselenides on monolayer boron oxide (MBO), focusing on adsorption energy, charge density distribution, Gibbs free energy changes, and metallic characteristics for efficient lithium-selenium batteries. The initial results showed that the adsorption energies of these lithium polyselenides on pristine MBO are relatively weak, ranging from -0.25 to -1.43 eV. In contrast, doping MBO with scandium (Sc) significantly increased the adsorption energies, ranging from -2.65 to -3.74 eV, indicating a notable enhancement compared to other tested single-atom catalysts (SACs). The higher adsorption energy of Sc-doped MBO suggests an improved ability to prevent the dissociation of lithium polyselenides into the electrolyte, which is critical for addressing the shuttle effects. Charge density distribution analyses further support the presence of electronic interactions between the substrate and the adsorbed lithium polyselenides via Sc catalysts, as evidenced by charge transfer from the adsorbate to the substrate. Additionally, the investigation of Gibbs free energies revealed low charge, discharge, and overpotential values (0.1 V for pristine MBO and 1.53 V for Sc-doped MBO). The Sc-doped MBO structure exhibits significantly enhanced metallic characteristics after the adsorption of Li_2Se and Li_2Se_4. Furthermore, the low diffusion (1.56 eV) and dissociation (1.72 eV) energy barriers for stable Li_2Se on Sc-doped MBO suggest the material's potential to improve electrochemical processes and enable higher charging rates in lithium-selenium batteries. Ultimately, while pure MBO alone may not effectively address the challenges associated with lithium-selenium batteries, doping it with Sc substantially enhances its properties as a cathode material.

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None

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Applied Physics / 364

Preliminary Investigation of the Mechanical Properties of Tissue Biopsies

Author: Kayode Dada[1]

Co-author: Risimati Mavunda [1]

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Corresponding Author: kayodeayodejidada@yahoo.com

Cancer induction and progression have been significant challenges that face humanity. Several procedures and methods have been used to detect the different stages within the clinical setting. However, many of these clinical tests are geared towards biochemical cues. This study studied the inherent nanomechanical properties of two breast and colorectal biopsies. The tissues were obtained from a biobank and then stored in 10 % formalin for onward transportation to the laboratory. A slice from the tissue samples was cut out, attached to a disc, and placed inside a Cypher VRS atomic force microscope. The tissue was then hydrated with phosphate buffer saline. The indentation curves of the samples were then acquired. The indentation curves were then fit into the Hertz model to extract the mechanical properties needed. The range of Young's modulus obtained for the colorectal normal biopsies was between 2.174±0.299 and 35.005±5.025 MPa, while the values obtained for the cancer biopsies range between 0.524±0.017 and 5.120±0.218 MPa. However, the range obtained for the normal breast biopsies was 113.319±7.770 and 140.202±11.696 kPa, while the range of Young's modulus obtained for the cancer breast tissues was between 1.009±0.040 and 4.038±0.282 kPa. The study concluded that there is a significant difference in the indentation measurements between cancer tissues, and these differences also vary with the tissues.

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Poster Session / 365

Structural, mechanical, and electronic stability of Li7-xLa3Zr2-xNbxO12 (x = 0.25, 0.5) solid electrolyte

Author: KHUMBULANI TIBANE[1]

Co-authors: Cliffton Masedi [1]; Phuti Esrom Ngoepe [2]; Raesibe Ledwaba [1]

[1] *University of Limpopo*

[2] *University of LImpopo*

Corresponding Author: tibanekhumbulani01@gmail.com

Lithium-ion batteries are extensively utilised in portable electronics and are increasingly employed in electric vehicles and stationary energy storage. To improve safety and energy density, solid-state electrolytes (SSEs) are being explored for their non-flammability and stability with lithium metal anodes. Among these, garnet-type Li₇La₃Zr₂O₁₂ (LLZO) is a leading candidate due to its high ionic conductivity (~1×10⁻⁴ S/cm) and chemical compatibility with lithium metal.
However, in its tetragonal phase, LLZO exhibits low room-temperature conductivity (~1×10⁻⁶ S/cm), limiting its practical use. Substitutional doping at the Zr site with niobium (Nb) offers a potential route to enhance both the structural and electrochemical performance of LLZO.
Therefore, in this study, first-principles calculations based on density functional theory (DFT) were performed using the projector augmented wave (PAW) method within the Vienna Ab initio Simulation Package (VASP), applying the PBE-GGA functional for exchange-correlation energy. The lattice parameters reveal that pristine LLZO adopts a tetragonal structure, whereas Nb-doped compositions Li_{6.75}La₃Zr_{1.75}Nb_{0.25}O₁₂ and Li_{6.5}La₃Zr_{1.5}Nb_{0.5}O₁₂ stabilize in monoclinic and orthorhombic phases, respectively. All structures satisfy mechanical stability criteria corresponding to their crystal symmetries. Moreover, the Pugh's ratio indicates enhanced ductility in the 12.5% Nb-doped system (x = 0.25), suggesting improved mechanical performance. The density of states analysis indicates insulating behavior, with band gaps decreasing from 4.345 eV (pristine) to 3.734 eV and 3.649 eV as Nb content increases. Despite this reduction, the high band gaps ensure low electronic conductivity, supporting the suitability of Nb-doped LLZO for solid-state electrolyte applications.
Keywords: Solid electrolyte, Nb-doped garnet-type, and Lithium-ion battery

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PhD

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Poster Session / 366

Enhancing the Robustness of Structured Light Communication via Skyrme Number in Complex Medium

Authors: Andrew Forbes[1]; Cade Peters[None]; Moslem Mahdavifar[1]; SHUAILING WANG[2]

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[2] *Tongji university*

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Structured light, owing to its ability to carry orbital angular momentum (OAM) as an additional degree of freedom for information encoding, has attracted significant attention in optical communication and information processing. However, in practical applications, the helical phase structure of structured light is inevitably distorted by turbulence effects during propagation through complex medium, leading to a significant decline in the accuracy of OAM mode recognition and subsequent information loss. In this study, we propose a robustness-enhancing scheme based on the Skyrme number to improve mode recognition accuracy in turbulent environments. We further experimentally validate the feasibility of this approach by transmitting vector beams through turbulence simulated by a digital micromirror device (DMD) multiple times. The experimental results demonstrate that, even after three turbulence-induced distortions, the Skyrme number can still be accurately identified. These findings suggest that the Skyrme number, as a more resilient topological degree of freedom, provides a solid foundation for the development of large-scale, stable free-space optical communication systems.

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PhD

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Nuclear, Particle and Radiation Physics-2 / 367

Investigation of Radiation-Resistant Components for the TileCal-ATLAS Detector

Authors: Elias Sideras-Haddad[1]; Gaurav Lall[1]; Othmane Mouane[1]

Co-author: Bruce Mellado [2]

[1] *University of the Witwatersrand*

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The performance and longevity of photomultiplier tubes in high-radiation environments, specifically the Tile Calorimeter, are crucial to the ATLAS detector's efficiency. This research is part of an ongoing investigation into the electron emission yield and electronic properties of various materials to be used in the dynode chain, the main component of the photomultiplier tubes. This study aims to inform material selection for future radiation-hard PMT designs in the upcoming high-luminosity upgrade to the Large Hadron Collider. The materials of interest include aluminium oxide, gallium arsenide, thallium doped caesium iodide, and magnesium oxide. The changes in the electronic properties and electron emission yield before and after irradiation are studied. Results for the electronic properties were obtained using an electrical system optimised to measure high resistance. In addition to this, data pertaining to the electron emission yield has also been acquired using the Proton Microprobe at iThemba LABS'TANDEM accelerator.

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Nuclear, Particle and Radiation Physics-2 / 368

Measurement of the top quark Yukawa coupling from tt kinematic distributions in the dilepton final state

Author: Cameron Garvey[1]

[1] *University of Cape Town*

Corresponding Author: grvcam001@myuct.ac.za

An extraction of the top quark Yukawa coupling (Y_t) from top quark pair production is presented using proton-proton collisions at $\sqrt{s} = 13$ TeV, corresponding to an integrated luminosity of 140 fb^{-1}, recorded by the ATLAS experiment. Corrections from a Higgs boson exchange between the top quark and top anti-quark can produce non-negligible modifications to differential distributions near the energy threshold of $t\bar{t}$ production. The kinematic distributions sensitive to these modifications at parton level, are the invariant mass of the $t\bar{t}$ system (m_{tt}) and the azimuthal angle of the top quark with respect to the beamline in the rest frame of the $t\bar{t}$ system known as $\cos(\theta^*)$ This analysis aims to constrain Y_t indirectly using the kinematic distributions of $t\bar{t}$ pair events using the eμ dilepton final state.

Since we are working in the dilepton channel $t\bar{t} \rightarrow \mathrm{W^+bW^-b} \rightarrow \ell^+\nu b\ell^-\nu b$. The ATLAS experiment cannot measure the neutrinos and as such we need to reconstruct the $t\bar{t}$ kinematics sensitive to variations in Y_t. Machine learning was used to reconstruct the mass of the top quark system as this provides the greatest sensitivity to variations in Y_t. A binned profile likelihood fit was then implemented to extract a blinded estimation of Y_t using Asimov data including a complete set of statistical and systematic uncertainties.

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Nuclear, Particle and Radiation Physics-2 / 369

Searches for scalar resonances with di-photon in association with taus using the easyjet analysis framework in ATLAS detector at the LHC

Author: Kutlwano Makgetha[1]

Co-authors: Baballo-Victor Ndhlovu [1]; Bruce Mellado [1]; Kgothatso Ntumbe [1]; Mukesh Kumar [1]; Njokweni Mbuyiswa [1]; Rachid Mazini [1]; Vuyolwethu Kakancu [1]

[1] *University of the Witwatersrand*

Corresponding Author: 2134657@students.wits.ac.za

Recent studies (arXiv:2109.02650, 2306.17209, 2503.16245) have identified growing excesses in scalar resonances with di-photon at the Large Hadron Collider (LHC), suggesting the presence of scalar particles beyond the Standard Model. These scalar resonances are motivated by the multi-lepton anomalies at the LHC which indicate a potential new scalar particle S with a mass of approximately 151.5 GeV, originating from a heavier scalar H with a mass near 270 GeV, with a global significance of $\sim 5\sigma$. Motivated by these findings, the HBSM group within the HMBS physics group at ATLAS has launched a new analysis using the easyjet analysis framework. This analysis focuses on searching for scalar resonances through di-photon production in the process $gg \to H \to SS'$, where $S \to \gamma\gamma$ and S' decays to $S' \to \tau_h \tau_\ell$. We are preparing to use the analysis tools to analyse the 2022-2024 Run~3 data with an integrated luminosity of $183\ \mathrm{fb}^{-1}$ at $\sqrt{s} = 13.6\ \mathrm{TeV}$

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MSc

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Theoretical and Computational Physics / 370

Superconformal indices in closed form

Author: Kayleigh Mathieson[1]

Co-authors: Pratik Roy [1]; Sam van Leuven [1]

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Superconformal indices are a type of partition function that encode the protected spectrum of a superconformal field theory (SCFT). They are invariant under continuous deformations and renormalization-group flows, and provide insights into physical and mathematical equivalences between dual SCFTs and their low energy dynamics. In this talk, I will explain the background and motivation for calculating superconformal indices, present the results of our computation of well-defined closed form expressions for the full Superconformal Index, and its supersymmetric limits, namely the Hall-Littlewood, Schur and Macdonald indices in the cases of $\mathcal{N} = 1$, $\mathcal{N} = 2$, and $\mathcal{N} = 4$ SCFTs. Lastly, I will conclude with a review of their physical interpretation of our results.

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Poster Session / 371

Ab initio studies of Platinum alloyed with Chromium for jewellery applications: energetic stabilities and structural properties

Author: Mawisha Jan Mafifi[1]

Co-authors: Donald Mkhonto [2]; Edwin Mapasha [1]; Maje Phasha [2]

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The Pt-based materials are widely used in industries, including metallurgy, medicine, jewellery, fuel cells, and hydrogen evolution reactions due to their excellent electrochemical properties. However, in its pure form, platinum (Pt) is soft, thus prone to surface scratching, a concern in jewellery applications. Hence, alloying to enhance its mechanical properties is key to improving scratch resistance. This study employs first-principles calculations to investigate the effect of alloying with high corrosion resistant chromium (Cr) on phase stability, structural and mechanical properties of Pt. Calculations are carried out on FCC (face-centered cubic) structure using density functional theory (DFT) based Quantum Expresso package.

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Nuclear, Particle and Radiation Physics-1 / 372

The use of Machine Learning techniques to analyse the h-> Zy process within the SMEFT framework at the Large Hadron Collider (LHC)

Author: Kutlwano Makgetha[1]

Co-authors: Abduluazem Fadol [1]; Bruce Mellado [1]; Mukesh Kumar [1]; Njokweni Mbuyiswa [1]; Srimoy Bhattacharya [1]

[1] *University of the Witwatersrand*

Corresponding Author: 2134657@students.wits.ac.za

Building on the ATLAS and CMS discovery of the Higgs boson decaying into a Z-boson and a photon (with a 3.4σ significance), the current Standard Model (SM) predictions for the $h \rightarrow Z\gamma$ signal rate exceed the measured value by 2.4 ± 0.9, indicating possible new physics effects or systematic uncertainties that warrant further investigation. This analysis investigates this rare process using machine learning techniques where we employ classifiers such as the Boosted Decision Trees (BDT), XGBoost, and the kernel density estimation to analyse the production modes of $h \rightarrow Z\gamma$ including gluon-gluon fusion (ggF), vector boson fusion (VBF), associated production with a vector boson (VH), and associated production with a top quark pair (ttH), within the framework of the Standard Model Effective Field Theory (SMEFT). This machine-learning approach aims to constrain the six-dimensional Wilson coefficients and shed light on potential deviations from SM prediction.

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Nuclear, Particle and Radiation Physics-2 / 373

Monte Carlo generation involving searches for scalar resonances with diphoton in association with tau+ tau-/2 b-jets in ATLAS detector at the LHC

Author: Njokweni Mbuyiswa[1]

Co-authors: Baballo-Victor Ndhlovu [1]; Bruce Mellado [1]; Kgothatso Ntumbe [2]; Kutlwano Makgetha [1]; Mukesh Kumar [1]; Paballo Ndhlovu [3]; Rachid Mazini [4]; Vuyolwethu Kakancu

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A Monte Carlo generation campaign has been submitted under the HBSM subgroup to study a simplified model featuring the resonant production of scalar particles at the electroweak scale. The process under consideration is $gg \rightarrow H \rightarrow SS'$, where the scalar S (with a mass of approximately 150 GeV) decays to a diphoton final state $(\gamma\gamma)$, and the accompanying scalar S' (with a mass of approximately 95 GeV) decays to either $b\bar{b}$ or $\tau^+\tau^-$. The motivation for these studies is rooted in the persistent multi-lepton anomalies observed in various channels at the LHC, as highlighted in combined searches for scalar resonances by ATLAS and CMS and further explored in the context of electroweak-scale scalar states decaying to photons, leptons, or b-jets [arXiv:2109.02650, arXiv:2306.17209, arXiv:2503.16245].The MC production is designed for Run 3 conditions at a center-of-mass energy of $\sqrt{s} = 13.6$ TeV and will facilitate detailed kinematic studies and optimization of selection strategies in these channels.

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MSc

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Theoretical and Computational Physics / 374

Probing the Dead Cone using the Lund Jet Plane

Author: Ofentse Matlhakola[1]

Co-authors: Deepak Kar [1]; Isobel Kolbé [1]

[1] *University of the Witwatersrand*

Corresponding Author: 1701776@students.wits.ac.za

In high-energy particle collisions, high-momentum quarks and gluons (collectively called partons) are emitted from the colliding particles. As these partons move away from the collision point, they transfer their energy to multiple lower energy particles in a cascading process known as a parton shower. Eventually, the low-energy partons combine to form hadrons, which are collected into a jet. To study the evolution of such jets, we exploit a jet substructure observable known as the Lund Jet Plane (LJP), which maps the momentum and angular separation of emissions originating from a jet-initiating quark. This approach is useful for probing the Dead Cone phenomenon, a predicted suppression of soft-gluon radiation around the forward axis of a radiating massive quark. We present results from an analysis of the emission density within the LJP of bottom-tagged jets generated in PYTHIA8 simulations. Furthermore, we discuss opportunities for extensions to heavy-ion collisions where medium-induced radiation is expected to fill the Dead Cone region, providing a tool to isolate and characterize the high temperature phase of the Quark-Gluon Plasma.

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MSc

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Poster Session / 376

Optimizing Renewable Energy Generation in South Africa using ARENA FlexTool

Authors: Marandela Mulalo Valencia[None]; Eric Nnditshedzeni Maluta[None]; SOPHIE MULAUDZI[1]; Lufuno Takalani[1]

[1] *University of Venda*

Corresponding Author: mulalo.marandela@univen.ac.za

South Africa, with abundant renewable energy resources, is undergoing a significant transition as it strives to integrate renewable energy into its energy mix to meet the country's growing demands sustainably. However, the efficient utilization and integration of renewable energy sources into the grid poses several technical, economic, and regulatory challenges. This research proposes a comprehensive study and analysis that aims to optimize renewable energy generation in South Africa using FlexTool, an innovative software platform designed specifically for energy system modelling and analysis. By harnessing the capabilities of FlexTool, this study aims to develop advanced optimization strategies and decision-making tools tailored to South Africa's unique energy landscape. The study will consider various factors, grid infrastructure, and socioeconomic considerations such as the country's renewable energy potential. The outcomes of this research will provide valuable insights and recommendations for policymakers, energy stakeholders, and investors, thereby facilitating the transition toward a sustainable and resilient energy future in South Africa
Keywords: Renewable energy, Irena flex tool, solar energy, biomass, wind energy, hydro energy, nodes and scenarios.

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PhD

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Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 377

Analysing h to Zy decay at the Large Hadron Collider using SMEFT

Author: Njokweni Mbuyiswa[1]

Co-authors: Abduluazem Fadol [1]; Bruce Mellado [1]; Kutlwano Makgetha [1]; Mukesh Kumar [1]; Srimoy Bhattacharya

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The ATLAS and CMS collaborations have jointly reported the first evidence of the Higgs boson (h) decay into a Z boson and a photon, with a statistical significance of 3.4σ. The observed signal strength, 2.2 ± 0.7 times the Standard Model (SM) expectation, exceeds the SM prediction even when next-to-leading order (NLO) QCD corrections and signal-background interference are taken into account. This persistent deviation motivates an interpretation in the context of the Standard Model Effective Field Theory (SMEFT). In this study, we investigate the $h \to Z\gamma$ decay process at the LHC, focusing on gluon-gluon fusion (ggF) as the primary production mechanism. We aim to constrain the relevant dimension-six SMEFT operators by fitting model parameters to cross-section measurements and differential kinematic distributions that are sensitive to new physics. To improve the efficiency of this exploration, we employ kinematic interpolation methods across the SMEFT parameter space. Beyond the ggF channel, we also investigate additional Higgs production mechanisms including vector boson fusion (VBF), associated production with top quarks (ttH), and vector bosons (VH) to capture a broader range of dynamics and improve the robustness of the SMEFT interpretation. Multiple Z decay final states are considered, including leptonic ($Z \to \ell^+\ell^-$) and hadronic ($Z \to jj$) modes, to maximize signal acceptance and provide complementary constraints on new physics scenarios.

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MSc

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Poster Session / 378

Tailoring Optoelectronic Properties of All Inorganic Perovskites Through B-site Doping: A DFT Study

Author: Prettier Morongoa Maleka[1]

Co-authors: David Tshwane [1]; Lethabo Mogakane [2]; Martin. O Ntwaeaborwa [3]; RATSHILUMELA STEVE DIMA [1]; Regina Maphanga [4]; Thabani Ngcobo [1]

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Lead halide perovskites have shown great promise as solar absorbers for next-generation photovoltaics, but their toxicity poses significant challenges for practical use. As a result, considerable research has focused on developing environmentally friendly, lead-free alternatives with similar optoelectronic properties, including perovskites based on Sn, Ge, Mo and Bi. In this study, the first-principles calculations based on density functional theory were used to determine the structural, electronic and optical properties of $CsPb1\text{-}xMxBr_3$ ($0 \leq x \ll 1$) perovskite, where M = Bi and Mo. These calculations reveal that low-level doping leads to significant changes in the electronic density of states, introducing localized defect states and bandgap tuning effects, without compromising the host lattice stability. Bi doping induces shallow states near the conduction band, promoting improved charge transport, while Mo doping introduces deeper levels, potentially enhancing light absorption in the visible region. The optical spectra show enhanced absorption coefficients in the solar spectrum, indicating potential improvements in light-harvesting efficiency. These results demonstrate that controlled doping with Bi and Mo in CsPbBr3 provides a promising solution for optimizing all-inorganic perovskites in solar cell applications and paves the way for further experimental exploration of dopant engineering in halide perovskites.

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None

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Astrophysics & Space Science / 379

Structure growth in the thawing dark energy models

Authors: Amare Abebe[1]; Shambel Akalu[2]

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In this work, we study the dynamics of the universe using Thawing Dark Energy (TDE) model with a minimally coupled scalar field that evolves away from the dominance of potential energy. As the equation of state parameter ⍰(⍰) evolves, this offers a dynamic framework where the impact of dark energy may change over time. The structure formation of the universe will be highlighted in TDE using the redshift space distortion data together with cosmic chronometers (CC) baryon acoustic oscillation (BAO) data taken from the Dark Energy Spectroscopy Instrument (DESI) and the SNIa distance moduli measurements from the Pantheon + SH0ES survey, which consist of 1701 light curves of 1550 distinct supernovae. After introducing the background cosmological solutions and numerical findings, the linear cosmological perturbation equations will be derived in the 1+3 covariant formalism to analyse the numerical density fluctuations. The detailed statistical analysis will be performed after we calculate the best fit cosmological parameters through MCMC simulations.

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None

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Theoretical and Computational Physics / 380

The rich topological tapestry embedded in entangled states

Authors: PEDRO DINIS ORNELAS[1]; Robert de Mello Koch[2]; Neelan Gounden[1]; Bo-Qiang Lu[3]; Isaac Nape[1]; Andrew Forbes[1]

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Topology has emerged as a fundamental feature across diverse physical systems, from cosmology and condensed matter to high-energy physics and wave dynamics. Yet, despite its broad relevance, topological studies have largely been confined to low-dimensional classical systems. Here, using entangled quantum states, we uncover a vast landscape of diverse topological maps derived from high dimensional entangled states. By engineering our quantum states to mimic a non-Abelian field in SU(d) Yang-Mills theory, we predict multiple topological structures as mappings between a reference 2-sphere and multiple submanifolds embedded within the high dimensional manifold yielding a topological spectrum of invariants which scales with the dimension of the states. Notably, partitioning this spectrum into trivial and non-trivial components enables simultaneous robustness against perturbations while also serving as a probe for them, achieved by detecting emergent signatures in the initially trivial partition. While the results and analysis are presented using the orbital angular momentum of photonic quantum states as an example the theoretical framework provided is broadly applicable to any particle type, dimension, or degree of freedom. This work opens exciting prospects for quantum sensing and communication through topology.

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PhD

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Photonics / 381

Noisy quantum channels fail to rip the fabric of entanglement

Authors: PEDRO DINIS ORNELAS[1]; Robert de Mello Koch[2]; Bo-Qiang Lu[3]; Isaac Nape[1]; Andrew Forbes[1]

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Non-local entangled states are an important resource for future quantum technologies, but their practical use is hindered by the effects of noisy quantum channels. However, recently discovered quantum Skyrmions, topologically structured entangled states, offer a promising solution. In this work, we develop a theoretical framework to study the evolution of entangled states and their topology in general quantum channels. Using photons entangled in orbital angular momentum and polarization as an example, we demonstrate that noise can be interpreted as a smooth geometric transformation of the mapping between the two-photon state spaces. From this, we predict complete resilience of the topology of the states against both depolarizing and non-depolarizing noise. Additionally, we identify specific sources of local noise that may destabilize the topology and discuss mitigation strategies. Our results have direct implications for quantum information distribution in noisy environments, including quantum computing and quantum networks.

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Physics of Condensed Matter and Materials 2 / 382

Comparative Analysis of Co-precipitation and Sol-Gel Derived $Sm_2Ni_2O_5$ Nanoparticles: Structural, Chemical, Thermodynamic, and Magnetic Properties

Author: Khethiwe Cele[1]

Co-authors: Buyi Sondezi [1]; Leelakrishna Leelakrishna Reddy [2]; Sibusiso Nqayi [1]

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In this study, crystalline $Sm_2Ni_2O_5$ nanoparticles (SNONPs) were synthesized using both the co-precipitation and sol-gel methods to compare the influence of the synthesis'method on the structural, chemical, thermodynamic, and magnetic properties of the material. X-ray diffraction (XRD) analysis revealed that samples from both methods crystallized in an orthorhombic structure of the Ima2 space group after annealing at 800 ℃. SEM images revealed that co-precipitated samples had spherical particles, while sol-gel samples exhibited irregular, textured morphologies. EDS results showed comparable elemental compositions in both samples, with slight variations in oxygen content. Specific heat (Cp) measurements under a 0.5 T magnetic field revealed a ferromagnetic transition at ~42.3 K in both cases. Additionally, a sharp increase in Cp below 150 K and a deviation in Cp/T below 9 K suggested the onset of spin ordering due to magnetic interactions between Sm^{3+} (4f) and the mixed oxidation states of Ni (Ni^{2+} and Ni^{3+}). These findings highlight the impact of synthesis route on the crystallinity and consequently the chemical, thermodynamic and magnetic behavior of SNONPs, suggesting its potential for spintronic and low-temperature magnetic applications.

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MSc

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Poster Session / 383

The effect of Ir on the magnetic and electronic properties of FePt alloy: A DFT study

Authors: Mashilo Matlala[1]; Malili Matshaba[1]; Hasani Richard Chauke[1]; Ramogohlo Diale[2]

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[2] *Mintek*

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L1₀-ordered FePt alloy is a promising material for high-density magnetic recording media due to its high magnetic anisotropy energy, density and coercivity. However, it was reported that this alloy faces challenges including issues with thermal stability and noise. Hence, ternary alloying with Ir was conducted to enhance the stability in response to the orientation of the magnetic spin moment of the binary FePt system. The structural, magnetic electronic and thermal properties of L1₀-ordered Fe₅₀Pt_{50-x}Ir_x alloys (0≤x≤25) were studied using the Density Functional Theory. It was found that the lattice parameters and magnetic moments of the binary Fe₅₀Pt₅₀ are well in agreement with previous theoretical and experimental data to within 5 %. In all Fe₅₀Pt_{50-x}Ir_x alloys, the calculated heats of formation were negative, demonstrating their thermodynamic stability. The magnetic moments and density of states were determined to evaluate the magnetic behaviour of Fe50Pt50-xIrx alloys. These results contribute to the development of Fe₅₀Pt_{50-x}Ir_x alloys as the next generation of magnets for high-density magnetic recording media.

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MSc

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Yes, I ACCEPT

Poster Session / 384

Engineering Exotic Hybrid States

Authors: Tatjana Kleine[1]; Pedro Ornelas[1]; Isaac Nape[1]

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Entangled quantum states find themselves in many active fields, such as cryptography and information transfer. High dimensional states are highly sought after as they can carry large amounts of information. One method used to scale the amount of information carried by these states is to use higher dimensional degrees of freedom (DOFs). However, these states are fragile, easily disturbed by noise, and difficult to measure. Luckily, one can create a hybrid entangled state, where we entangle higher dimensional DOFs with robust, 2D DOFs. This shifts us from one high dimensional fragile entangled state to multiple robust 2D entangled states, allowing us to leverage the advantages of both DOFs. Using a novel interferometric device, hybrid states were generated using a spin to orbit conversion technique implemented on photons produced from a spontaneous parametric down conversion process. This compactly designed interferometer was used to generate arbitrary hybrid states entangled in orbital angular momentum and polarisation. Several hybrid states of high purity were generated using this interferometer and Bells inequalities were violated with high visibilities. The high visibilities and purities indicate that high quality states with high fidelities can be produced by our interferometer. Our approach allows for a wide variety of hybrid states packed with a large amount of easily measurable information. These hybrid states have great potential for use in real world information transfer.

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MSc

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Nuclear, Particle and Radiation Physics-1 / 385

The photon strength functions from (p, γ) capture reactions.

Author: Adivhaho Netshiya[1]

Co-authors: Luna Pellegri [2]; Mathis Wiedeking [3]

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Abstract:
In the 1970s and 80s, (p, γ) reactions 1 were successfully utilized to measure the Photon Strength Function (PSF) using the Average Resonance Proton Capture (ARPC) Method [1, 2]. In this research, these reactions have been used to extract the slope of the PSF from the ^{50}Cr(p, γ)^{51}Mn proton capture data using the Shape method [3] with no s-wave resonance spacing data (D_0). The reactions populated entry states between the 5.3 MeV proton and 13.7 MeV neutron separation energies, which decayed through primary γ-ray transitions to low-lying discrete states. For the proof-of-principle ^{50}Cr(p, γ)^{51}Mn reaction, the Tandetron accelerator at iThemba LABS delivered proton beams of 2500 to 2740, 2760 to 3000, 3675 to 4100 and 4100 to 4500 keV in intervals of 20-25 keV with the primary γ-rays emitted being detected using a segmented Clover detector. A total of 64 γ-ray spectra were collected and with the use of the ARPC method were summed into ARPC spectra, which cover 260, 260, 425 and 400 keV excitation-energy bins. Using the average intensities of the primary γ-rays from these ARPC spectra, the slopes of the PSFs to $1/2^-$, $3/2^-$, $5/2^-$ and $7/2^-$ final states of known spin and parity in ^{51}Mn were extracted. The scaling and sewing techniques of the Shape method were used to determine the shape of the total PSF to $1/2^-$, $3/2^-$, $5/2^-$ and $7/2^-$ final states despite having no spin distribution data. The shape of the total PSF was normalized to the Simple Modified Lorentzian (SMLO) and DM1 Gogny force plus Quasi-Particle Random Phase Approximation (D1M+QRPA) PSF models 2 to obtain the absolute values of the shape of the total PSF. Despite predicting different absolute values, the two models predict slopes that are comparable to each other. The shape of the total PSF shows what might be three low-lying $E1$ structures that could influence nuclei abundance calculations. The ^{50}Cr(p, γ) cross sections calculated with the Hauser-Feshbach statistical model by using the total PSF as input when compared with the cross section calculated from direct methods shows good agreement. The level scheme of the ^{51}Mn compound nucleus was built with several new transitions and states being identified.

Acknowledgments
This work is supported in part by the National Research Foundation (NRF) of South Africa (Grant No: 118846 and REP_SARC180529336567), the Department of Higher Education and Training (DHET) through its New Generation of Academics Programme (nGAP) and Walter Sisulu University (WSU). It is also based upon work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics under Contract No. DE-AC02-05CH11231.

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2 S. Goriely et al, Eur. Phys. J. A, 55:172 (2019).
[3] M. Wiedeking et al, Phys Rev C, 104(1):014311, (2021).

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PhD

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Poster Session / 386

Exploring Surface Stability in Titanium Nickel Using DFT

Author: Vukosi Chauke[1]

Co-authors: Hasani Richard Chauke [1]; David Tshwane [2]; Phuti Ngoepe [1]

[1] *University of Limpopo*

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Corresponding Author: 201735909@keyaka.ul.ac.za

Titanium Nickel (TiNi) alloys are widely used in biomedical and aerospace applications due to their unique shape memory effect and superelastic properties. However, their susceptibility to corrosion in aggressive environments limits their long-term performance and reliability. Understanding the surface stability of TiNi is crucial for developing strategies to enhance corrosion resistance and optimise its functionality in various applications such as biomedical devices and robotics. This study employs density functional theory (DFT) calculations to investigate the surface stability of TiNi alloy, focusing on the (100), (110), and (111) surfaces. The calculations revealed that the (110) surface has the lowest energy illustrating stability. The PDOS results corroborate the enhanced stability of the (110) surface, showing a more favourable electronic configuration compared to the (100) and (111) surfaces. Additionally, we calculated the work function for each surface and it was observed that the (110) surface has higher work function than the (100) and (111) surfaces, suggesting that the (110) surface is less reactive and more stable. This data will provide insights into the stability, reactivity, and potential applications of TiNi in catalysis and electronic devices.

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MSc

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Photonics / **387**

Evaluation of Ce6 Photosensitisers-Induced Dark Toxicity and Phototoxicity (660 nm) on Melanoma Cells

Author: Aishat Obalola[1]

Co-authors: Abrahamse Heidi [2]; Sathish Sundar Dhilip Kumar [3]

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Skin cancer may be classified into three types - cutaneous malignant melanoma, squamous cell carcinoma, and basal cell carcinoma. Radiotherapy, chemotherapy, targeted therapy, and immunotherapy are some of the traditional therapies, all of which present significant side effects. Photodynamic treatment has revolutionized cancer treatment because of its effectiveness against various cancer types and low side effect rates. One non-invasive, localized therapeutic option is photodynamic therapy. Photodynamic therapy (PDT) relies on a photosensitizer to create cytotoxic reactive oxygen species that destroy cancer cells. Since PDT's effectiveness primarily depends on the photosensitizer, much effort has been put into identifying the ideal one. Chlorin E6 (Ce6) is a second-generation photosensitizer that has FDA clearance and meets the clinical standards for PDT. Its potent ability to generate reactive oxygen species (ROS) and its potent anticancer impact on various cancer types are well established.
The phototoxic effects of Ce6 on the melanoma cancer cell line (A375) are examined in this study. The A375 cells were grown and maintained in a culture medium at 37° C, 5% CO_2, and 85% humidity. The cells were subjected to a diode laser with a wavelength of 660 nm and gradually increasing concentrations of Ce6 photosensitizer. To ascertain how A375 cells responded to treatments, the cellular activities were assessed 24 hours after PDT using microscopy and biochemical testing. The substantial morphologic alterations, enhanced cytotoxic damage, and decreased cell viability and proliferation in PDT-treated cells demonstrated a dose-dependent response. Our findings reveal that Ce6 significantly inhibits the growth of A375 melanoma cells, offering a more precise and less toxic alternative to conventional treatments. Ce6 has shown success in treating melanoma cancer in vitro; however, when used clinically, the ensuing PDT efficacy will ultimately rely on biological characteristics. PDT might be regarded as an adjuvant treatment until established procedures for different tumor types and a relevant PS have been confirmed. These findings highlight the potential of Ce6-based PDT as a promising, targeted therapy for melanoma with reduced toxicity compared to conventional treatments.

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PhD

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Yes, I ACCEPT

Poster Session / 388

Optimization of TiO2 processing parameters using the slot die-coating technique for dye-sensitized solar cells.

Author: Mano Mosalakgotla[None]

Co-author: Mmantsae Diale [1]

[1] *University of Preoria*

Corresponding Author: u20753782@tuks.co.za

Dye-sensitized solar cells (DSSCs) are photovoltaic devices that provide high solar to electric energy conversion efficiency through light sensitization of metal oxides by adsorbed dyes. Recently, considerable research has focused on enhancing the efficiency of DSSCs by improving individual elements of the device. Among all the elements, porous TiO2 thin-films sensitized with light-absorbing dyes play a vital role as photoanodes, which function as charge collectors for the dye molecules in a DSSC. This research aims to optimize TiO2 thin films for enhanced DSSC performance.
In this study, TiO2 thin-films were optimized through several processing parameters, namely deposition time, film thickness, and annealing temperature, using the slot die-coating technique for DSSC applications. The structural properties and crystallinity of the prepared films were examined using X-ray diffraction (XRD) and RAMAN spectroscopy, respectively. The surface morphology and the cross-sectional view of the films were investigated using the Field Emission Scanning Electron Microscope (FE-SEM). Ultraviolet–visible spectroscopy (UV-Vis) was used to study the photoabsorbance of the films. Atomic Force Microscopy (AFM) was used to study the roughness of the films. Lastly, the thin films were sensitized with anthocyanin dye and employed as photoanodes in DSSC devices to study their electrochemical properties. This study will be a pathway to forming highly efficient photoanodes which exhibit enormous potential in the hydrogen production and bioenergy industry.

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PhD

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Physics of Condensed Matter and Materials / 389

The effects of annealing temperature on physical properties of $Ce_2Zr_2O_7$ materials

Author: Saheed Omotosho Yissah[1]

Co-authors: Buyisiwe Sondezi [1]; Moise B Tchoula Tchokonte [2]; Sibusiso Nqayi [1]

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Pyrochlore oxides are fascinating class of materials known for their remarkable thermal stability and adaptability, making them excellent candidates for energy-related applications. In this study we explore the effects of thermal treatment on structural, morphological, optical, thermodynamic and magnetic properties of $Ce_2Zr_2O_7$ nanoparticles (CZONPs) prepared using sol-gel method and then followed by thermal annealing treatment. The micro-structure, size, optical, and magnetic properties of prepared samples were analyzed using X-ray diffraction (XRD), transmission electron microscopy (TEM), UV-Vis and photoluminescence spectroscopy, and physical properties measurement system (PPMS), respectively. The results showed mixed phases of CeZrO4 and $Ce_2Zr_2O_7$ at various annealing temperature ranges. The ratio between these phases was changing as a function of annealing temperature. The pure phase of CZONPs was obtained at high temperature. These findings point to a strong correlation between pyrochlore's stability, making the material highly relevant for high-temperature applications.

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PhD

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Yes, I ACCEPT

Poster Session / 390

Machine learning the magnetocaloric effect in perovskite oxides

Author: Eugene Sibanda[None]

Co-authors: Charis Harley [1]; Martin. O Ntwaeaborwa [2]; Buyisiwe Sondezi [3]

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This study aims to apply a machine learning methodology to model and predict the magnetocaloric effect in perovskite oxides. A specialized machine learning approach was developed to predict the magnetic entropy change (Δ<i>S</i>_M) of both double and single perovskite oxide materials using data extracted from the literature. A dataset comprising 1 727 entries was constructed using ChatGPT, based on published studies. The input features include composition, synthesis method, crystal structure, space group, particle morphology, lattice parameters (<i>a</i>, <i>b</i>, <i>c</i>), magnetic phase transition type, and transition temperature. Ten machine learning (ML) models were trained using a combination of compositional and experimental features. Both linear and non-linear ML algorithms were employed to predict the negative magnetic entropy change (−Δ<i>S</i>_M) of the materials. Among the evaluated models, the Extra Trees algorithm demonstrated the best performance, achieving an R² score of 0.82. The results provide valuable guidelines for future research on magnetocaloric materials. Furthermore, the methodology is transferable and can be extended to other perovskite-related material domains, such as catalysts and solar cell materials.

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PhD

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Poster Session / 391

Synthesis and characterization of TiO2: Evaluation for possible application as light trapping layer in thin film solar cells.

Author: Rida Jaffar[1]

Co-authors: Langutani Mathevula [1]; Mbule Pontsho [2]

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In this study, titanium dioxide (TiO_2) nanoparticles were synthesized using the sol–gel method, setting the reaction time at 2, 4, and 6 h. The synthesized samples were then annealed at 500°C for 3 h. Structural, morphological, compositional, and optical characterization was carried out using X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM) coupled with energy-dispersive X-ray (EDX) spectroscopy, and UV-VIS spectroscopy. The XRD patterns confirmed the crystalline nature and tetragonal structure of the TiO_2 nanoparticles, while the average grain size and dislocation line density were also estimated using the Debye–Scherrer relation. The Anatase (2 hr and 6 hr samples) and rutile (4 hr sample) phases were confirmed, and the average crystallite size was found to be 4.75 nm for the sample prepared at 2 hrs, 27.24 nm for 4 hrs, and 4.38 nm for 6 hr reaction time. The crystallite size for the 2-hr sample decreased from 4.75 nm before annealing to 3.69 nm after annealing, while the dislocation density increased from 0.01×10^{15} to 0.245×10^{15} lines/m². A significant reduction in crystallite size was also observed in the 4-hr sample. Before annealing, the crystallite size of the 4-hr sample was 27.24 nm, which significantly dropped to 3.97 nm after annealing, accompanied by a decrease in dislocation density from 0.484×10^{15} to 0.108×10^{15} lines/m².Moreover the crystallite size for the 6-hr sample decreased from 4.38 nm before annealing to 3.72 nm after annealing, while the dislocation density increased from $0.770\times10^{1}5$ to $1.125\times10^{1}5$ lines/m². FTIR identified the functional groups comprising O–H (broad band around 3400 cm^{-1}), H–O–H bending (1620 cm^{-1}), and Ti–O/Ti–O–Ti stretching vibrations (in the range of 500–700 cm^{-1}). Raman spectroscopy further validated the presence of anatase and rutile phases through peak analysis .The presence of sharp and intense Raman peaks, particularly for the anatase samples, indicates improved crystallinity and reduced structural disorder after annealing. SEM analysis showed that longer stirring times (2–6 h) and subsequent annealing led to increased grain size, better particle uniformity, and enhanced crystallinity with reduced porosity. EDS analysis confirmed the elemental composition of TiO_2 with high purity, showing predominant peaks for titanium and oxygen. The UV-Vis spectra showed absorption at approximately 390 nm for the 2 hr and 6 hr samples, corresponding to the anatase phase, and around 420 nm for the 4 hr sample, indicating the rutile phase.The samples prepared with 2hr and 6hr reaction times, exhibited a relatively improved absorption. This study is conducted to fine-tune and optimize the properties of TiO_2 nanoparticles for potential applications in photovoltaics, such as perovskite-based solar cells.

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Poster Session / 392

Grover's ghost: Quantum searches in a new light

Author: Fazilah Nothlawala[1]

Co-authors: Isaac Nape [1]; Neelan Gounden [1]; Paola Concha Obando [1]; Thomas Konrad [2]; Andrew Forbes [1]

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The ghost imaging protocol captures the phase details of transparent objects and encodes them into the amplitude of the reconstructed image, all through joint projective measurements between two entangled photons. Similarly, Grover's algorithm amplifies the inverted amplitude of a marked element, isolating it from a larger dataset through quantum interference. Despite their different origins, both methods achieve the same fundamental effect: mapping phase information into amplitude enhancements through interference to boost detection probability. In this work, we reveal a deep and unexpected connection between Grover's search algorithm and ghost imaging. Borrowing from Grover's algorithm, we show that incorporating its diffusion operator allows ghost imaging to access hidden phase information, mapping phase details into measurable amplitude variations without the explicit need for interference. Moreover, ghost imaging's inherent robustness to noise offers a distinct advantage, enhancing the potential of this combined approach in quantum-enhanced imaging and information retrieval.

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MSc

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Poster Session / 393

Electrical characterization of vacuum-deposited all-inorganic perovskite solar cells

Author: Kyle Venter[1]

Co-author: Mmantsae Diale [2]

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Organic-inorganic perovskite solar cells suffer from low stability and the solution methods used for fabrication are not always scalable or reproducible. Perovskite solar cells with inorganic absorber layers and charge transport layers are an attractive route towards achieving long-term stability. Additionally, resistive evaporation allows for scalable and reproducible thin films. The $CsPbBr_3$ active layer is prepared using the multi-step sequential resistive evaporation of CsBr and $PbBr_2$. Charge transport layers are prepared using resistive evaporation of the metal followed by thermal oxidation to form a metal oxide. These layers are combined to form an all-inorganic, solvent-free solar cell. The optical bandgaps of the devices are found using ultraviolet-visible spectroscopy. Current-voltage measurements are used to determine the power conversion efficiency of the devices and to show hysteresis effects. Current-time measurements are used to show electronic and ionic responses under different biasing conditions. Impedance spectroscopy is measured with different voltages and light biasing to determine an equivalent circuit for the devices.

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PhD

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Photonics / 394

Revealing the unseen with tailored quantum light

Author: Fazilah Nothlawala[1]

Co-authors: Chané Moodley [1]; Neelan Gounden [1]; Isaac Nape [1]; Andrew Forbes [1]

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Quantum ghost imaging offers an interesting approach to imaging, harnessing entangled photon pairs to capture images using photons that never directly interact with the object. Traditionally, this technique relies on costly single-photon cameras or pixelated projective masks, where image resolution is fundamentally limited by the pixel size of the detectors or masks. We propose a shift from pixel-based reconstruction to modal-based reconstruction. Unlike conventional pixels, the resolution in this modal framework is no longer dictated by detector limitations but instead by the inherent optical resolution of the system. This means that basis elements can be generated with exceptionally high fidelity, as they are computed externally rather than being constrained by hardware. By capitalising on the unique properties of tailored light modes, we achieve sharper, more accurate image reconstruction while leveraging modal sparsity to further enhance fidelity. Remarkably, even when the chosen mode set is not strictly orthogonal, effective reconstruction remains possible. We illustrate this using phase-only approximations of the Hermite-Gauss (HG) modes, sidestepping the efficiency losses associated with full complex amplitude modulation. By harnessing modal sparsity, we significantly reduce the number of required measurements, allowing fast image convergence even with a non-orthogonal reconstruction set. The result? High-resolution, high-fidelity quantum ghost imaging of complex objects, achieved faster and with fewer measurements, paving the way for breakthroughs in low-light biological imaging.

Apply for student award at which level::

MSc

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Yes, I ACCEPT

Poster Session / 395

Ferroelasticity of EuTiO3 and TbMnO3 Thin Films on (001) Si

Author: Geoffrey Mwendwa[1]

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$EuTiO_3$ and $TbMnO_3$ are perovskite rare-earth-transition metal-based oxides hosting multiple ferroic order states (multiferroics). Ferroic ordering refers to the spontaneous alignment of ferroic orders due to an applied stimulus, like magnetic or electric fields. The three primary ferroic orders are ferromagnetism (spontaneous spin ordering), ferroelectricity (spontaneous charge ordering), and ferroelasticity (spontaneous strain). This work studies the ferroelasticity of $EuTiO_3$ and $TbMnO_3$ thin films under a finite magnetic field to determine the correlation between the spin and lattice electronic degrees of freedom in these materials at room temperature.
Surface Brillouin scattering (SBS) of light is investigated in $EuTiO_3$ and $TbMnO_3$ thin films deposited on (001) Si at k||d in the range of 0 to 5. These perovskite oxide films could exhibit magnetoelastic properties, and therefore, we explore their phonon-light interaction behavior under zero and non-zero magnetic field conditions.
The magnetic responses of the films show that $EuTiO_3$ and $TbMnO_3$ are paramagnetic between 200<T<300 K and exhibit complex magnetic transitions driven by competing exchange interactions at T ~ 60, 40, and 20 K. $EuTiO_3$ and $TbMnO_3$ exhibit coupled electric and magnetic order parameters. Therefore, the findings of this study provide insights into the spin, lattice, and charge dynamics in the two materials for potential implications in advanced tunable acoustic devices and spintronics applications.

Key words: Multiferroics, perovskite, SBS, electronic degrees of freedom

Apply for student award at which level::

PhD

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Yes, I ACCEPT

Poster Session / 396

Effect of Temperature on Structural and Optical Properties of Sm2O3

Author: BHARATI BAMANA[1]

Co-authors: Buyisiwe Sondezi [2]; PANKAJ MOHANTY [3]; SANYASI SITHA [1]

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Metal oxides are very popular because of their irreplaceable properties. In recent times, these metal oxides are used in several areas and particularly a number of research activities have been undertaken to explore rare-earth metal oxides. A series of rare-earth-based compounds are extensively used in several grounds of current science and technology as a result of their unusual optical, magnetic, electrical and catalytic properties ascending from their distinctive 4 <i>f</i> electrons. Samarium oxide (Sm₂O₃) amongst other rare-earth metal oxides is one of the promising rare-earth oxide functional materials due to its high electrical resistivity, high dielectric constant, energy gap, better chemical and thermal stability. This work focuses on the synthesis of Sm₂O₃ sample which has synthesized and calcined at 500 and 700 ˚C. These are followed by structural, morphological and optical properties analysis. The structural analysis through x-ray diffraction (XRD) confirmed that the compounds crystallizes in a cubic structure with lattice parameter, a, is 10.94 Å. The optical and surface morphology results are found to corroborate the crystal growth at two different temperatures.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Poster Session / 397

DESIGN OF NiO-Co3O4 HETEROSTRUCTURES LOADED WITH Pr AND Er RARE EARTH ELEMENTS FOR DETECTION OF HAZARDOUS AIR POLLUTANTS.

Author: Mathabo Joy Mothiba[None]

Co-author: Solethu Nkosi

Corresponding Author: 201832963@keyaka.ul.ac.za

Mothiba Joy1, Solethu Nkosi1

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3National Institute for Theoretical and Computational Sciences, NITheCS, Gauteng, 2000, South Africa

Developing high performance gas sensors that are less complicated is a challenge. In this work, a simple-architecture and high performance gas sensors will be designed and fabricated on inter digital electrodes. These gas sensors are made of Co_3O_4 and NiO intero-faces that are loaded with Er and Pr rare earth metals. These rare earths will bring in their electronic charge dynamics and different ionic radius into the mix. These intero-faces mixtures that are both p-type charge carriers are expected to display superior interplay properties that are beneficial to the gas sensing performance for extremely sensitive, selective and stable at affordable temperatures.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics of Condensed Matter and Materials / 398

Spectroscopic studies on $In_xGa_{1-x}N$ and $In_xGa_{1-x}N$:Si

Author: Ongeziwe Mpatani[1]

Co-authors: Dominik Muth [2]; Rajdeep Adhikari [3]; Marina Gerhard [2]; Alberta Bonanni [3]; Hilary Masenda [4]

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{$In_xGa_{1-x}N$} is a semiconductor widely used in optoelectronics[1]. Significant advancements are being made to semiconducting materials to enhance their properties. One noteworthy approach is doping InGaN with silicon Si. Photoluminescence studies were conducted on samples with 10% In concentration, both with and without silicon (Si) doping. Earlier literature indicates that introducing Si reduces the full width at half maximum (FWHM) of the band-edge emission peaks[2]. The spectra measured for the InGaN:Si samples display sharper peaks than those of pure InGaN, highlighting the potential of InGaN:Si as an ideal candidate for active layers in LEDs and laser diodes, thanks to its high emission efficiency. Additionally, measurements were performed from 10 K to room temperature to investigate the peak position shift as temperature changes. Our findings revealed an S-shape behaviour, indicating the presence of alloy disorder in both materials. Furthermore, the spectra show peaks of deep-level emissions, which were not found in earlier literature on InGaN[3]. An explanation for these emission peaks and their temperature dependence will be discussed.

Refereneces

1. S. Nakamura, Rev. Mod. Phys., 87(4), 2015.
2. S. Nakamura et al., Jpn. J. App. Phys., 32, 1993.
3. S. Nakamura et al, Jpn. J. App. Phys., 31, 1992

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics of Condensed Matter and Materials 2 / 399

Influence of SrO Concentration on Radiation Shielding Efficiency of Boro-Tellurate Glasses at High Photon Energies

Author: Sifiso Mthalane[None]

Co-authors: Busani Bhengu [1]; Linda Mdletshe [2]; Sifiso Senzo Ntshangase [2]

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In this study, the effect of radiation ionization on various glass compositions—$40SrO–30B_2O_3–10TeO_2–20Bi_2O_3$, $35SrO–30B_2O_3–10TeO_2–25Bi_2O_3$, $30SrO–30B_2O_3–10TeO_2–30Bi_2O_3$, $25SrO–30B_2O_3–10TeO_2–35Bi_2O_3$, and $20SrO–30B_2O_3–10TeO_2–40Bi_2O_3$—was investigated using Phy-X/PSD and XCOM simulation software, and validated with GEANT4 simulations. In the high-energy range of 1 MeV to 15 MeV, the mass attenuation coefficient (MAC), linear attenuation coefficient (LAC), and effective atomic number (Z_eff) were calculated for each glass sample. The results indicate that increasing the Bi_2O_3 concentration enhances the radiation shielding capability of the glasses. Additionally, parameters such as half-value layer (HVL), tenth-value layer (TVL), and mean free path (MFP) were analyzed. The findings show that glasses with higher Bi_2O_3 content attenuate more photons at smaller thicknesses. Notably, the $20SrO–30B_2O_3–10TeO_2–40Bi_2O_3$ composition demonstrated superior radiation shielding performance compared to other materials previously studied.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 400

SnO2-loaded Ga2O3-nanorods for selective and sensitive isopropanol sensing at low operating temperature.

Author: Nyepudzai C. Gatsi[1]

Co-authors: Daniel M. Wamwangi [1]; Gugu H. Mhlongo [2]; Rudolph M. Erasmus [1]

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N-type low-dimensional semiconducting oxides such as Ga₂O₃ and SnO₂ have received significant interest in the detection of toxic gases due to their excellent opto-electronic response, thermal and chemical stability. However, key challenges such as high operating temperatures and poor selectivity continue to impede their practical usage. In this study, pure Ga₂O₃ nanorods and SnO₂ nanoparticle-loaded Ga₂O₃ nanorods composite have been synthesized by hydrothermal method. A systematic comparison of their gas sensing performance, focusing on sensitivity and selectivity was conducted. The Ga₂O₃/SnO<sub>2 nanocomposite-based sensor exhibited an 8-fold enhancement in response to isopropanol compared to pure Ga₂O₃, with efficient operation at a reduced operating temperature of 80 deg;C. Moreover, the sensor showed superior selectivity towards isopropanol compared to other gases. These improvements can be attributed to the synergistic effects of high surface area, enhanced electron transport in nanorods, formation of depletion layers on Ga₂O₃ and SnO₂ microstructures, creation of heterojunction interfaces between Ga₂O<sub>3</sub and SnO₂, and abundant surface-adsorbed oxygen species. The proposed sensing mechanism of the Ga₂O₃/SnO₂ nanocomposite demonstrates the advantage of engineered nanostructures in advancing Ga₂O₃-based gas sensors.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-2 / 401

Event Selection and Analysis Strategy for Diphoton Resonance Searches Accompanied by Leptonic Final States in 2022-2024 ATLAS Run 3 data

Author: Kgothatso Ntumbe[1]

Co-authors: Baballo Victor Ndhlovu [1]; Kutlwano Makgetha [2]; Njokweni Mbuyiswa [2]; Vuyolwethu Kakancu [1]; Bruce Mellado [2]; Mukesh Kumar [2]; Rachid Mazini [3]

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The search for new scalar resonances at the Large Hadron Collider (LHC) is motivated by beyond the Standard Model (BSM) scenarios such as the Two-Higgs-Doublet Model with an additional scalar singlet (2HDM+S) and the Real Higgs Triplet Model. The 2HDM+S and Triplet model BSM frameworks is being used to study new scalar particles that may decay into final states involving photons and leptons. In particular, these models motivate searches for di-photon signatures accompanied by leptons. This study focuses on scalar resonance production via the process $gg \to H \to SS'$, where $S \to \gamma\gamma$, and S' decays into one or more leptons and/or hadrons. Relevant decay modes of S' include τ, $\ell + b$ ($\ell = e, \mu$), and multi-body final states such as 2ℓ, 2τ, or combinations thereof. Among the various final states, particular attention is given to the channels $\gamma\gamma + \ell$ and $\gamma\gamma + 2\ell/2\tau$, given their sensitivity to scalar resonances and experimental accessibility. We are currently developing analysis strategies and selection tools in preparation for the analysis of Run~3 data, corresponding to an integrated luminosity of $183\ \mathrm{fb}^{-1}$ at $\sqrt{s} = 13.6\ \mathrm{TeV}$. The goal is to identify signal-like events while mitigating dominant SM backgrounds.

Keywords: $\gamma\gamma + \ell$,$\gamma\gamma + 2\ell$

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 402

MIDI tea for biochar, possible graphite candidacy? Let's explore.

Author: Thokozane Mlotshwa[1]

Co-authors: Eric Nnditshedzeni Maluta ; Joseph Kirui ; Lordwell Jhamba

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From the rich soil of Tshivhase tea estate in Thohoyandou, blooms the green fields of Midi tea plantation and processing units. This delicious and locally produced black tea is largely available locally and open for market anywhere in the world. The increase in demand for storage devices prompted researchers to consider other possible, low cost and commercially viable alternatives to meet the demand. The synthesis and application of biomass as carbon have drawn attention due to the host of biomass available for conversion, sustainability, and cost-effectiveness. Graphite is the most popular substance used in lithium-ion batteries (LIB) as an anode material. Current LIB batteries require critical raw materials, efficient manufacturing, recycling processes and end of life management. To address the later factors, use of biodegradable materials such as biomass to produce useful products is of interest. Biomass conversion into useful materials is one of the contributing factors towards green energy techniques and achieving the 2030 sustainable development goals. The current work focuses on converting biomass wastes (MIDI tea) into synthetic graphite and analyse it for graphite-like material and application in LIB's. Heat is used to process biomass into desired carbon products. The results show that the obtained graphite-like crystallite-based nanomaterials with tunable dimensions and morphologies has remarkable features, such as high-degree of refined-graphitization.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 403

Study of the interactions between independent variables in the grade and recovery of phosphorus bearing minerals during flotation from a low- grade ore.

Author: Antoine F. Mulaba-Bafubiandi[1]

Co-authors: Mbalenhle Mpanza [2]; Pfukani Sibuyi [2]

[1] *University of Johannesburg and Universite de Mbuji-Mayi*

[2] *University of Johannesburg*

Corresponding Author: sibuyipn112@gmail.com

Often extracted from an ore with a grade ranging between 25 and 35%, phosphorus is an important element in fertilizers, medicines, selected chemical compounds, cleaning products, steels, animals' food and sensor devices. In addition to the physical magnetic and chemical concentration methods, direct concentration by flotation of phosphorus bearing minerals is employed. With an emphasis on the grade and recovery of phosphorus bearing minerals, this paper will discuss the interactions between flotation independent variables namely pH, time and reagent dosages. The contribution of their impact on the process responses will be articulated through the use of response surface model with outcomes on their sensitivity levels towards the response.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics for Development, Education and Outreach / 404

Trends in Mathematical and Physical Sciences Education in South Africa

Authors: Nthangeni Rofhiwa[1]; Aluwani Guga[None]; Tshifhiwa Ranwaha[1]; Eric Nnditshedzeni Maluta[None]; Azwinndini Muronga[2]

[1] *University Of Venda*

[2] *Nelson Mandela University*

Corresponding Author: nthangenirofhiwa01@gmail.com

The South African education system has had difficulties in delivering quality mathematics and physical science instruction to all students, as demonstrated by the nation's performance in international assessments such as the Trends in International Mathematics and Science Study (TIMSS). Almost three decades post-apartheid, the education system still fails to ensure fair access to STEM education, especially in mathematics and physical sciences. This project seeks to investigate and analyze the performance of South African learners in mathematics and physical science, scrutinizing the pre- and post-pandemic school curricula to assess their alignment with 21st-century skills expectations through a data collection method that explores national assessment reports for insights. The investigation concentrated on factors affecting learners' performance in mathematics and science, including teaching quality, resource availability, learners' socio-economic backgrounds, and curriculum and assessment policies. Through the analysis of these aspects, the study sought to elucidate the present condition of STEM education in South Africa and has effectively pinpointed areas necessitating enhancement. This project's findings further the efforts to improve the quality and accessibility of mathematics and physical science education in South Africa, thereby equipping learners for the challenges and opportunities of the 21st century.

Keywords: Performance, Socio- economy, Pandemic

Apply for student award at which level::

Honours

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 405

Effect of rare-earth doping on structural and magnetic properties of Ni-Mg spinel ferrite

Author: Amos Nhlapo[1]

Co-authors: Chester Kotsedi [2]; Justice Msomi [3]; Thomas Moyo [4]

[1] *Sefako Makgatho Health Sciences University*

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Nanocrystalline Ni0.5Mg0.5RE0.03Fe1.97O4 (RE =Dy3+, Pr3+, and Sm3+) nanoferrites were synthesized using the hydrothermal method. The X-ray diffraction (XRD) and The Fourier transform infrared spectroscopy (FTIR) confirmed the formation spinel structure. The obtained crystallite sizes ranged between 9.33 and 22.89 nm, while lattice parameters increased from 8.285 to 8.462 Å depending on the ionic radii of dopants. X-ray densities ranged between 4.761 and 5.021 g/cm^3. The specific surface area (SSA) ranged between 52.3 and 125.9 m^2/g. Hopping lengths on A- and B-sites ranged between 3.588 and 3.664 and 2.929 and 2.991 Å, respectively. The scanning electron microscopy (SEM) revealed physically shaped and agglomerated nanoparticles. The evolution of coercive fields upon reducing the measuring temperature from room temperature (300K) to 4K indicates the thermal instability of the blocked magnetic moments. Relatively high coercive fields make the materials suitable for application in transformers and high-frequency devices.

Apply for student award at which level::

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Applied Physics / 406

Quantum state reconstruction on a quantum computer

Author: Mwezi Koni[1]

Co-authors: Shawal kassim [2]; Paola Concha Obando [3]; Andrew Forbes [3]; Isaac Nape [3]

[1] *university of the witwatersrand*

[2] *University of The Witwstersrand*

[3] *University of the Witwatersrand*

Corresponding Author: 1856324@students.wits.ac.za

Quantum state tomography is an essential technique for characterizing quantum systems. It involves performing projective measurements and computationally reconstructing the density matrix from the measurement data by solving a system of linear equations. The discovery of the HHL algorithm has sparked significant interest in leveraging quantum computers to solve these equations, promising a quantum advantage. However, current quantum computers are limited by noise and constrained qubit counts—which restricts effective error correction—rendering the HHL algorithm impractical in the near term. In this work, we propose a hybrid classical-quantum approach using variational quantum eigensolvers (VQEs) for efficient state reconstruction.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics of Condensed Matter and Materials / 407

First-Principles Study of Zn-Site Transition Metal Doping in ZnSnO3 for Enhanced Performance in Dye-Sensitized Solar Cells (DSSCs)

Author: Modjadji Rebecca Letsoalo[1]

Co-authors: Ratshilumela Steve Dima [2]; Rudolph Erasmus [1]; Katekani Shingange [1]

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Zinc stannate ($ZnSnO_3$) is a wide-bandgap oxide semiconductor with considerable potential for application in solar energy conversion devices, such as dye-sensitized solar cells (DSSCs). However, its practical use is limited by its low visible spectrum absorption. The current study investigates the Zn-site partial doping with transition metals specifically Cu, Ni, and Co effect on the electronic structure and optical absorption properties of orthorhombic $ZnSnO_3$ using first-principles density functional theory (DFT). Zn-site doping was utilized owing to its superior ionic compatibility and reduced formation energy. The results obtained indicated that doping with transition metals significantly narrows the bandgap and generates shallow electronic states near the canter of the valence and conduction bands, hence enhancing light harvesting. Optical property calculations utilizing the complex dielectric function showed a red shift in the absorption edge and a general increase in absorption intensity across the visible spectrum from Cu-doped systems showing the most notable change. This computational effort provides a theoretical foundation for creating $ZnSnO_3$ photoanode materials with enhanced light absorption and electrical performance for future solar-energy systems.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 408

Atomistic simulations of iron sulphide mineral (marcasite-FeS2) based on a modified interatomic potential

Author: Mofuti Mehlape[1]

[1] *University of Limpopo*

Corresponding Author: mofuti.mehlape@ul.ac.za

Iron sulphides minerals are used for metal extraction and present in various types of rock such as igneous, sedimentary, and metamorphic ones. Marcasite-FeS2, an iron sulphide mineral is ubiquitous in nature, its oxidation plays a vital role in acid mine drainage, mineral resource recov-ery, and photoelectric material applications. In this work, we employed atomistic simulations to investigate the structural, dynamic, elastic and thermodynamic properties of marcasite-FeS2. To ensure the sufficient performance of atomistic simulations in various applications, the available interatomic potentials of marcasite are modified for better performance. The interatomic potential is validated to exhibits sufficient accuracy and transferability to various properties of bulk marca-site and surfaces. Moreover, the potential model is used for molecular dynamic simulations to study marcasite at elevated temperatures. The model predicts the melting temperature of marcasite to be in good agreement with the experimental. Furthermore, the model was used for the surface calculations of marcasite and predicted the most stable surface, i.e. {101} to compare better with the DFT data than the calculated surface energy with the original potential model. The developed inter-atomic potential can be used directly in future studies to investigate atomic-scale phenomena in minerals.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-2 / 409

A Search for a Scalar Resonance using Di-Photons in Association with a lepton and a b-jet with the ATLAS Detector

Author: Baballo-Victor Ndhlovu[1]

Co-authors: Bruce Mellado [1]; Kgothatso Ntumbe [1]; Kutlwano Makgetha [1]; Mukesh Kumar [1]; Njokweni Mbuyiswa [1]; Rachid Mazini [1]; Vuyolwethu Kakancu [1]

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The Multi-lepton anomalies at the LHC are indicative of a scalar resonance with a mass around 150 ± 5\,GeV in the $\gamma\gamma$ and $Z\gamma$ spectra in association with leptons and jets with a global significance of 5.4σ. This provides a compelling avenue for exploring new physics beyond the Standard Model using the di-photon channel. This project investigates the hypothesized resonance, where the scalar decays into a photon pair accompanied by a muon or electron and a b-jet $S(\rightarrow \gamma\gamma)+ \geq 1\ell + b$-jet. An analysis of the ATLAS data will be done in this channel, using the easyjet analysis framework, thus possibly reinforcing the hypothesis.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 410

The Evolution of the Dark Matter Paradigm

Author: Raees Noorbhai[1]

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While Dark Matter (DM) is treated as a single substance in contemporary astrophysics research, the process whereby this DM paradigm has been established is a complex one, involving both theoretical contributions and astronomical observations. In defining this paradigm, we trace the growth in the number of citations since publication for a number of seminal papers. These include theoretical papers, such as those postulating the WIMP, Axion, Sterile Heavy Neutrino and MOND hypotheses respectively. We also consider the papers containing Zwicky's 1933 Coma Cluster calculations, the 1965 discovery of the CMB, the observations of anomalous galaxy rotation curves in the early 1970s, and the results of N-body simulations of disk galaxies. We analyse trends in the citation data for these papers, accounting for the published results of collider searches, DM direct detection experiments, and indirect DM searches. Thus, we assess the impact of new evidence upon the relative prominence of the hypotheses that define the contemporary DM paradigm. We also discuss the potential of multi-messenger astronomy, using next generation telescopes, to further define this paradigm.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 411

Heat transfer Study of Lagenaria Siceraria Cucurbitaceae Material : Python Coding

Authors: Antoine F. Mulaba-Bafubiandi[1]; Samkelo Bhongoza[2]

[1] *University of Johannesburg and Universite de Mbuji-Mayi*

[2] *University of Johannesburg*

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Lagenaria Siceraria Cucurbitaceae , a biomass commonly known as calabash, is utilized in African rural communities as a transport means for fluid often water of traditional beverages and for food conservation in African rural communities. Material Heat Transfer for Food Conservation. Python coding was employed to study heat transfer process in the event hot or warm pap commonly eaten as the main meals for middle class household. The paper will discuss the observed mode of heat transfer through the material. The paper will discuss the mode observed as laboratory experiments were conducted.

Apply for student award at which level::

Consent on use of personal information: Abstract Submission:

Poster Session / 412

Development of a nonlinear response surface model to predict the volume of biogas yield of a fixed dome digester charged with cow manure.

Author: Mandilakhe Mzobotshe[1]

Co-authors: Patrick Mukumba [1]; Stephen Tangwe [1]

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Corresponding Author: 201716588@ufh.ac.za

Waste-to-energy conversion is contributing significantly in enhancing the economic growth and health quality in society. One of the technologies that utilized waste-to-energy transformation is biomass technology. The study focused on the development of a nonlinear multiple regression (response surface) model to predict the biogas production with input parameters being relative pH of slurry, slurry temperature, and product of ambient temperature and relative global irradiance using an underground fixed dome digester fed with cow dung by continuous method. The fixed dome digester was fabricated with high-density polyethylene (HDPE) PVC plastic. The data acquisition system comprised of temperature sensors, pH transducer, pyranometer, biogas analyzer, a gas flow meter, and dataloggers. The results depicted that the hydraulic retention period for the anaerobic digestion was 50 days and the cumulative volume of biogas produced was 39.41 m3 while the reactor volume was 2.15 m3. It was determined that the measured daily biogas yield and the predicted values during the hydraulic retention period demonstrated no significant difference with a determination coefficient of 0.945 and a root mean square error of 0.023. The findings from the study can lead to the conclusion that the nonlinear surface response model can predict the biogas yield with high accuracy based on the acceptable values of both the root mean square error and determination coefficient.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Photonics / 413

Tunable hybrid and non-local entanglement in photon pairs

Author: mwezi koni[1]

Co-authors: Fazilah Nothlawala [2]; Vagharshak Hakobyan [3]; Etienne Brasselet [3]; Andrew Forbes [2]

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Tailoring light's degrees of freedom and coupling them to enable complex transformations has become topical, with applications spanning high-dimensional information processing to advanced imaging systems at both classical and quantum levels. In this work, we introduce a voltage-controlled, multiwavelength spin–orbit coupling approach to engineer the entanglement properties of photon pairs generated via non-degenerate spontaneous parametric down-conversion. By adjusting the operational voltage, the device modulates its transformation rules, enabling a controlled transition from a configuration with non-local correlations across photons to one featuring local hybrid entanglement within a single photon. This versatile tool for structuring photonic states paves the way for interesting applications in quantum information processing.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Applied Physics / 414

Exciting applications for a turn-key structured light generator

Authors: Bertus Jordaan[1]; Agelo Theophilopoulos[2]; Leroy Ndlazi[2]; Mongezi Ndhlovu[1]; Cathy Maako[1]; Chibuzo Arinze[2]; Cade Peters[None]; Angela Dudley[1]; Andrew Forbes[1]

[1] *University of the Witwatersrand*

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Many applications exist for structured light. However, a barrier of entry exists for non-experts. Button Optics has created an all-in-one solution for generating different kinds of beams. Over the last year we have created a fully functional product interfacing with cameras and computer software. Moreover, we have expanded our product suite to include a diagnostic device. In this talk I will highlight some of the applications that are relevant for the immediate future and also our longer-term plans.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics of Condensed Matter and Materials / 415

First-principles and experimental insights into the structural stability and thermoelectric properties of SnSb

Author: Mmapula Baloi[1]

Co-authors: Abhishek Pandey [2]; Arthur Van Der Spuy [1]; Daniel Wamwangi [1]; Mahlaga Molepo [1]

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This study reports on the structural, electronic, dynamical, mechanical, thermodynamic, and thermoelectric properties of SnSb as a possible material for harvesting waste-heat energy. Complementary ab-initio density functional theory (DFT) and experimental studies have been carried-out to evaluate the thermoelectric performance of SnSb in the NaCl-type structure via the figure of merit, ZT. The computed ZT of 8.0 × 10⁻⁴ is an order of magnitude higher than the measured one, 5.03 × 10⁻⁵ at 300 K. The latter is limited by the measured total thermal conductivity of 76.84 Wm⁻¹K⁻¹ and the low power factor of 12.90 × 10⁻⁶ Wm⁻¹K⁻². Additionally, the elastic constants C_{11}, C_{12}, and C_{44} were computed but show disparity between the PBE and PBEsol approaches leading to deviations in the obtained Debye temperature $_D$ values. Furthermore, the computed $_D$ is overestimated when compared to the measured one of 162.83 K. The measured specific heat capacity, C_P, matches the computed one at low temperatures, while for $T >{}_D$, there was a clear deviation as the measured one does not reach a constant of 3NR as expected near 300 K. Other properties such as the electronic, dynamical, mechanical and thermodynamic properties were determined computationally. Also, the effect of an applied field was investigated on the measured resistivity ρ and C_P, respectively.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 416

Magnetic behavior of Ar implanted ZnO

Author: Vusumuzi Masondo[1]

Co-authors: Krish Bharuth-Ram [1]; Carsten Ronning [2]; Hilary Masenda [3]; Heraldur Gunnlaugsson [4]; Ongeziwe Mpatani [3]; Lehlohonolo Lisema [3]; Sanele Dlamini [1]; Torben Molholt [5]; Deena Naidoo [3]; Juliana Heiniger-Schell [6]; Bingcui Qi [4]; Petko Krastev [7]; Sveinn Olafsson [4]

[1] *Durban University of Technology*

[2] *University of Jena*

[3] *University of the Witwatersrand*

[4] *University of Iceland*

[5] *DTU Health Technology*

[6] *CERN*

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Our research is driven by the goal to realize ferromagnetism at room temperature on non-magnetic materials such as semiconductors, among other materials. If realized, semiconductor functionality should coexist with ferromagnetism, ideally above room temperature (practical operating temperatures). In our work, ZnO single crystals implanted with 45 keV ⁴⁰Ar ions up to fluences of 4.5×10¹⁵ ions/cm² were selected as a system of interest. Emission Mössbauer Spectroscopy (eMS) measurements were then carried out on the samples following implantation with ⁵⁷Mn* radioactive ion beams, which decay to the Mössbauer atom ⁵⁷Fe via β⁻ decay. Radioactive ion beams were produced at the ISOLDE facility, at CERN, through a fission reaction induced by 1.4 GeV protons on a UC₂ target, followed by a multi-stage laser ionization and mass separation by pure magnets. Two sets of measurements were carried out: (a) Temperature series measurements on the as-implanted sample and on another Ar implanted ZnO sample following annealing at 400 ⁰C in vacuum for 15 minutes, and (b) Angle dependence measurements on the annealed sample, in the presence of an external magnetic field. Temperature dependence measurements show strong magnetic features in the spectrum, with the magnetic field not dependent on the temperature, thus paramagnetism instead of ferromagnetism. Paramagnetism is further confirmed by the angle dependence of magnetic sextet lines in each spectrum. A comparison and discussion of results obtained will be presented.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Theoretical and Computational Physics / 417

Piston-Driven Shock Wave Test Problem for Validating Magnetohydrodynamic Models in Astrophysics

Author: Magdeline Seabi[1]

Co-author: Azwinndini Muronga [1]

[1] *Nelson Mandela University*

Corresponding Author: s226052184@mandela.ac.za

Computational magnetohydrodynamics (MHD) provides a powerful framework for modelling matter in extreme environments where both fluid dynamics and magnetic fields are critical. These conditions arise in heavy-ion collisions (HIC) and astrophysical events like core-collapse supernovae (CCSNe). To ensure solver accuracy, we validate our RMHD model using a piston-driven shock wave test problem, ideal for simulating the bounce stage of CCSNe, where a magnetised shock forms and propagates outward. Following validation, a complementary model for HIC will be developed to study early-stage shock evolution. This will enable the investigation of post-shock pressure and density profiles, flow coefficients (notably v2), and CME-induced charge separation. In CCSNe, we explore magnetic versus thermal pressure contributions and gravitational waveforms. Together, these observables allow for a comparative analysis of how magnetic fields influence shock propagation and structure in both astrophysical and high-energy nuclear systems.

Apply for student award at which level::

PhD

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Yes, I ACCEPT

Physics of Condensed Matter and Materials / 418

Accelerated Construction of Equations of States for Elemental and Binary Alloys via Physics-Informed Message Passing Neural Networks

Author: Thabani Ngcobo[1]

Co-authors: David Tshwane [2]; Lethabo Mogakane [3]; Prettier Morongoa Maleka [2]; RATSHILUMELA STEVE DIMA [2]; Regina Maphanga [4]

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The current paradigm of discovering, designing and optimising new materials from first-principles simulation can be prohibitively expensive to simulate. Despite the growth in popularity of machine learning to accelerate first principles design and optimisation of materials, data scarcity (Experimental and/or simulated) still poses a challenge. In this study, Physics-Informed Message Passing Neural Network (PI-MPNN) architecture is proposed to construct equations of state from sparse data obtained through Materials project and DFT calculation for elemental and binary metal alloys. The performance of this is compared to traditional MPNN and other machine learning algorithms such as Random Forest, Gradient Boost and regression at 0-15% noise level.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 419

Improving isotope production using machine learning techniqures at iThemba Labs

Authors: Bruce Mellado[1]; Donald Ngobeni[2]; Edward Nkadimeng[3]; Mukesh Kumar[2]

[1] *WIts University and iThemba LABS*

[2] *WIts University*

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Corresponding Author: 2378144@students.wits.ac.za

The production of high-quality radioisotopes is essential for nuclear medicine, scientific research and various industries. These radioisotopes are produced using advanced particle accelerators at iThemba LABS and have become the leading organization for radioisotope production. The process requires precise control over the beam parameters, the target material, and the chemical processing. However, small changes in beam parameters, target material, or chemical processing can significantly impact the amount and quality of isotopes produced. To improve on the production, we investigate the use of machine learning (ML) techniques to make the production more efficient and reliable. These techniques will mainly focus on the intelligent knowledge systems, to optimize production pathways using historical production records and real-time beam related data to enhance isotope yield and reduce inefficiencies

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 420

Density functional theory study on the effect of pressure on structural, mechanical and electronic properties of A15 M3Ru alloy

Author: Bhila Oliver Mnisi[1]

Co-authors: Evans Moseti Benecha [2]; Meriam Malebo Tibane [3]

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[2] *Senior scientist*

[3] *Acting chair of the department*

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Ruthenium-based alloys exhibit strong potential for aerospace applications. This study employs first-principles DFT calculations to examine the impact of pressure on the structural, electronic, mechanical, and phonon properties of Mn_3Ru in its A15 crystallographic phase. At zero pressure, Mn_3Ru has a negative formation energy of -0.64 eV, indicating thermodynamic stability. However, as the pressure increases from 50–200 GPa, the heat of formation becomes slightly positive, hence compromising its stability at equilibrium conditions. The density of states reveals a transition from half-metallic to metallic behavior under pressure. The alloy is mechanically unstable at 0 and 50 GPa due to negative C_{44} values but stabilizes at elevated pressures of between 100–200 GPa. Phonon dispersion confirms dynamic stability across all pressure ranges. This study demonstrates that while the application of pressure may marginally reduce the thermodynamic stability of Mn_3Ru, it significantly improves its mechanical and dynamic properties, thereby making it a promising alloy for high-temperature structural application.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 421

METHANOL FORMATION FROM SYNGAS ON ZnO (010) SURFACE: INSIGHTS FROM DFT

Author: Tshegofatso Phaahla[1]

Co-authors: Hasani Richard Chauke [1]; Phuti Esrom Ngoepe [1]

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The synthesis of methanol from syngas ($CO/CO_2/H_2$) via hydrogenation on the ZnO (010) surface supported by CuPd cluster has been studied using periodic density functional theory (DFT) calculations. Our findings indicate that direct hydrogenation of CO_2 to methanol is selective. In the presence of surface atomic hydrogen and oxygen, CO_2 tends to form highly stable formate (HCOO) and formyl (HCO). Conversely, methanol production through CO hydrogenation is both thermodynamically and kinetically viable. CO undergoes successive hydrogenation steps, forming intermediates such as formyl (HCO), formaldehyde (H_2CO), and methoxy (H_3CO), ultimately yielding methanol (H_3COH). In the sequential hydrogenation of CO, the rate-limiting step is the conversion of methoxy (H_3CO) to methanol (H_3COH). Notably, the presence of CuPd cluster significantly promotes this final hydrogenation step, reducing the adsorption energy from -0.65 eV to -3.25 eV.

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None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 422

The detection of HIV using plasmonically active colloidal gold nanoparticles

Author: Masixole Lugongolo[1]

Co-authors: Phumulani Mcoyi [1]; Luleka Mngwengwe [1]; Saturnin Ombinda-Lemboumba [1]

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Localized surface plasmon resonance (LSPR) phenomenon occurs when incident light of specific wavelength excites the free electrons on the gold nanoparticles surface, which then leads to the enhancement of the nanoparticle surface electromagnetic field. The enhanced electromagnetic field has a short decay length and is localized in LSPR as opposed to the surface plasmon resonance (SPR) where the activated surface plasmons propagate. The short electromagnetic field decay length in LSPR means that it is highly sensitive to the refractive index changes near the gold nnopaticles surface rather than the bulk refractive index in SPR. This makes this technique efficient particularly to changes induced by subtle interactions.
In this work, LSPR was used to differentiate between samples with HIV and the ones with no HIV. A glass slide was treated with 1% APTES solution in ethanol before depositing a layer of gold nanoparticles. An anti-HIV-gp120 antibody was added as a biorecognition element prior to the addition of the HIV pseudovirus as the analyte. Thereafter the slide was analyzed on an LSPR system using a green LED light.
The results showed that when using 60 nm gold nanoparticles, there was a clear distinction between a sample with the pseudovirus and the one without it as shown by the varying light transmission intensities between the negative sample and the sample with the virus.
This denotes that LSPR is sensitive enough as a label free detection method for virus detection. This can be used for the development of simple and cost effective ways of detecting various diseases in developing countries.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 423

Gas sensing properties of annealed and unannealed CoWO4 for air quality monitoring

Author: Thokozani Mpanza[1]

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The cobalt tungstate (CoWO4) nanostructures were prepared using the hydrothermal method. Nanostructures were annealed to compare the structural, optical and gas sensing properties of annealed and unannealed CoWO4. The UV-VIS spectroscopy, x-ray diffraction (XRD), scanning electron microscope (SEM) and energy dispersive x-ray spectroscopy (EDS) were used to examine the samples opti-cal, structural, morphological and composition properties respectively. The samples showed different XRD phases, where unannealed was hexagonal and annealed sample was monoclinic in structure. Dif-ferent SEM morphologies and optical band gaps of nanostructures were observed. The samples were further tested for their gas sensing properties and the unannealed CoWO4 showed the promising gas sensing performance towards NH3.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 424

Label-free optical biosensing as an alternative for HIV-1 drug resistant mutation detection

Author: Michael Mcoyi[1]

Co-authors: Kelvin Mpofu ; Masixole Lugongolo [1]; Patience Mthunzi-Kufa

[1] *Council for Scientific and Industrial Research*

Corresponding Author: mmcoyi@csir.co.za

Collectively, conventional technologies for HIV-1 drug-resistant mutation detection have established the basis for understanding the mechanisms involved in drug-resistant mutations and have thus led to the development of antiretroviral therapy (ART) regimes that target and suppress drug-resistant variants. Technologies like Sanger sequencing, Next Generation Sequencing (NGS), and Polymerase Chain Reaction (PCR) are considered gold standards for HIV-1 drug-resistant mutation detection and have since been used to inform global guidelines, particularly the World Health Organization (WHO) resistance monitoring protocols. However, their significant impact has been hindered by high costs, turnaround time, speed, accessibility, complexity, and multiplexing. This study uses optical biosensor based on localized surface plasmon resonance spectroscopy as an alternative drug-resistant detection technique. Optical biosensors offer cost effectiveness, simple and potential for point-of-care development alternative, which is important particularly in resource-limited settings. Localized surface plasmon was successfully optimized for HIV-1 drug-resistant mutation detection, moreover, the achieved wavelength shifts are comparable with our simulation results for nanoparticle response to refractive index changes.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics for Development, Education and Outreach / 425

African collaborations and related benefits

Author: Mmantsae Moche Diale[1]

[1] *University of Preoria*

Corresponding Author: mmantsae.diale@up.ac.za

In this paper, I will present on the successful collaborations and initiatives in physics in Africa. There are available funding streams for Africa collaborations from South African NRF and MRC. The examples of bilateral funding between South Africa-Zambia, SA-Egypt, and SA-Algeria, to mention but a few, have continued for many years, benefiting many South African researchers. The collaboration with Africa allows for South Africa to train brilliant minds from Africa and receive innovations for the continent. Physics initiatives like Fundamental Physics program and conference, focusing on high energy physics, ASESMA for electronic materials and structure, taking place bi-annually, traveling in Africa, and AIMS with offices in West-Africa, East Africa and South Africa are important for IUPAP - C13 - physics for development. In addition, there are also international funding like EU-Africa, SWISS-South Africa-Africa, French-South Africa and Astronomy related projects. The funded projects by South Africa at ESR, CERN, and JINR are benefiting Africa and relate to addressing skills issues for development. A recent example to EU funded project, managed by SANEDI is LEAP-RE which has produced a motorbike which was tested here in Africa, with University of Stellenbosch and Kenya. The bike was driven from Nairobi to Stellenbosch and completed the trip successfully. Also, the Africa- Materials Research Society (AMRS) taking place bi-annually is a very successful inter-disciplinary, intra-disciplinary project towards African development and attaining sustainable development goals

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Applied Physics / 426

Advancing solar energy research with perovskite materials

Author: Mmantsae Diale[1]

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Corresponding Author: mmantsae.diale@up.ac.za

Perovskite materials used for solar cell, demonstrated remarkable PCE, that increased from 3.8% in 2009 to approximately 19.44% in 2019. However, challenges such as stability and scalability remain significant obstacles to commercialization. Improvement of the perovskite solar cell stability includes material composition and crystal quality, using both intrinsic and extrinsic methods. Researchers have reported that utilizing strategies like multi-cations, multi-halides, doping, altering crystal structure and incorporating chalcogenides have improved PCE. In addition, extrinsic methods such as encapsulation, interfacial engineering and buffer layers have been used to improve stability of perovskite materials system. Furthermore, engineering solar cell systems, which include Si-tandems are reported to be capable of improving both stability and scalability. This paper will present the results from published work towards achieving stability of perovskite solar cell.

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None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 427

A First-Principles Study of the Structural, Mechanical, Dynamical and Electronic properties of HfSnPt: Half-Heusler Structure

Author: Ibrahim Omer Abdallah Ali[1]

Co-authors: B O BO Mnisi [1]; E. M. Benecha ; M M Tibane [1]

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The density functional theory (DFT) is applied to systematically investigate the geometrical structure, electronic, mechanical, vibrational, and optical properties of half-Heusler HfSnPt in its cubic phase. To the best of one's knowledge, many physical properties of this compound are still not well established or not yet investigated; such as phonon properties, mechanical behavior, thermal properties, and so on. In this work, the stability of HfSnPt is explored by looking at its thermodynamical behavior through calculation of formation energy, cohesive energy, and phonon dispersion. HfSnPt compound shows a negative heat of formation, indicating thermodynamic stability, which is consistent with it's cohesive energy. Its mechanical properties are examined based on various characterization descriptors such as the independent elastic coefficients, bulk, shear, and Young's modulus, ratios such as Pugh and Poisson's, Kleinnman parameter, Zener anisotropy factor, Debye temperature, and melting temperature. The equilibrium elastic constants satisfy all the mechanical stability criteria for cubic crystals. The analysis of band structures, along with total and partial density of states, reveals that HfSnPt structure is semiconductor with indirect band gaps of 0.910 eV for HfSnPt. Finally, the phonon calculations confirm that HfSnPt is dynamically stable. This compound exhibits thermodynamic, mechanical, and dynamic stability, along with a high melting point, making it a strong candidate for high-temperature structural applications.

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PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Applied Physics / 428

Ptychography in Ti64 alloy at the Diamond Light Source

Author: Kudakwashe Jakata[1]

Co-authors: Darren Batey [1]; Gideon Chinamatira [2]; Ronald Machaka [3]

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[2] *University of the Witwatersrand*

[3] *Idya Factory*

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We have studied a Ti6Al4V made by metal injection molding (MIM) using synchrotron X-ray imaging techniques. This alloy has superior mechanical properties compared with other titanium alloys 1. We have managed to determine the porosity, defects, and the morphology using Computed Tomography and Ptychography.

Fabrication of the alloy was carried out at the Council for Scientific and Industrial Research (CSIR) in South Africa 2. The MIM is a near-net shaping process that offers a unique ability to manufacture components with a wide range of porosity level which can provide useful scope to exploit various industrial applications 2.

Tomography was carried out at the European Synchrotron Radiation Facility, BM05 at a pixel sizes of 2.5 µm at an energy centered around 97 keV using a combination of aluminium and molybdenum filters and at 73 keV with 40 mm of SiO2 and 2.3 mm of Al as filters. A full volume reconstruction was carried out using PyHST2 software. According to these measurements, the porosity decreases as we move from the top of the specimen to the bottom. The inline phase contrast also shows that the elements are not uniformly distributed.

We have also carried out ptychography tomography measurements on the Ti6Al4V samples at the i13-1 Coherence beamline at the Diamond Light Source [3]. Two samples of cylindrical shape with a 10 µm radius were extracted using a focused ion beam (FIB). A monochromatic beam was used with a Fresnel zone plate lens to obtain the required probe size at the sample. Reconstruction of the projections was carried out using the ePIE algorithm implemented in PtyREX [4] and the reconstruction of the 3D volumes using TomoPy [5]. We will present the results obtained at nanometer resolution and the analysis.

References:
1 Kolli, R. P. and Devaraj, A., (2018). A Review of Metastable Beta Titanium Alloys. Metals, 8.7 (2075-4701)
2 Seerane, M. N. and Machaka, R., (2019). Metal injection moulding of 17-4PH stainless steel: Effects of porosity on the mechanical properties of the sintered products, IOP Conf. Ser.: Mater. Sci. Eng., 655 (012033)
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[4] Batey, D. J., (2014). Ptychographic Imaging of Mixed States, University of Sheffield
[5] Gürsoy, D. et al., (2014). TomoPy: a framework for the analysis of synchrotron tomographic data, Journal of Synchrotron Radiation, 21(5) (1188–1193)

Apply for student award at which level::

Consent on use of personal information: Abstract Submission:

Physics of Condensed Matter and Materials / 429

Bragg Coherent Diffraction Imaging and Ptychography at the Diamond Light Source i13-1 beamline

Author: Kudakwashe Jakata[1]

[1] *Diamond Light Source*

Corresponding Author: kudakwashe.jakata@diamond.ac.uk

The Diamond Light Source is an X-ray synchrotron light source in the United Kingdom with over 30 beamlines. The beamline i13-1 is an imaging beamline that takes advantage of the coherence of the coherent X-ray beam produced. Bragg coherent diffraction imaging (BCDI) and Ptychography are the main techniques available at i13-1 which has a an experimental station that is 220 m from the undulator source. Here, we will describe the main aspects of the the techniques available at the beamline and showcase some of the results that have been obtained by users. The results will include BCDI on perovskite materials and ptychographic tomography on pollen particles and a brain phantom.

Apply for student award at which level::

Consent on use of personal information: Abstract Submission:

Poster Session / 430

Study of Parton Distribution Functions using the Muonic Decay Channel of Electroweak Bosons at ALICE

Author: Joshua Browne[1]

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Corresponding Author: brwjos004@myuct.ac.za

We study the role of Parton Distribution Functions (PDFs) in calculating cross sections of Drell-Yan processes in proton-proton collisions at $\sqrt{s} = 13.6$ TeV. The theoretical production cross-sections of $W^{\pm}$ and Z bosons are calculated via their muonic decay channel using POWHEG and PYTHIA8 event generators. The contributions from each parton's PDF are explicitly shown in the rapidity-differential cross sections of Drell-Yan processes. PDF uncertainties in rapidity-differential and total cross sections are calculated. Different methods for calculating PDFs are briefly discussed and multiple modern PDF sets from different research groups are compared. This study is performed while considering the perspectives for the upcoming measurement of muons produced during proton-proton collisions at $\sqrt{s} = 13.6$ TeV with the ALICE detector, on which a corresponding data analysis can be performed to constrain PDFs.

Apply for student award at which level::

MSc

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Yes, I ACCEPT

Poster Session / 431

Investigation of structural and electronic properties of BCC Ti4V4Cr4Mn3Al high entropy alloy

Author: Ashley Phala[1]

Co-authors: Charles Siyasiya [1]; David Tshwane [2]; Regina Maphanga [2]; Sisa Pityana [2]; Steve Dima [2]

[1] *University of Pretoria*

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Hydrogen generation is predicted to replace fossil fuels in the future due to its capacity to manufacture low-carbon hydrogen through electrolysis with renewable electricity. Storage remains a challenging issue that impacts safe end utilization of hydrogen as fuel as well as its distribution and delivery. Hydrogen storage criteria for solid-state fuel cell applications include high volumetric storage capacity, good heat transmission, recharge time, and reasonable charging and discharging temperatures. Recently, high entropy alloys (HEA) enabled extensive compositional freedom for the creation of advantageous simple solid solution phases for hydrogen storage. In this work first principle computations are employed to investigate the structural, electronic and mechanical properties of Ti4V4Cr4Mn3Al HEA. It was found that Ti4V4Cr4Mn3Al HEAs compounds are energetically stable with heats of formation value greater than zero. Moreover, it was observed that the computed stability vary with with HEAs phase formation. The Ti4V4Cr4Mn3Al HEAs was found to the most stable with the BCC phase and lattice parameter a=b=c 5.86Å. . Density of states and elastic constant were computed to investigate the electronic and mechanical properties. It was found that the Ti4V4Cr4Mn3Al satisfy mechanical stability criteria for BCC phase.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 432

Study of low-medium spin states in ¹⁵⁶Er

Authors: N.N Khanyeza[1]; S.N.T Majola[2]; T.T Hlatshwayo[1]; B.V Kheswa[2]

[1] *University of Pretoria*

[2] *University of Johannesburg*

Corresponding Author: u18110283@tuks.co.za

This work aims to shed light on the low to medium spin states of ¹⁵⁶Er by analysing coincidence relationships following the ¹⁴⁷Sm(¹²C, 3n)¹⁵⁶Er reaction at 65 MeV. This experiment was performed using the AFRODITE array of iThemba LABS. A level scheme has subsequently been built using this information and a total number of 9 bands has been observed. The current work has not only observed almost all the rotational bands reported by the previous work but also suggests some changes. The implications of the new findings are therefore discussed.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 433

Atomistic Insights into Amorphisation and Recrystallisation of Nano-Spherical LiNiO₂: Phase Retention and Microstructural Evolution.

Author: Mamonamane Mphahlele[1]

Co-authors: Phuti Esrom Ngoepe [2]; Raesibe Ledwaba [1]

[1] *University of Limpopo*

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LiNiO₂ (LNO) has emerged as a promising high-capacity cathode material for lithium-ion batteries (LIBs), offering a theoretical capacity of 270 mAh/g. However, its commercialisation is hindered by structural instability and rapid voltage degradation during cycling, primarily resulting from mechanical stress induced by phase transitions and volume changes. These effects lead to particle cracking and performance decay. Nanostructuring has been proposed as a potential solution to mitigate these issues by stabilising phase transitions and enhancing mechanical integrity. In this study, a simulated synthesis approach was employed to generate nano-spherical LiNiO₂ models and track the evolution of their microstructure during crystal growth. The synthesis involves simulated amorphisation, then proceeds to recrystallisation under a canonical ensemble with constant temperature and volume, and ends with gradual simulated annealing of the recrystallised structure. Through systematic trial and error, the optimal temperatures were identified as 1400 K for amorphisation and 1200 K for recrystallisation. The formation of LiNiO₂ was confirmed through simulated X-ray diffraction (XRD) patterns and atomic snapshots. However, the XRD analysis also revealed impurity peaks corresponding to spinel NiO phases. Post-cooling structural analysis confirmed phase retention, with both XRD and radial distribution function (RDF) analyses providing insights into the structural evolution of the material. These findings contribute to the optimisation of thermal processing conditions, paving the way for more structurally stable and high-performance LiNiO₂ cathodes in lithium-ion batteries.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Theoretical and Computational Physics / 434

Advancing Dark-QCD searches: Model Development, Constraints, and Novel Anomaly Detection Technique

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[1] *University of Witwatersrand*

Corresponding Author: deepak.kar@cern.ch

Strongly interacting dark sectors, colloquially referred to as dark-QCD, is becoming increasingly popular in the collider community, primarily because of the rich phenomenology and the novel signatures it offers. The author pioneered the first search for semi-visible jets in ATLAS, and is following that up with multiple studies focussing on other final states (arXiv:2207.01885), new generator setups to simulate the signals (WiP), new discriminating observables (arXiv:2209.14964, WiP), setting constraints on these models based on existing results (arXiv:2502.11237) and a novel use of anomaly detection algorithms (WiP) to aid finding these signatures. In the presentation, the lessons learnt from the ATLAS result will be discussed, and these work-in-progress results on model development, constraints of the models, as well anomaly detection method being proposed will be presented, essentially summarising the state-of-the art in the semi-visible jets.

Apply for student award at which level::

None

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Yes, I ACCEPT

Poster Session / 435

Wind Energy Potential in Local Areas

Authors: Matumba Rotondwa Muriel[None]; Lufuno Takalani[1]; Tshifhiwa Ranwaha[2]; Eric Nnditshedzeni Maluta[None]

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Rural regions are largely reliant on non-renewable energy sources and frequently experience energy shortages. Alternative renewable energy sources like wind energy must be investigated to lessen dependency on fossil fuels and advance sustainability in these areas. This study evaluates wind energy potential in nearby locations by examining wind speed, direction, and flux data gathered using a weather station and eddy covariance flux tower. The aim was to determine the viability of small-scale wind energy plants. The demand for renewable energy sources has increased and has intensified global interest in wind energy as an effective alternative to fossil fuels. Wind energy is also environmentally beneficial, which makes it a very important component in the shift to sustainable energy systems. Wind energy has become an intense alternative to non-renewable energy systems. If wind energy is effectively used, it can supply a substantial amount of the worlds electrical needs because it is abundant, renewable and not polluting.The analysis show small-scale projects are possible and whether the local wind conditions are appropriate for wind energy generation. It might also draw attention to the seasons or environmental factors with the most significant potential for wind generation. The study recommends small-scale wind energy systems in appropriate locations considering the findings. The best sites and wind turbine parameters should be investigated in further detail. Policymakers must incorporate wind energy into regional energy planning plans to promote sustainable growth. The need to minimize greenhouse gas emissions, the finite nature of fossil fuel resources, and growing concerns about environmental sustainability have all changed the global energy landscape. Even though wind energy is becoming more popular, few region-specific evaluations still consider both technical and meteorological considerations.

Apply for student award at which level::

Honours

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Astrophysics & Space Science / 436

Investigating the latitudinal-dependent solar differential rotation rate using SDO/HMI Dopplergrams

Author: Thembalethu Zulu[None]

Co-author: Ruhann Steyn [1]

[1] *Supervisor*

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The solar photospheric differential rotation rate has novel implications to the structure of the heliospheric magnetic field. The period of the solar poles is ~ 35 days, and ~ 25 days at the equator. In this study, the Doppler shift (either blue or red) of 116 Dopplergrams from the Helioseismic and Magnetic Imager instrument on board the Solar Dynamics Observatory are investigated to experimentally determine the photospheric differential rotation rate at different solar latitudes. A model is developed to describe the variation of surface speed with solar latitude. The results are compared to well-established models in the literature and shows strong consistency in trend and behaviour. The findings confirm the latitudinal differential rotation of the Sun. The developed model shows a deviation of less than 10% when compared to established models in the literature, demonstrating its accuracy and consistency. This is particularly significant considering the difference in time scales, with the models in the literature using data spanning more than a decade, compared to the model developed using approximately an hour and a half of collected data. This study not only confirms the theoretical expectations regarding solar rotation but also demonstrates the effectiveness of Doppler spectroscopic analysis and space-based solar observations in studying solar dynamics. The results contribute to a broader understanding of solar behaviour.

Apply for student award at which level::

Honours

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Yes, I ACCEPT

Applied Physics / 437

Modulating properties of solid carbon nanospheres via ion implantation with hetero-ions

Authors: Joyce Matsoso[1]; Trevor Derry[None]

Co-authors: Daniel Wamwangi [2]; Rudolph Erasmus [3]; Neil J. Coville [4]

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[3] *University of the Witwatersrand, Johannesburg*

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Solid carbon nanospheres of ~200 nm diameter have been prepared and then doped by ion implantation, using a specialized end-station adapted for the uniform implantation of powders. Boron, nitrogen and neon ions were chosen initially, the latter for control purposes. Herein, the dependence of the physicochemical properties of solid carbon spheres on the fluence of the implanted ions was investigated by controlling the dosage of the 100 keV of B+, N+ and Ne+ ions into the carbon shell over 7 h and 14 h implantation periods at room temperature. SEM analysis revealed significant surface deformation in the form of cracks for the Ne+ implanted samples, whilst little structural deformation was observed when N+ and B+ implanted samples. Furthermore, TEM micrographs confirmed dependence of the structural properties on the ion fluence, as shown by formation of varying thickness of an amorphous carbon layer after implantation with B+, N+ and Ne+ ions, respectively. Finally, magnetic properties showed that the type of the hetero-ion as well as the affiliation of the carbon to the hetero-ion influenced the transition from diamagnetism to super-paramagnetism. The Néel temperature varied somewhat but was below about 10 K. Boron conferred a much greater paramagnetic susceptibility at low temperature than the other ions, and showed indications of a higher electrical conductivity at higher temperatures, suggesting an electronic doping effect. The study showed the importance of the choice of the heteroatom ion on the properties of the solid carbon spheres for the development of next generation carbon-based electronic devices.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Astrophysics & Space Science / 438

MeerKAT view of serendipitously discovered MGCLS GRGs

Author: Nceba Mhlahlo[1]

Co-authors: Kabelo Kesebonye [1]; Kenda knowles [2]; Nadeem Oozeer [3]

[1] *University of the Witwatersrand*

[2] *Rhodes University / SARAO South Africa*

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Corresponding Author: nceba.mhlahlo@wits.ac.za

Giant radio galaxies (GRGs) are peculiar astrophysical objects because of their exceptionally large linear sizes (>0.7 Mpc). The cause for their huge sizes remains a mystery.
We investigate the spectral behaviour of a small sample of seven (7) GRGs detected from the MeerKAT Galaxy Cluster Legacy Survey (MGCLS). These sources have a minimum linear size of 0.723 Mpc to a maximum linear size of 2.209 Mpc. The spectral index analysis reveals steeper spectral indices around the lobes and flatter spectral indices toward the core for most of the sources. In one of our sources (MKT J021309.59-474414.1), we observe a signature of a backflow while in another (MKT J002659.83-121831.3) a potential episodic activity. We further confirm that one of our sources is most likely to be found in a cluster environment. We detect a new GRG which is the largest in our sample, with a radio morphology that shows complex features. The source is hosted by an elliptical galaxy with a stellar mass of $7.413^{+0.222}_{-0.216}\times 10^{11}$ M .

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Applied Physics / 439

A Comparative Analysis of Radiation-Induced Wavelength Shift in Radiation-Soft and -Hard Fibre Bragg Gratings Exposed to Proton Irradiation

Author: Bongani Maqabuka[None]

Co-author: Simon Connell [1]

[1] *University of Johannesburg*

Corresponding Author: bmaqabuka77@gmail.com

Fibre Bragg Gratings (FBGs) have emerged as highly sensitive sensors for monitoring environmental parameters such as temperature, strain, radiation dose, etc. Moreover, they can withstand extreme environments, of interest here, a high radiation dose environment. The goal of this work is to develop reliable sensing instruments for high radiation-hard environments, such as the ATLAS inner tracker where radiation can go up 20 MGy and in nuclear reactors which require radiation resistance up to at least 1 GGy.

This study presents a comparative investigation of radiation-induced wavelength shifts in radiation-soft and radiation-hard FBGs exposed to proton irradiation at CERN, reaching a cumulative dose of 2.6 MGy over one week. These values are extrapolated to the typical dose that would be received in a two-week to a month run in-core and full-power in a power reactor. The extrapolation is done using Monte Carlo modelling.

The core of the optical fibres consists of SiO2 base material. Dopants such as germanium (Ge), phosphorous (P), fluorine (F), and aluminum (Al) are incorporated into the silica matrix to modify its refractive index. Fibres with pure silica cores, and fluorine-doped cores, have been found to have much higher resistance to ionizing radiation (i.e. radiation-hard) than compared to other dopants.

The results highlight the degradation mechanisms in radiation-soft and radiation-hard FBGs, providing critical insights for their deployment in extreme radiation environments. This work advances the development of robust FBG-based sensors for particle physics, space instrumentation, and nuclear energy systems, where real-time dose monitoring in high-radiation fields is essential.

Apply for student award at which level::

Consent on use of personal information: Abstract Submission:

Poster Session / 440

Analysis of structural and electronic properties of LiTi2(PO4)3 solid-state electrolyte material for application in lithium-ion batteries

Author: MOLATELO MATLEKE[None]

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[2] *University of LImpopo*

[3] *University of Limpopo*

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Solid electrolytes (SEs) offer high energy densities, are compatible with high-voltage cathodes, and possess high thermal and electrochemical stability. Amongst other SEs, LiTi2(PO4)3 (LTP) with the NASICON-type structure has captured significant interest as a better SE owing to its excellent chemical stability, environmental friendliness, and economic viability. LiTi₂(PO₄)₃ (LTP) possesses the NASICON-type structure built from corner-sharing octahedra (LiO₆, TiO₆) and tetrahedra (PO₄) to form a chemically stable structural framework that facilitates Li+ transport. Unfortunately, the ionic conductivity (< 10-6 S/cm) of lithium ions was found to be less for practical use in LIBs. As such, the systematic introduction of sulphur will be carried out as a remedial approach for this challenge. However, prior to that, there is a need to understand the fundamental properties of LiTi₂(PO₄)₃ that will pave way as a benchmark for the contribution of sulphur towards the electrochemical enhancement of this solid electrolyte material. In this current study, the electronic and structural properties of undoped LTP are studied to form a strong foundation for the partial substitution of oxygen with sulphur. The Vienna ab initio Simulation Package was used to generate the ground state structure of LTP with a cutoff energy of 550 eV and Monkhorst-Pack K-points of 8x5x4. The lattice parameters we found to be a=b=8.618 Å and c=21.079 Å, which are comparable to the experimental values (a=b=8.534 Å and c=20.843 Å). Additionally, the electronic inactivity of the material was confirmed by band structure and density of states (DoS) calculations. The band structure and DoS showed a band gap of ~2.49 eV, comparable to the value of 2.38 eV determined by Chen L.J. et. al., indicating insulating properties of solid electrolyte materials, which is an essential parameter for application in LIBs. These findings and parameters set a good basis for the groundwork of investigating the effect of sulphur on the electrochemical properties of this structure.

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Apply for student award at which level::

Honours

Physics for Development, Education and Outreach / 441

Implications of Separate Marks for Physics and Chemistry in Matric Results

Author: VHUTSHILO NEKHUBVI[1]

Co-authors: Malebogo Legodi [1]; Rene pearce [1]; Wandile Nhlapo [1]

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Passing the matriculation examination with a bachelor's status is a prerequisite for admission to most university degree programmes in South Africa. However, many learners struggle to obtain enough Physical sciences and Mathematics scores to be admitted to a full degree program. Such learners are admitted to the extended curriculum program, which equips them with skills to improve their matric results. This study examines the effects of separation of chemistry and physics subjects in the post-matriculation certificate rather than the overall grade in physical science. It uses historical data (11 years) from first-year ECP students to explore the potential benefits. The study identified challenges and implications, including related to students, lecturers, administrators, and higher education stakeholders. Key findings include (1) improved, enhanced subject mastery and informed career choices for students. (2) Improved teaching strategies and curriculum adaptations. The study recommends a pilot trial to investigate the feasibility of separate grades for physics and chemistry in South African schools. Ethical considerations and limitations of the current research are addressed, and the need for careful implementation and ongoing evaluation of the separate grading marks system is emphasized. The conclusion emphasises the potential of this study to significantly impact the physics and chemistry education landscape in South Africa, necessitating further research investigation.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 442

A Python-Flask Application for Modelling Surface Plasmon Resonance in Biosensors for Educational and Research use

Author: Kelvin Mpofu[1]

Co-author: Patience Mthunzi-Kufa [1]

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We present a browser-based simulation tool for Surface Plasmon Resonance (SPR) sensor modelling, developed using Python and Flask. The tool allows users to visualize reflectance curves based on selected or custom parameters, incorporating Drude models for metals and experimentally validated refractive index equations for biological media such as plasma and blood. Users can generate real-time SPR curves for educational and research purposes, with interactive plotting and an embedded example from recent literature. The app is lightweight, accessible, and suited for under-resourced environments, promoting deeper engagement with SPR physics.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Poster Session / 443

Organic use of chlorophyll extracted from green algae in Dye-Sensitized Solar Cell

Authors: Lindiwe Mthimunye[1]; Mmantsae Diale[2]

Co-author: Lucy Moleleki [3]

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This study investigates the extraction methods of chlorophyll extracted from green algae to be used a natural photosensitizer in dye-sensitized solar cells (DSSCs). Three extraction meth-ods were employed: solvent-assisted extraction (SAE), ultrasonic-assisted extraction (UAE), and microwave-assisted extraction (MAE). Chlorophyll was then characterized for its optical, morphological, and structural properties. Ultraviolet-visible (UV-vis) spectroscopy revealed absorption peaks which corresponds with chlorophyll a, chlorophyll b, carotenoids and flavo-noids. The MAE method produced the highest chlorophyll yield. Furthermore, direct band gap of the extracted chlorophyll was estimated using Tauc's plot analysis which revealed 1.67 eV and 2,5 eV suggesting efficient light absorption. Photoluminescence (PL) showed a higher in-tensity in MAE and UAE as compared to SAE. Confocal microscopy images further confirmed the presence of chlorophyll a (green) and chlorophyll b (red), providing visual insight into the distribution of pigments within the algae. Scanning electron microscopy (SEM) morphology revealed line-array surface structured with longitudinal orientation. Fourier transform infrared (FTIR) spectroscopy identified structural and function groups with prominent peaks around 878 cm-1, 1045 cm-1, 1639 cm-1, and 3341 cm-1, correlating with C-H, C-O, C=C and N-H stretches, respectively. Consequently, the results suggest that MAE and UAE techniques are the most efficient for DSSC application.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 444

Cooperative Energy Transfer and Upconversion Luminescence of Sr5(PO4)3OH:Eu3+,Yb3+ phosphor powders

Author: Puseletso Mokoena[None]

Co-authors: Babiker Jaffer ; ntwaeaborwa ; swart [1]

[1] *UFS*

Corresponding Author: puseletso.mokoena@spu.ac.za

In this study, strontium hydroxyapatite ($Sr_5(PO_4)_3OH$) doped with europium (Eu^{3+}) and ytterbium (Yb^{3+}) were successfully synthesized by combustion method. The structural, morphological, and optical properties of the phosphors were determined using X-ray diffraction (XRD), high resolution scanning electron microscopy (HRSEM), energy dispersive X-ray spectroscopy (EDS), and photoluminescence (PL) spectroscopy. XRD data confirmed crystallization of pure hexagonal phase of $Sr_5(PO_4)_3OH$ and HRSEM revealed a network of particles with irregular shapes having small bright particles encrusted on the surface of the bigger particles. The EDS analysis confirm that bright particles were dominated by rare earth elements, while darker particles are primarily composed of the host material. Upon UV excitation, prominent orange emission and minor red emission peaks corresponding to Eu^{3+} transitions were observed. The red emission was enhanced significantly upon co-doping with Yb^{3+}, which facilitated non-radiative energy transfer from Yb^{3+} to Eu^{3+}. The enhanced red upconversion luminescence of $Sr_5(PO_4)_3OH:Eu^{3+},Yb^{3+}$ phosphors shows promising potential for applications in photodynamic therapy (PDT).

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Astrophysics & Space Science / 445

Tracing the origin of radio emission in galaxies with MIGHTEE

Author: Sthabile Kolwa[1]

Co-authors: Lennart Heino [2]; Mattia Vaccari ; Russ Taylor [3]; Sushant Dutta [3]

[1] *UNISA*

[2] *UCT*

[3] *IDIA*

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Pinpointing the true source of radio emission in galaxies is a rather complex task that requires detailed modelling of radio spectral energy distributions. With the recent availability of catalogues of radio sources detected with interferometers such as MeerKAT, uGMRT, and LOFAR, we are able to push down the detectable flux range to the point where we can detect the faintest radio emission in galaxies. At this faint flux end, it is generally unclear which specific mechanisms produce radio emission. In this foundational study, we begin to tackle this quandary by obtaining constraints on spectral curvature using four-band radio detections spanning observed frequencies of 100 MHz - 2 GHz for radio-loud AGN. Considering the Eddington and Malmquist biases which skew our results at low and high radio fluxes, respectively, we find a dominance of steep spectrum sources among the radio-loud active galactic nuclei (AGN) population indicative of synchrotron processes originating from the jets and lobes. For non radio-loud AGN (assumed to be normal star-forming galaxies and radio-faint AGN), we see a predominance of flat spectra associated with thermal processes occurring in HII regions.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 447

Computational Modelling Study on Stability of Li-S/Se System

Author: Cliffton Masedi[1]

Co-author: Phuti Ngoepe [1]

[1] *University of Limpopo*

Corresponding Author: cliffton.masedi@ul.ac.za

Lithium Sulphur batteries suffers from the low conductivity of S and the solubility of intermediary polysulfide species during cycling. It has been reported that Se and mixed SexSy represent an attractive new class of cathode materials with promising electrochemical performance in reactions with both Li ions. Notably, unlike existing Li/S batteries that only operate at high temperature, these new Se and Li/SexSy electrodes are capable of room temperature cycling. To study large systems and impact of temperature effectively, empirical interatomic potentials of Li2S were derived and validated against available experimental structure and elastic properties. Complex high temperature transformations and melting of Li2S was reproduced, as deuced from molecular dynamics simulations. Li2S was found to withstand high temperatures, up to 1250K each which is a desirable in future advanced battery technologies. Cluster expansion and Monte-Carlo simulations were employed to determine phase changes and high temperature properties of mixed Li2S-Se. The former generated 42 new stable multi-component Li2S-Se structures. Monte Carlo simulations produced thermodynamic properties of Li2S-Se system for the entire range of Se concentrations obtained from cluster expansion and it demonstrated that Li2S-Se is a phase separating system at 0K but changes to mixed system at approximately 350K.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 448

Orthogonality study for the A/S→ZdZd→2l2v/2l2j with the ATLAS detector at the LHC

Author: Doomnull Unwuchola[1]

Co-authors: Ketevi Assamagan [2]; Lerothodi Leeuw [1]; Loan Truong [3]; Michiel Veen [4]; Rafael Coelho Lopes De Sa [4]; Simon Connell [3]

[1] *University of the Western Cape*

[2] *Brookhaven National Lab*

[3] *University of johannesburg*

[4] *University of Massachusetts*

Corresponding Author: doomnull@gmail.com

The hidden abelian Higgs model is used for a search for an additional scalar decaying to two Z-dark bosons (Zd) to two leptons, two neutrinos (2l2v) . The search uses ⊠⊠ collision data collected with the ATLAS detector at the LHC with an integrated luminosity of 139 fb^{-1} at a centre-of-mass energy $\sqrt{s}$= 13 TeV . This is a follow up to the study of the 4l final states 1. In our 2l2v channel analysis, using the HAHM on Run-2 and Run-3 data with the ATLAS detector to conduct the search for an additional scalar with a distinct mass from the Higgs boson demands study of signal overlap from the 2l2j channel. A technique is introduced to separate signal events of our 2l2v channel from that of the 2l2j channel . We present the work and result of orthogonality study done to achieve this.

1 ATLAS Collaboration. (2024). Search for a new scalar decaying into new spin-1 bosons in four-lepton final states with the ATLAS detector (CERN-EP-2024-248). arXiv:2410.16781 [hep-ex].

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Applied Physics / 449

Development and Qualification of a Fiber Optic Sensor Package for ITk Environmental Monitoring

Author: Doomnull Unwuchola[1]

Co-authors: Abdool Cassim [2]; Bongani Maqabuka [2]; Lerothodi Leeuw [1]; Loan Truong [2]; Simon Connell [2]; Xola Mapekula [2]; matthew Connell [2]

[1] *University of the Western Cape*

[2] *University of johannesburg*

Corresponding Author: doomnull@gmail.com

The High-Luminosity Large Hadron Collider requires precise environmental monitoring in the ATLAS Inner Tracker to prevent water condensation that could damage detector electronics. This study focuses on the development and the performance of Fibre Optic Sensor packages. Each package is made up of a Long Period Grating sensor and two Fibre Bragg Grating sensors for accurate temperature, dose and relative humidity measurements in a harsh radiation environment 1. Extraction of the relative humidity (and Dew point) involves the decoupling of the effects of the measured temperature and radiation dose which requires compensation to be accurate. The temperature and relative humidity measurements may depend on location in the 2D (temperature, relative humidity) plane, as indicated by some measurements. This could be an effect of the packaging or a systematic physics effect of the FOS sensors. Calibration studies were performed to assess any possible dependency of temperature calibration on relative humidity in order to determine whether it arises from real sensor sensitivity or external factors such as packaging constraints. Calibration protocols were extended, and compensation algorithms refined to improve measurement accuracy. We present the outcome of the made Fibre Optic Sensor package and compensation methodology to ensure stable ATLAS Inner Tracker conditions for the High-Luminosity Large Hadron Collider era.

1 L. Scherino et al., “Fiber optic sensors in the ATLAS Inner Detector,” Nucl. Instrum. Methods Phys. Res., Sect. A, vol. 1029, p. 166470, 2022, doi: 10.1016/j.nima.2022.166470.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 450

Nuclear Forensic Science: A Tool for Mitigating Environmental Impact and Risks Associated with Nuclear Wastes

Author: Stephen Friday OLUKOTUN[1]

Co-authors: Manny MATHUTHU [1]; Olubusayo Felix OLADEJO [2]; Samuel Odumu Ogana JOHN [1]; Tebogo Gilbert KUPI [1]; Tsholofelo Desiree MOKGELE [1]

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Nuclear Forensic Science (NFS) plays a crucial role in enhancing nuclear security, primarily through the detection and attribution of illicit nuclear materials. However, its application in nuclear waste management remains underexplored. Inadequate disposal and poor tracking of nuclear waste pose significant environmental and public health risks, especially in regions with limited regulatory oversight. This study intends to investigate the potential of NFS techniques to mitigate environmental threats associated with nuclear wastes. Analytical methods such as isotopic ratio analysis, rare earth element (REE) profiling, trace element analysis, and radiochemical dating will be applied to determine the origin, composition, and transport pathways of nuclear wastes. These tools can help identify sources of contamination, trace unauthorized disposal activities, and assign responsibility to relevant parties. By integrating NFS into nuclear waste management frameworks, regulatory bodies can improve accountability, ensure compliance with international standards, and prevent future environmental contamination. In conclusion, NFS can offer a promising pathway for strengthening environmental protection and promoting responsible nuclear practices through enhanced waste traceability and oversight.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 451

Determine the Mn-rich phases of transition metal carbonate precursors using Universal Cluster Expansion code

Author: Mogahabo Morukuladi[1]

Co-authors: Clifton Masedi [1]; Noko Ngoepe [1]; Phuti Ngoepe [1]

[1] *UL*

Corresponding Author: 201216310@keyaka.ul.ac.za

Of all the different types of batteries available and currently developed, lithium-ion batteries (LIBs) have gained a significant segmentation in the market and are the most promising and the fastest growing battery technology. However, the performance of any Li-ion battery greatly depends on the physical and chemical properties of the cathode material, which serves as a host for Li ions. As such, three classes of metal oxide cathodes such as olivine, spinel and layered have been discovered. From the transition metal oxides discovered, this study focuses on the layered composites as they have recently attracted a lot of interest, as the alternative high energy density cathode due to their low cost and less toxicity as compared to other commercialized cathodes for lithium ion batteries. This study reports first-principles calculations on the structural, thermodynamic, electronic, elastic and dynamic properties of layered transition metal oxide at 0 K. The Universal Cluster expansion code managed to generate the manganese rich phases namely Ni0.3Mn0.5Co0.17CO3, Ni0.17Mn0.67Co0.17CO3, Ni0.13Mn0.75Co0.13CO3, Ni0.17Mn0.84Co0.17CO3 and Ni0.13Mn0.87Co0.13CO3. The results showed the thermodynamic stability as follows: Ni0.13Mn0.87Co0.13CO3 > Ni0.13Mn0.75Co0.13CO3 > Ni0.17Mn0.84Co0.17CO3 > Ni0.17Mn0.67Co0.17CO3 > Ni0.3Mn0.5Co0.17CO3.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 452

Understanding the structure of ^{16}C and the $B(E2)$ problem through Large-Scale Shell-Model (LSSM) calculations

Author: Khuliso Murulane[1]

[1] *University of Johannesburg*

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The structure of neutron-rich carbon isotopes continues to be a subject of interest in nuclear physics, particularly the nucleus ^{16}C. One of the key unresolved issues is the variation in measured $B(E2)$ values for the transition from the first-excited 2_1^+ state to the ground state, with reported values spanning nearly an order of magnitude. Traditional interpretations assume a simple model in which two valence neutrons couple to a ^{14}C core, requiring the introduction of a large effective charge to match experimental data. However, this approach does not fully capture the complexity of ^{16}C's nuclear structure.

This work presents results from a large-scale $(2 + 4)\hbar\omega$ no-core shell-model calculation of ^{16}C, incorporating six major shells and employing the Zheng *et al.* interaction within the OXBASH framework. The analysis of the wave functions indicates significant mixing of higher-order configurations, challenging the validity of the simple two-neutron model. The theoretical predictions are further validated by comparing the computed excitation spectrum and intermediate-energy elastic proton scattering cross-sections with experimental data. Notably, the results demonstrate that a smaller, or even negligible, effective charge is sufficient to reproduce the accepted $B(E2)$ value, resolving discrepancies observed in previous studies.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-2 / 453

Strategy for Particle Physics: Opportunities for South Africa

Author: Bruce Mellado[1]

Co-authors: Elias Sideras-Haddad [2]; Mukesh Kumar [3]; Rachid Mazini [3]

[1] *University of the Witwatersrand and iThemba LABS*

[2] *University of the Witwatersrand*

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The field of collider particle physics is at a pivotal juncture, with global debates intensifying over the direction of future accelerators and large-scale international collaborations. As the scientific landscape continues to evolve, it is imperative for the global particle physics community to refine its strategic priorities and align around shared goals. The European Strategy for Particle Physics, last updated in 2020, is slated for revision in 2026, providing a timely opportunity for reflection and repositioning. While the High-Luminosity LHC defines the short- to mid-term horizon, proposed next-generation electron-positron colliders—including the ILC, FCC-ee, and CEPC—stand as prominent contenders for the future. Additionally, new bridge projects and alternative accelerator concepts are gaining traction, particularly at CERN. This talk will review the current global landscape and explore how South Africa can strategically position itself within these developments, highlighting potential avenues for participation, leadership, and impact in the next era of particle physics.

Apply for student award at which level::

Consent on use of personal information: Abstract Submission:

Poster Session / 454

Preliminary Analysis of Energy Demand Characteristics in a Renewable Microgrid at Masia Agricultural Development Centre.

Author: Ipfi Mnandi[None]

Co-authors: David Tinarwo [1]; Shandukani Muronga [1]; Sophie Mulaudzi [1]; Thandeka Dlamini [2]

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The global shift towards sustainable energy highlights rural electrification via renewable energy microgrids. In South Africa, agricultural development centres are crucial for ensuring food security and fostering rural economic growth, yet they frequently struggle with unreliable electricity access. Understanding the energy consumption patterns of these facilities is essential for effective system design and energy planning. This study offers a preliminary analysis of the energy demand at Masia Agricultural Development Centre in Limpopo, supported by a hybrid renewable energy microgrid. Rather than assessing an existing energy system's performance, this research explores the potential for adaptive demand-side management strategies in similar rural microgrid settings. The analysis centres on essential agricultural energy demands, including irrigation, water pumping, and cold storage, which exhibit significant fluctuations over short periods. Short-term energy consumption data were gathered in real-time using a data logger to track daily load variations and pinpoint peak demand times. These insights were utilised to simulate and evaluate diverse hybrid system configurations through the Hybrid Optimization Model for Electric Renewables (HOMER) software. The simulation examined various dispatch strategies to determine the most feasible and effective microgrid setup for satisfying the centre's energy requirements. The results of this study provide initial benchmarks for future comprehensive investigations and help improve energy access and sustainability in off-grid farming communities. This is consistent with national electrification goals and supports Sustainable Development Goals.

Keywords: Renewable Microgrid, Energy Consumption, Agricultural Energy Demand, Preliminary Analysis

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 455

Looking for axion decay around a black hole

Author: Geoff Beck[1]

Co-author: Javeria Makda [2]

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[2] *PhD Student - Wits University*

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In this work, we aim to compute the radio flux from the decay of axions close to Saggitarius A*, the supermassive black hole at the center of our galaxy. These particles can undergo stimulated decay in the presence of photons with energies of half the axion mass. We make use of an observed spectrum for Sgr A** emission in the frequency range of SKA and the VLBA, to find the effect of stimulated decay on a range of axion masses. We also follow recent studies that indicate the existence of a dark matter spike near the black hole to boost the observed flux. These quantities are used in the computation of the predicted axion flux and in obtaining limits on the axion coupling as a function of axion mass that would result from a non-observation of an axion line via VLBI.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-2 / 456

Highlights of ALICE results from heavy-flavour measurements at LHC energies

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[1] *NRF-iThemba LABS*

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Edith Zinhle Buthelezi for the ALICE Collaboration

Heavy quarks or heavy flavours (charm and beauty) are produced mainly in initial hard-scattering processes of hadron-hadron collisions. Due to their large masses, their production cross sections are predicted via perturbative quantum chromodynamics (pQCD) models. They offer a unique perspective to study quark fragmentation and hadronisation. In ALICE, heavy flavours are measured via the hadronic and leptonic decay channels in small-system collisions, e.g. proton-proton (pp) and proton-lead (p-Pb), as well as in heavy-ion (Pb-Pb) collisions at ultrarelativistic energies provided by the CERN Large Hadron Collider (LHC).

This presentation will focus on a selection of heavy-flavour results published by the ALICE collaboration.

Apply for student award at which level::

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 457

Improving isotope production using machine learning techniqures at iThemba Labs

Author: Donald Ngobeni[None]

Co-authors: Bruce Mellado [1]; Edward Nkadimeng [2]; Mukesh Kumar [3]

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The production of high-quality radioisotopes is essential for nuclear medicine, scientific research and various industries. These radioisotopes are produced using advanced particle accelerators at iThemba LABS and have become the leading organization for radioisotope production. The process requires precise control over the beam parameters, the target material, and the chemical processing. However, small changes in beam parameters, target material, or chemical processing can significantly impact the amount and quality of isotopes produced. To improve on the production, we investigate the use of machine learning (ML) techniques to make the production more efficient and reliable. These techniques will mainly focus on the intelligent knowledge systems, to optimize production pathways using historical production records and real-time beam related data to enhance isotope yield and reduce inefficiencies.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Astrophysics & Space Science / 458

Wits Astronomical Plate Archive –preservation of a century of Southern Hemisphere astronomy at the Johannesburg Observatory

Authors: Alec Jamieson[1]; John Carter[2]

Co-authors: A Joubert [3]; Amy Carter [2]; Andrew Chen [2]; Constant Volschenk [2]; D Pheiffer [4]; Hillary Veale [5]; Jane Carruthers [6]; Melvyn Hanibal [1]; Nukri Komin [2]; Sergio Colafrancesco [2]; Vincent Carruthers [7]

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The trend worldwide is to preserve astronomical photographic plates by digitisation, with some plates dating back to over a century. Indeed, South Africa should be no exception and has a long tradition of observing the night sky of the Southern Hemisphere, initially to produce star charts for improved navigation by seafaring ships. This gave way to observatories for mapping star positions precisely by using telescopes to record images on photographic plates. The John Franklin-Adams wide-angle telescope, donated in 1909, was originally sited at the Union Observatory (present-day Johannesburg Observatory, Johannesburg) and was later moved to the Observatory's Dark Sky Outstation at Toppieshoek, Hartbeespoort. Here, it was joined by the Rockefeller 16"Twin Astrograph in 1938, constituting the Netherlands Leiden Observatory Southern Station. In particular, observations were made for variable stars, binaries and transients. It should be noted that from 1911 to 1970 the Franklin-Adams telescope was used in the discovery of 148 asteroids and the production of a set of 556 sky maps south of -19 degrees.

In total the Franklin-Adams telescope produced over ten thousand, monochrome, photographic plates, up to a size of 15"x 15". This heritage is not conveniently accessible and, in addition, the emulsion of such plates deteriorates over time. By taking high-resolution digital photographs of the plates, the plate information is preserved and becomes easily accessible using modern computers and networks.

This presentation follows the steps for setting up the Wits Astronomical Plate Archive in 2015 in order to preserve the Franklin-Adams plates and digitise the images for future long time-based astronomical use. Also, attention is paid to the heritage value of the Franklin-Adams and Rockefeller telescopes, championed by the Magaliesberg Association for Culture and Heritage (MACH).

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics of Condensed Matter and Materials / 459

Tuning interlayer exciton emission in binary-ternary heterobilayers based on $Mo_{0.5}W_{0.5}Se_2$

Author: Hilary Masenda[1]

[1] *University of the Witwatersrand*

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Semiconductor heterostructures have been pivotal in the progress of electronic and optoelectronic devices. A notable category within this realm is the type II band alignment, where optically excited electrons and holes localise in separate material layers. The distinctive properties exhibited by two-dimensional transition metal dichalcogenides, coupled with the potential for engineering van der Waals heterostructures, position them as strong contenders for future high-tech applications. In these structures, electronic, optical, and magnetic properties can be tuned through the interlayer coupling, thereby opening avenues for developing new functional materials. The possibility of explicitly tuning the emission of interlayer exciton energies in the binary–ternary heterobilayer of $Mo_{0.5}W_{0.5}Se_2$ with $MoSe_2$ and WSe_2 is reported. The respective interlayer energies of 1.516 eV and 1.490 eV were observed from low-temperature photoluminescence measurements for the $MoSe_2$- and WSe_2- based heterostructures, respectively. These interlayer emission energies exceed those reported for $MoSe_2/WSe_2$ (⊠1.30 −1.45 eV). Consequently, binary–ternary heterostructure systems provide a broader energy range and tailored emission energies not available with binary counterparts. Moreover, although $Mo_{0.5}W_{0.5}Se_2$ and $MoSe_2$ have nearly identical optical gaps, their band offsets differ, which results in charge transfer between the monolayers after optical excitation. This confirms that TMD alloys allow for tuning the band offsets, adding another design parameter for application-specific optoelectronic devices.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-2 / 460

Searches for a scalar resonance with Di-photon in association with leptons in the range 130 –200 GeV in the ATLAS detector at the LHC

Author: Vuyolwethu Happyboy Kakancu[1]

Co-authors: Bruce Mellado [2]; Kgothatso Ntumbe [2]; Kutlwano Makgetha [2]; Mukesh Kumar [2]; Njokweni Mbuyiswa [2]; Paballo Ndhlovu [2]; Rachid Mazini [2]

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Corresponding Author: 2329045@students.wits.ac.za

Searches for di-photon resonances at the ATLAS experiment have primarily focused on the mass range of $200–3000\,\mathrm{GeV}$. However, phenomenological studies based on Run 1 data have reported excesses-commonly referred to as multi-lepton anomalies-suggesting the possible existence of a scalar resonance with a mass of $150 \pm 5\,\mathrm{GeV}$. Further investigations of $\gamma\gamma$ and $Z\gamma$ sidebands, using ATLAS and CMS data, have further motivated the presence of a narrow resonance in this region, with a reported local significance of 5.4σ. The analysis aims to highlight this gap by proposing further investigation into this phase space, which is deliberately chosen to avoid overlap with the Standard Model (SM) Higgs boson. Two theoretical models are explored: the Two-Higgs-Doublet Model with an additional singlet (2HDM+S), and the Triplet Model (ΔSM) with hypercharge $Y = 0$. Both frameworks predict rich di-photon phenomenology in association with final states containing tau jets (τ), leptons ($\ell = e/\mu$), b-jets, jets, and missing transverse energy (MET). Significant progress has been made within the 2HDM+S framework, particularly in key channels such as $gg \to H(250\,\mathrm{GeV}) \to S(\gamma\gamma)\, S'(\tau\tau/b\bar{b}/\ell + b/\ell\ell)$. Future work will extend the analysis to the ΔSM model to fully explore this promising region of parameter space.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 461

Aqueous chemically grown ZnO nanosheets for gas sensing applications

Authors: Joseph Sithole[1]; Luyanda Noto[1]; Vladimir Skuratov[2]

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A facile aqueous chemical growth method was used to synthesize layered zinc hydroxide nitrate (ZHN) and subsequent thermal treatment of ZHN resulted in zinc oxide (ZnO) nanosheets. The SEM images of ZHN and ZnO show that the morphology of the two remain similar even after calcination at 400℃. The elemental composition of ZHN and ZnO was confirmed using EDS and the functional groups present in both nanostructures were examined by FTIR.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 462

Probing Charged Current B-anomalies via a U (1)μ−τ Extension of the Standard Model

Author: Vuyolwethu Happyboy Kakancu[1]

Co-authors: Ammar Abdalgabar [2]; Ashok Goyal [3]; Mukesh Kumar [1]; Sneha Jaiswal [4]; Srimoy Bhattacharya [1]

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The lepton flavor universality ratios $R(D)$ and $R(D^*)$, defined as $R_{D^{(*)}} \equiv \mathcal{B}(\bar{B} \to D^{(*)}\tau^-\bar{\nu}_\tau)/\mathcal{B}(\bar{B} \to D^{(*)}\ell^-\bar{\nu}_\ell)$ where$(\ell = e, \mu)$, are measured in semi-leptonic B decays and serve as sensitive probes of new physics beyond the Standard Model (SM). Recent experimental averages, $R(D) = 0.342 \pm 0.026$ and $R(D^*) = 0.287 \pm 0.012$, show a combined deviation of 3.2σ from SM predictions, indicating the possibility of new physics in semi-leptonic B meson decays. We base our attention on the Charge Current(CC) process $b \to c\tau^-\bar{\nu_\tau}$, where we explore this process using a well-motivated extension of the SM, featuring a $U(1)_{\mu-\tau}$ gauge symmetry. The model introduces new vector-like quark doublets (Q'_a) and a singlet scalar (χ), both charged under $U(1)_{\mu-\tau}$ and odd under Z_2 symmetry. The corresponding Wilson coefficients are derived and a χ^2-fit is performed with the current experimental data to constrain the model parameters.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 463

Performance Analysis of a Hybrid Renewable Energy Microgrid through Simulation-Based Evaluation and PLC-Controlled Load Management

Author: Avhatakali Ramalata[None]

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Corresponding Author: 15014778@mvula.univen.ac.za

As South Africa grapples with ongoing energy shortages and rising demand, hybrid renewable energy microgrids have emerged as an effective and scalable approach for supplying power to off-grid and rural communities. This study, which explores the performance of a hybrid microgrid that integrates photovoltaic (PV) panels, fuel cells, and battery storage systems, plays a crucial role in providing valuable insights for implementing sustainable electrification solutions. The focus is on intelligent load management through Programmable Logic Controllers (PLC). A comprehensive system model was developed using MATLAB/Simulink, incorporating actual Masia Community Development Centre load data. Additionally, HOMER software was utilized for system sizing and optimization, tailored to local resource availability and load requirements. Adopting PLC-based load control strategies significantly improved the system's operational efficiency, responsiveness, and reliability in fluctuating demand conditions. The results underscore the essential role of automation and advanced control techniques in enhancing the effectiveness of hybrid renewable energy systems, providing valuable insights for implementing sustainable electrification solutions in underserved and remote regions throughout South Africa.

Apply for student award at which level::

Honours

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics for Development, Education and Outreach / 464

Electrical Transport Measurements from First Principles: a Senior Undergraduate Experiment

Author: Jonathan Keartland[1]

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Corresponding Author: jonathan.keartland@wits.ac.za

A final year undergraduate experiment has been designed and constructed with the aim of illustrating numerous aspects of low temperature measurements, with the objective of determining the electrical transport properties of materials. The experiment is designed to ensure that the students cannot treat the experimental apparatus as a data-producing "black box", and the students are obliged to manually control the temperature, take much of the data by hand, and to calibrate the thermocouple used to measure the temperature. The use of a desktop computer and software packages during the experiment are encouraged. Much of the apparatus was assembled at relatively low cost.

Apply for student award at which level::

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 465

Effect of annealing temperature on structural, optical, and morphology properties of TiO2 synthesized via sol-gel method.

Authors: Amos Nhlapo[1]; TD Malevu[2]; Tshedza Rasilingwani[1]

[1] *Sefako Makgatho Health Sciences University*

[2] *North-West University*

Corresponding Author: 201903781@swave.smu.ac.za

TiO2 nanoparticles (NPs) were synthesized using sol-gel method. The samples obtained were subsequently annealed at different temperatures from 450℃ to 1200℃. The structural, optical, and morphological properties of TiO2 are investigated. The X-ray diffraction (XRD) results of as prepared revealed an amorphous structure. The annealed samples revealed a mixed phase of anatase and rutile, with rutile becoming more prominent as the temperature rose. The crystallite size increased from 3.183 nm to 35.328 nm. The macrostrain decreased from 2.5 to 0.21. The Fourier Transform Infrared (FTIR) also revealed the presence of the anatase and rutile phases. The Field Emission Gun Scanning Electron Microscopy (FEG SEM) showed a spherical shape of nanoparticles. The elemental composition of Ti and O was revealed by Energy-dispersive X-ray spectroscopy (EDX). The Transmittance Electron Microscopy (TEM) showed an irregular morphology shape at higher annealing temperatures. Photoluminescence (PL) spectra were used to analyze the optical properties of TiO2. TiO2 annealed at 600℃ showed low PL intensity, whereas TiO2 annealed at 1200℃ had the highest PL intensity.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 466

The development of the atmospheric monitoring system for a balloon-borne system

Author: Kwanele Mazibuko[1]

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[2] *SANSA*

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Atmospheric monitoring systems play a crucial role in tracking weather conditions and assessing air quality, which is essential for both climate research and public health. While ground-based monitoring systems provide valuable localized data, they are limited in their ability to capture measurements at higher altitudes. Balloon-borne systems offer a solution to this gap, enabling the monitoring of atmospheric conditions at high altitudes, which is vital for understanding global climate patterns, air quality, and upper atmospheric phenomena.

The proposed balloon-borne atmospheric monitoring system aims to overcome the limitations of ground-based monitoring systems, such as Automatic Weather Stations, by providing a cost-effective method for collecting atmospheric data at various vertical levels. In addition to monitoring atmospheric conditions, the system will also track the position and velocity of unmanned vehicles, such as rockets or drones. The system consists of sensors, a Global Positioning System (GPS) for determining the system's position in the atmosphere, and a radio transmitter for real-time data transmission.

The collected data will be transmitted to the nearest ground base station, which will then relay the data globally via the Global System for Mobile Communications (GSM). To ensure compliance with safety regulations, the payload will be designed to weigh no more than 2 kg. The system will be built to withstand the harsh environmental conditions encountered during the balloon's flight, including rapid changes in temperature, pressure, and humidity.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Theoretical and Computational Physics / 468

Reservoir Computing for Predicting Chaotic Dynamical Systems

Authors: Taheer Jooma Abbajee[1]; Keegan D Anderson[1]; Muaaz Bhamjee[2]; Maria V Visaya[1]

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Time series prediction is the process of forecasting future values of a system by analysing historical data to identify patterns, trends and variations. There are two main approaches to time series prediction: model-based and data-driven. Chaotic dynamical systems are often difficult to predict due to sensitive dependence on initial conditions leading to possible long-term divergence in trajectories. Data-driven models make use of machine learning methods for training. Reservoir computing, a type of recurrent neural network, makes use of an existing dynamical system as a reservoir to train the neural network instead of having numerous hidden layers. "Classical"machine learning models often require extensive data and computational resources for training, while reservoir computing achieves comparable results with less. Due to its design, reservoir computing excels in the prediction of chaotic time series arising from unknown dynamical systems. In order to demonstrate the predictive ability of reservoir computing, a reservoir computing model was trained on samples of time series from the Sine, Logistic and Hénon maps. The reservoir computing model was then used to predict both the time series and essential dynamics of the three dynamical systems. The reservoir computing model was only capable of performing short to medium term time series predictions. However the model was also capable of learning dynamical properties not found in the training data such as a systems fixed points, attractor, and Lyapunov exponents. The results demonstrate that reservoir computing can be used to successfully predict and analyse various chaotic dynamical systems.

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MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 469

Electrochemical impedance spectroscopy. Potentiostat device.

Author: Senzo Hlongwane[1]

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Corresponding Author: mariolam@ukzn.ac.za

We view electrochemical impedance spectroscopy as a specialized case that characterizes an electrochemical system by measuring its alternating current or potential signals. The measurements are normally used to identify the physical phenomena that control electrochemical reactions in the system and to determine the corresponding physical properties. It does provide an indirect means to measure a variety of electrochemical quantities that are not easy to assess accurately. The proposed research aims to develop systems and the methods to characterize a material and media's physical properties by hardware. The design of the hardware is less expensive, and when it is possible, it is open source hardware.
Any substance subjected to a variable electrical signal responds like a passive electrical circuit. The electrochemical impedance spectroscopy aims to characterise the equivalent circuit of a given substance. The characterisation of the equivalent circuit is essential when the material should be used for battery or to determine any other application. In this work, the design of the system is the Potentiostats device. The primary circuit of the Potentiostats is operational amplifier that provides the feedback mechanism to allows the Potentiostats to maintain the constant potential in electrochemical system.

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None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 470

Time to digital converter based on FPGA

Author: Lizwi Shabalala[1]

Co-author: Marco Mariola [2]

[1] *University of KwaZulu-Natal, School of Chemistry and Physics*

[2] *University of KwaZulu-Natal*

Corresponding Author: mariolam@ukzn.ac.za

This research focuses on the design and development of high-resolution Time-to-Digital Converters (TDCs) and explores key parameters for evaluating their performance. Among various time-to-digital conversion methods, three approaches are examined in detail: counter-based, delay line-based (including Vernier, buffer, and inverter-based delay lines). The study specifically investigates the implementation of a buffer delay line TDC, where inverters connected with ideally zero-delay wires serve as buffers. A counter-based TDC is used for coarse measurement, while the buffer delay line is employed for fine measurement, enabling the detection of smaller time intervals that cannot be resolved by a counter alone.

The proposed TDC architecture can be implemented on both Field-Programmable Gate Arrays (FPGAs) and Application-Specific Integrated Circuits (ASICs).The building blocks of the TDC circuit are simulated using Verilog HDL, and the overall TDC block diagram is presented. The simulations of both coarse and fine measurement components yield results consistent with the operating principles of a TDC, demonstrating the effectiveness of the proposed design.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Applied Physics / 471

Weather Forecasting Using Graph Neural Networks and Physics-informed Neural Networks

Authors: Mhlambululi Mafu[1]; Naleli Matjelo[2]; Kevin Garapo[3]; Molibeli Benedict Taele[2]

Co-author: Makhamisa Senekane [4]

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The weather plays a crucial role in decisions that people make on daily basis, especially in the agriculture, transportation, energy sectors. Therefore, accurate and efficient weather forecasting is of utmost significance. Predicting weather patterns has been an endeavor humanity has engaged in since ancient times. Over the years, various approaches have been used to forecast the weather. Currently, there are two main methods for weather forecasting: numerical modeling and machine learning (ML)-based modeling. Numerical modeling relies on complex numerical simulations of atmospheric physics, while ML-based modeling is data-driven and does not depend on such simulations. We explore the application of machine learning in weather forecasting, with a specific focus on two ML architectures: Graph Neural Networks (GNNs) and Physics-informed Neural Networks (PINNs). The GNNs model atmospheric interactions on a graph structure, while PINNs incorporate physical laws to constrain model learning and improve generalization. We also compare the performance of GNNs and PINNs in weather prediction. Our results demonstrate improved accuracy, efficiency, and enhanced prediction especially in capturing complex spatial and temporal relationships in weather data.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 472

Effect of Ion Implantation on Structural and Optical Properties of CZTS Thin Films

Author: Tshegofatso Moipolai[1]

Co-authors: Morgan Madhuku [2]; Sabata Moloi [3]; Mamogo Masenya [2]; Christopher Mtshali [2]

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[3] *University of South Africa*

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The study presents the findings of the effect of ion implantation on pristine Copper Zinc Tin Sulphide (CZTS) thin films. The CZTS films were prepared by utilizing a two-stage process, i.e. e-beam deposition of metal precursors; Cu, Zn, and Sn followed by sulphurization process in the tube furnace at 500℃ for 30 min. These samples were further implanted with 150 keV V+ ions utilizing fluences, 1x10^16, 3x10^16, and 1x10^17 ions/cm^2. Fundamental properties that govern the photovoltaic applications, i.e., structural and optical were investigated on pristine and ion-implanted CZTS thin films using XRD, Raman, and UV-VIS techniques. The Raman results highlighted the presence of defects in the CZTS samples. UV-VIS revealed an energy band gap in the 1.83 - 1.45 eV range, and absorption within the UV range.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 473

Systematics review of low-lying positive parity structures in the 160 mass region.

Author: Siyabonga Majola[1]

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For decades now, the low-lying first excited 0+ bands have been attributed to "β -vibrations", following the seminal works of Bohr and Mottelson [1, 2]. Recent discoveries have demonstrated that these bands could arise due to other modes excitations, such as quadrupole pairing [3] and shape-coexistence [4].

The current work performs a systematics review of low-lying structures in the 160 mass region. In particular, this work focus on the structural behaviour of bands built on the first excited 0+ and 2+ bands, which are traditionally understood as β and γ bands, respectively. The results of the systematic review are presented and the implications of the findings are there from discussed.

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Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Applied Physics / 474

GeoQAI: A Quantum Machine Learning Paradigm with Geospatial Data

Authors: Mhlambululi Mafu[1]; Makhamisa Senekane[2]; Naleli Matjelo[3]; Sekhants'o Lara[3]; Kevin Garapo[4]; Molibeli Benedict Taele[3]

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[4] *Kevin Garapo*

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Quantum Machine Learning (QML) lies at the intersection of classical Machine Learning (ML) and Quantum Computing (QC) and is currently experiencing significant growth in terms of both efficiency and applications. This expansion is largely driven by the availability of Noisy Intermediate-Scale Quantum (NISQ) processors, which enable the use of Quantum Computing without needing to tackle the challenges of error correction. As a result, there has been a surge in Quantum Computing applications, including QML. However, most QML implementations to date have relied on generic classical ML datasets, such as the Iris dataset, MNIST (Modified National Institute of Standards) dataset, and Fashion MNIST dataset. In this work, we introduce a novel QML paradigm called GeoQAI (Geospatial Quantum Artificial Intelligence). This paradigm explores the application of Quantum Machine Learning to geospatial data. Our goal is to unlock deeper insights into spatial dynamics, improve predictive capabilities, and facilitate better decision-making in various fields, including environmental science, urban planning, and resource management. Furthermore, we report on the use of QML for Land Use and Land Cover (LULC) classification. The results obtained in this study suggest the potential for further investigation into the GeoQAI paradigm, particularly for exploring QML applications in other geospatial contexts beyond LULC. This work provides insights on improving the accuracy and efficiency of spatial analysis tasks and developing new tools and frameworks for integrating geographic information systems with other disciplines.

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None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-2 / 475

Detector Research and Development projects for future High Energy Physics experiments

Author: Rachid Mazini[1]

Co-authors: Bruce Mellado [2]; Elias Sideras-Haddad [3]; Mukesh Kumar [4]

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The European Strategy for Particle Physics stimulated the preparation of the European Detector Roadmap document in 2021 by the European Committee for Future Accelerators ECFA. This roadmap, defined during a bottom-up process by the community, outlines nine technology domains for HEP instrumentation and pinpoints urgent R&D topics, known as Detector R&D Themes (DRDTs). Task forces were set for each domain, leading to Detector R&D Collaborations (DRDs), now hosted at CERN. Eight DRD collaborations have been established and set up their collaboration structures, with some having already started their R&D
I will give a brief overview of the current status of DRD collaborations covering detector developments in the field of gaseous detectors, noble liquid detectors for rare event searches, semiconductor detectors, photodetectors and concepts for particle ID, quantum sensors, calorimetry, electronics for HEP instrumentation and mechanical and integration aspects. Many of these topics would be of great interest to South African particle physics community to plan their involvement in future accelerator projects such as CEPC, FCC as well as in technology transfer and applications in other fields.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 477

Compositional Analysis of Heterostructural Ti-Doped Li1.2Mn0.8O2 Cathode Materials during the Computational and Experimental Crystal Growth Processes

Author: Moloko Emmanuel Kgoedi[1]

Co-authors: Cliffton Masedi [2]; Noko Ngoepe [3]; Phuti Esrom Ngoepe [4]; Raesibe Ledwaba [2]

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This study investigates the structural and morphological properties of pure and titanium-doped Li1.2Mn0.8O2 cathode materials through integrated computational modelling and experimental techniques. Titanium doping was chosen due to its ability to enhance structural stability, reduce capacity fading, and mitigate voltage decay in lithium-rich manganese oxides.. Molecular dynamics simulations reveal that Ti doping improves local atomic ordering, as evidenced by radial distribution function analysis showing reduced Mn-O bond distortion compared to undoped samples. Experimentally, Li1.2Mn0.8O2 and its Ti-doped variants (6% and 10%) were synthesized via a co-precipitation method. X-ray diffraction (XRD) analysis confirmed phase purity and reduction in the spinel variant that is brought about by Mn-migration. The particle size distribution analysis showed a reduction in agglomeration with optimal 6% Ti doping, corroborated by scanning electron microscopy (SEM) imaging that revealed more uniform spherical morphology. These findings highlight Ti's dual role as both a structural stabilizer through strengthened Mn-O-Ti bonding networks and a morphological modifier via surface energy manipulation during crystal growth. The integrated approach demonstrates that Ti doping influences particle size distribution, structural stability, and morphology, and revealed the optimal Ti-concentration to be implemented for improving these anomalities. By aligning with emerging strategies for LRMO optimization through controlled cation doping, this study provides quantitative insights into dopant concentration effects on both atomic-scale structure and microscale morphology. It establishes a framework for the rational design of high-stability, manganese-rich cathode materials through targeted elemental substitution, addressing broader challenges in the field of lithium-ion battery technology.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 478

The Diffusivity and Li^+ Conductivity of $LiTi_2(PO_4)_3$ Nanosphere for Solid State Battery Electrolytes

Author: Lisbon Maake[1]

Co-authors: Beauty Shibiri [2]; Phuti Esrom Ngoepe [3]; Raesibe Ledwaba [2]

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The NASICON-type $LiTi_2(PO_4)_3$ solid electrolyte is amongst the most promising electrolytes for solid-state batteries due to its broad electrochemical stability window and strong chemical durability. However, its relatively low ionic conductivity remains a major limitation for practical applications, hindering further development of $LiTi_2(PO_4)_3$-based technologies. Studies have shown that reducing the active particle size enhances solid-state electrolyte conductivity by increasing electrode-electrolyte contact and shorten the Li^+ diffusion path. In this study, molecular dynamics simulations are employed to investigate the diffusion coefficients of Li, Ti, P, and O atoms and the lithium-ion conductivity of the $LiTi_2(PO_4)_3$ nanosphere. The $LiTi_2(PO_4)_3$ nanosphere was generated using the METADISE code, and the temperature-dependent simulations were conducted under the NVT ensemble from 5 K to 2000 K. The diffusion coefficient increased with temperature for all atomic species, with a notable decline observed at 300 K, possibly caused by the lithium redistribution between the M1 and M2 sites that takes place at 270 K. Furthermore, the lithium-ion conductivity of the $LiTi_2(PO_4)_3$ nanosphere at room temperature was determined to be 5.297×10^{-1} S/cm using the Nernst-Einstein equation, which is three orders of magnitude higher than that of the bulk material (2.41×10^{-4} S/cm). The findings of this study indicate that indeed reducing the particle size of materials can enhance their performance since the nanosphere architecture of the $LiTi_2(PO_4)_3$ shows improved lithium-ion transport properties, potentially improving the performance of solid-state batteries.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Astrophysics & Space Science / 479

The ACT Data Release 6 Sunyaev-Zel'dovich Selected Cluster Catalog

Author: Matt Hilton[1]

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The Atacama Cosmology Telescope (ACT) conducted an arcmin resolution survey of the southern sky at millimetre wavelengths from 2008-2022. In this talk I will present an update on the ACT search for galaxy clusters using the redshift independent Sunyaev-Zel'dovich (SZ) effect, using data from the full ACT survey, covering 15,000 square degrees. The final ACT Data Release 6 (DR6) cluster catalog is expected to include more than 9,000 galaxy clusters with redshift and mass estimates. I will describe the construction of the catalog (in particular the differences with respect to ACT DR5), products and tools associated with the data release, and discuss some science applications of the catalog.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Applied Physics / 480

Benchmarking Quantum Phase Recognition with a Novel Quantum Convolutional Neural Network

Author: Chisomo Daka[1]

Co-author: Somnath Bhattacharyya [1]

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Corresponding Author: 2711819@students.wits.ac.za

Recognizing quantum phases of matter is a central challenge in quantum many-body physics and quantum machine learning. In this work, we introduce a Novel Quantum Convolutional Neural Network (No-QCNN) architecture tailored for efficient quantum phase recognition and benchmark its performance on IBM's superconducting quantum hardware. The No-QCNN leverages translationally invariant circuit motifs and entangling layers inspired by classical convolutional networks, adapted to operate natively on near-term quantum devices. We implement and evaluate No-QCNN using quantum circuits composed of parameterized single- and two-qubit gates, trained variationally to distinguish between distinct quantum phases in prototypical spin models, including the transverse-field Ising model. Benchmarking is performed both in ideal simulation and on real IBM Quantum backends, highlighting the model's robustness against hardware noise and circuit depth constraints. Our results demonstrate that No-QCNN achieves high phase classification accuracy with reduced circuit overhead compared to standard quantum neural network baselines, making it a promising candidate for practical quantum machine learning applications in near-term quantum devices. We discuss implications for quantum phase transition detection, scalability, and future deployment in hybrid quantum-classical workflows.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 481

Exploring the effect of hydrogen adsorption on Fe2SiCr surface

Authors: Ashley Phala[1]; David Tshwane[2]; Prettier Morongoa Maleka[3]; RATSHILUMELA STEVE DIMA[3]; Regina Maphanga[4]

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[2] *Council for Scientific and Industrial Research*

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Fe-Cr-based alloys are ideal for fusion reactor structural components because of their reduced activation and swelling, corrosion resistance, and excellent hardening or embrittlement properties in various radiation environments. However, Fe-Cr alloys have high hydrogen uptake capacity, and enhance hydrogen embrittlement can cause material degradation and premature failure, necessitating an understanding of the hydrogen interaction with this alloy surfaces. This paper investigates hydrogen adsorption on Fe2CrSi using first-principle calculations, considering three different adsorption sites: top, bridge and hollow sites to analyse hydrogen interactions with the surface. The current findings showed that the adsorption energy of the H atoms is thermodynamically stable, with E_ads < 0 for all adsorption sites. This suggests that H atoms spontaneously adsorb on the surface of Fe2CrSi (110). More importantly, the effect of van der Waals (vdW) forces and dispersion correction was investigated, it was found that all adsorption sites exhibit the most stable adsorption energies than standard density functional theory, with E_ads^(DFT-D)>E_ads^DFT. The adsorption energy strength of H at the top site was observed to follow the order of E_ads^Fe > E_ads^Cr >E_ads^Si. This means that the presence of Fe on the metal surface will expedite the formation of metal hydrides and hydrogen embrittlement, while the presence of Si on the metal surface will slow it down. Overall, the findings show that the Fe2CrSi surface, rich in Fe-Cr, may undergo metal hydride and HE formation during application, while an increase in Cr content may limit hydrogen embrittlement.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Applied Physics / 482

Automated photovoltaic module imaging for high throughput data capture and analysis

Author: Matthew Sivewright[1]

Co-authors: Ernest Van Dyk [1]; Frederik Vorster [1]

[1] *Neslon Mandela University*

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Photovoltaic (PV) module imaging has become a critical tool for assessing the performance, reliability, and degradation of PV modules. Automated imaging systems that use advanced hardware and image processing software tools allow for efficient high-throughput data capture across large-scale solar installations. These systems use different imaging techniques such as visible light (RGB) imaging, ultraviolet fluorescence (UV-F) imaging, electroluminescence (EL) imaging, and line sensor scanning. These imaging techniques allow for the detection of faults or anomalies in PV modules. We report on a project focussing on the development of a system for high throughput visual and UV-F imaging of PV modules deployed in utility-scale PV plants. The work follows a two-step approach whereby two systems will be built. The first-step consists of a laboratory-based imaging system to test proof of concept. The system will utilise an Arduino MEGA 328P microcontroller for position control and a Raspberry Pi 5 8 GB as the microprocessor for sensor control, image capturing and storage. The images will later be processed through stitching and basic visual classification.The second-step will use techniques determined to be effective from the initial system to build an onsite imaging and sensing system that allows for rapid large-scale image capture for further image processing and classification. This allows for more data and images to be captured, and thus processed as opposed to manual methods. At the same time, has a much greater resolution as opposed to drone imaging.
This paper will present the design, manufacture, optimisation and preliminary results from the laboratory-based system.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 483

The influence of UVO irradiation on structural, morphological and optical properties of SnO2 thin films deposited by slot-die method

Author: Fokotsa Molefe[1]

Co-authors: Mmantsae Diale [2]; Thapelo Seimela [3]

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[2] *University of Preoria*

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Tin (IV) oxide (SnO_2) is a promising metal oxide (MO) semiconductor with potential in perovskite solar cells (PSCs) as an electron transport layer (ETL). The development of an additive-free SnO_2 thin film with enriched optical properties using a cost-effective method is still a challenge. Herein, we report the influence of Ultraviolet ozone (UVO) on the additive-free hydrothermal synthesis of SnO_2 and the deposition of thin film using the slot-die method. The thin films were characterised using a range of analytical techniques to evaluate their structural, morphological, and optical properties. X-ray diffraction (XRD) confirmed SnO_2 crystallization into the tetragonal cassiterite phase. The surface irradiation of SnO_2 thin films with Ultraviolet ozone (UVO) led to the increase in average grain size. Variation in the bandgap energy was observed following distinct changes in optical absorption upon UVO irradiance. The photoluminescence (PL) studies revealed the enhancement in defect emission intensity following UVO irradiance. These findings emphasize the significance of UVO irradiance in tuning the optical properties of SnO_2 thin films for application as an ETL in PSCs.

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None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 484

A Comparative Study of VO2 Doped with In and Ga for Thermochromic Window Application

Author: Lutendo Phuthu[None]

Co-author: Eric Nnditshedzeni Maluta

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Thermochromic energy-efficient windows have been investigated intensively ever since the rise of an energy-efficient model for VO₂-based windows. However, pure VO₂ possesses an energetic difference of low-to-high-temperature infrared transmittance lower than 10% and visible transmittance at about 40%, which limits its commercial application as a coating material for smart windows. This work uses the method of elemental doping to lower the transformation temperature and improve the optical transmittance. Indium (In) and Gallium (Ga) were doped on VO₂ and the first principle calculations were used to calculate the structural, electronic and optical properties. These calculations are helpful for the experimental search of dopants used in the thermochromic VO₂ smart window.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics for Development, Education and Outreach / 485

An Introduction to Quantum Computing - Teaching the Basics

Authors: Ken Nixon[1]; Taariq Surtee[1]

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Quantum computing, a field that started gaining increased traction around 2016, uses quantum mechanics principles from around 1900 to compute with quantum phenomena rather than the random simulations of classical computers. This interactive presentation introduces quantum computing to people without a background in computing or quantum mechanics. It compares classical logic gates and circuits to quantum ones to build understanding. The session covers set theory and probability as steps toward quantum states and Bloch spheres. It ends with quantum circuits and simple algorithms, using hands-on examples to demystify quantum computing, allowing attendees to grasp its core principles and potential.

Apply for student award at which level::

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Yes, I ACCEPT

Poster Session / 486

Using different Vlsr 's to obtain better-pointing statistics and source confu- sion insights

Author: Phemelo Motloba[1]

Co-authors: Ntsikelelo Charles [1]; Stefanus van den Heever [2]

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In Radio Astronomy there are several steps to follow to calibrate the data before it can be used for scientific research. One of these steps, specifically for a single-dish telescope like the Hartebeesthoek 26m telescope, is to do pointing observations to determine if the pointing model of the telescope is working properly. The pointing observations consists of pointing the telescope at the half power beam width points North, South, East and West of the On-source position. The currently used approach to determine the pointing correction factor is to use the brightest spectral feature. In this work we have investigated the comparison between the currently used approach and a new approach for determining the pointing correction factor. The new approach consists of taking multiple spectral features and determining the pointing correction factor for each of them. The results from this is compared to the standard approach to see if a more accurate and statistically more significant pointing correction factor can be determined.

The results from determining the average pointing correction factor from multiple velocity features compares well with the standard approach of determining the pointing correction factor, as for all the sources, the standard pointing correction factor lies within the average and the error margin. This results in that the time-dependent average pointing correction factor compares reasonable well with the standard time-dependent pointing correction factor, for most of the sources investigated, however, one of these sources show a interesting deviation from this trend. Here we give possible reasons for this deviation. Lastly, we present the comparison between the time-dependent flux density for the multiple velocity feature pointing correction factor and the standard pointing correction factor and an opinion on whether this approach is viable to be used.

Keywords:Radio Astronomy ,calibration,Pointing Accuracy,HartRAO, Maser,Time-dependent analysis

Apply for student award at which level::

Honours

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 487

Influence of Ti-dopant during Crystal Growth of Li-rich Layered Li1.2Mn0.8O2 Cathode Materials using co-precipitation synthesis route

Author: Raesibe Ledwaba[1]

Co-authors: Cliffton Masedi [1]; Moloko Emmanuel Kgoedi [2]; Noko Ngoepe [1]; Phuti Esrom Ngoepe [3]

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The outstanding energy density and capacity exhibited by lithium-rich manganese-based layered oxide (LRLO) cathode materials have positioned them as emerging strong contenders for future lithium-ion battery systems. Their optimal utilisation is hindered by several challenges, such as Mn-migration and oxygen loss, contributing to structural reconstruction resulting in voltage fading and poor electrochemical performance. This inability to retain a layered phase during cycling is a challenge that disrupts the ability to maintain a consistent conductive ion flow (lithium). Herein, Ti doping was introduced into Li1.2Mn0.8O2 cathodes to monitor its influence on the crystalline internal microstructure, polymorph content control to later contribute towards the cycling retention, and Li+ kinetics. The Ti concentrations of 2,4,6,8, and 10% were introduced using the co-precipitation method applied in the synthesis of the metal hydroxide precursor. The scanning electron microscopy (SEM) imaging revealed spherical morphology of particles with 3-20 microns. Compositional analysis of the various doped samples obtained through the XRD spectra showed that Ti-doped LrLO (6% Ti) has achieved high polymorphic content of layered-layered cathode materials as desired, with 80,5% Li2MnO3 and 3,4 % LiMnO2 and only 15% spinel content. On the other hand; the samples containing 4, 8, and 10% Ti content demonstrated higher spinel contents of 24.1, 22.3, and 25.9 %, respectively. Overall, across all samples, the Li2MnO3 polymorphs exist in greater quantities above an impressive 75% yield, followed by spinel above 15% and whereas LiMnO2 has a minimum of as little as 0.2%. This dominance of the Li2MnO3 variant shows that when Ti is doped to replace a part of Mn, the Jahn–Teller effect is weakened, and a stable layered structure is formed. This may be ascribed to the fact that, unlike Mn, Ti–O bond energy is higher, and it does not participate in the redox reactions. Our findings provide a suitable element doping strategy for regulating the voltage decay and cycle retention of LrLO, thus promoting their real-world application in future batteries.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 488

Simulation of the X-ray and gamma-radiation shielding parameters of the Li2O+Sb2O3+PbO+GeO2 glass materials in the 20 - 300 keV energy range using Phy-X/PSD, XCOM, and Geant4 software programs

Author: Linda Mdletshe[1]

[1] *University of Zululand*

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Ionizing radiation is used in fields such as medical physics and nuclear research, with concrete and lead commonly serving as shielding materials. However, these materials carry health risks: lead is linked to harmful health effects, while concrete is heavy and susceptible to cracking over time, which raises safety concerns. Additionally, both lead and concrete block visible light, leading to a lack of transparency. Glass emerges as a suitable alternative, being cost-effective, transparent, and free from adverse health effects. In this study, the software programs Phy-X/PSD, Geant4, and XCOM have been employed to investigate the effect of chromium oxide (Cr₂O₃) on the radiation-shielding properties of glass systems with the chemical composition 10Li₂O+(30-x)Sb₂O₃+20PbO+40GeO₂+xCr₂O₃, where x = 0.1, 0.2, 0.3, 0.4, 0.5 mol%. The key properties examined include the linear attenuation coefficient (LAC), mass attenuation coefficient (MAC), mean free path (MFP), half value layer (HVL), tenth value layer (TVL), and effective atomic number (Zeff). These parameters were investigated for energies ranging from 20 to 300 keV. The results show that increasing the Cr₂O₃ content enhances the shielding properties of the examined glass systems. The analysis indicates that the sample with the highest Cr₂O₃ content exhibits the highest LAC and MAC, alongside the lowest HVL, TVL, and MFP, suggesting it offers better radiation shielding capabilities compared to the other samples. Furthermore, the shielding effectiveness of the glass samples was compared to literature data, focusing on the MFP at 100 keV and 200 keV. The findings reveal that the MFP of our samples is lower than that of other reported glass materials, suggesting that the glasses under investigation demonstrate improved attenuation characteristics.

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None

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Yes, I ACCEPT

Poster Session / 489

Understanding the fundamental properties of 1D Co3O4-ZnO nanofibers for enhanced gas sensing performance

Author: Khanyisile Nkuna[1]

Co-authors: Katekani Shingange ; Rudolph Erasmus [2]; Teboho Mokhena [3]

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Semiconductor metal oxides are widely recognized as effective materials for gas sensing due to their ability to detect gases at trace levels, high sensitivity, and low production cost. Among various strategies to enhance their performance, heterostructures combining n-type and p-type semiconductors have proven particularly effective. In this study, cobalt oxide (Co3O4)-doped zinc oxide (ZnO) nanostructures synthesized via electrospinning exhibit promising fundamental properties for gas sensing applications. The doping process significantly modifies the ZnO matrix, enhancing its surface area, electrical conductivity, and catalytic activity. Furthermore, the p-n heterojunctions formed between n-type ZnO and p-type Co_3O_4 facilitate efficient charge carrier separation, leading to improved sensor response and enhanced gas sensing performance.
One-dimensional (1D) nanostructures, such as electrospun fibers, offer distinct advantages in gas sensing. Their high surface-to-volume ratio provides abundant active sites for gas adsorption, while their continuous pathways ensure efficient charge transport and rapid diffusion of gas molecules. These properties make 1D nanostructures particularly suitable for achieving high sensitivity and selectivity in practical sensing environments.
To comprehensively understand the fundamental properties of Co3O4-ZnO nanofibers, various characterization techniques will be employed. X-ray diffraction (XRD) will confirm crystalline structure and phase composition; scanning electron microscopy (SEM) and transmission electron microscopy (TEM) will reveal fiber morphology; photoluminescence (PL) spectroscopy will highlight defect states; UV-Vis spectroscopy will assess bandgap changes; Raman spectroscopy will analyze vibrational modes; and X-ray photoelectron spectroscopy (XPS) will provide insights into chemical states. These analyses will enable a deeper understanding of how structural and optical properties influence gas sensing performance.
This study highlights the potential of Co3O4-doped ZnO nanofibers as high-performance materials for advanced gas sensors, through the combined advantages of semiconductor heterostructures and 1D nanostructures for enhanced functionality.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 490

Titanium carbide MXenes: Advancing gas sensing applications through 2D nanostructures and functional surface engineering

Authors: Katekani Shingange[None]; Modjadji Rebecca Letsoalo[1]

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Titanium carbide (Ti3C2Tx) MXenes have emerged as promising materials for gas sensing due to their unique two-dimensional structure, high surface area, metallic conductivity, and tunable surface chemistry. These properties enable efficient interaction with gas molecules, even at the physisorption level, resulting in significant shifts in electrical parameters. Unlike traditional semiconductor metal oxides, Ti3C2Tx MXenes exhibit excellent sensitivity and selectivity at room temperature (RT), reducing energy consumption and enhancing safety. In this study, Ti3C2Tx MXenes are explored for advanced gas sensing applications, focusing on their ability to detect trace levels of gases such as volatile organic compounds (VOCs) and toxic gases.
To comprehensively understand the fundamental properties of Ti3C2Tx MXenes, various characterization techniques will be employed which will assess microstructural properties such as structure and crystallinity, morphology, surface chemistry and defects properties. These analyses will interpret the relationship between structural features and gas sensing performance.
This study's highlights the potential of Ti3C2Tx MXenes as high-performance materials for advanced gas sensors, combining the advantages of 2D nanostructures and heterostructure engineering to achieve superior functionality in practical sensing environments.

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None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics of Condensed Matter and Materials 2 / 491

Ultra-low temperature transport property measurement of nanocrystalline diamond films

Authors: Chisomo Daka[1]; Shaman Bhattacharyya[None]

Co-authors: AIME Diakanwa Diantantu ; Daniel Wamwangi [2]; George Chimowa [3]; Roger Van Rensburg [4]; Rudolph Erasmus [5]; Somnath Bhattacharyya [1]; Venkateswara Sodisetti [1]

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We aim to establish the electronic transport properties of ultra-nanocrystalline diamond (UNCD) films at extremely low temperatures (specifically in the millikelvin regime) and under high magnetic fields up to 6 T in the z-axis. A dilution refrigerator was utilized to conduct the experiment in the millikelvin regime. UNCD, unlike its single-crystalline counterpart, is formed as small crystallites typically in the range of 3-10 nm. Their interaction is mediated by grain boundaries, which determine the transport properties of UNCD films. The electrical transport across two proximate grains can be tuned through p- or n-type doping with Boron or Nitrogen respectively. Unlike Boron, Nitrogen doping usually occurs at the grain boundaries. We performed low temperature resistance measurements to probe the mechanisms of electrical transport such as weak localization (WL), or spin orbit coupling under high magnetic fields. Nitrogen doped UNCD thin films were fabricated using plasma enhanced chemical vapour deposition (PECVD) technique. Electrical transport measurements on nitrogen doped UNCD thin films were analyzed using thermally activated transport, variable range hopping (VRH), and the WL models (with VRH and WL taking into account the dimensionality of the system). From our results, it is noted that the 3D WL best explains the experimental data.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Photonics / 492

Investigating Second-Order Correlation of a Single-Photon Source NV Centre under CW Excitation

Authors: Chisomo Daka[1]; Isaac Nape[2]; Shaman Bhattacharyya[None]

Co-authors: AIME Diakanwa Diantantu ; Daniel Wamwangi [3]; Roger Van Rensburg [2]; Rudolph Erasmus [4]; Somnath Bhattacharyya [1]

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In this work, we investigate the quantum light emission properties of single nitrogen-vacancy (NV) centres in diamond under continuous-wave (CW) excitation at a wavelength 532 nm while the emitted photons have a wavelength of 637 nm. Using Hanbury Brown and Twiss (HBT) interferometry, we measure the second-order correlation function ($g^2(\tau)$) to characterize the photon statistics of the single-photon source confirming the emission of one photon at a time, i.e. antibunching. NV centres are known for their exceptional stability at room temperature and their ability to emit single photons. These capabilities are driven by a high-power green laser, ensuring efficient excitation while minimizing multi-photon emission. Our findings reveal strong antibunching at zero-time delay in the HBT interferometer, indicative of single-photon emission, with detailed insights into the temporal coherence of the emitted photons. The study highlights the potential of NV centres as a robust source of quantum light for applications in quantum communication, quantum cryptography, and quantum information processing. Additionally, we discuss the effects of CW excitation on the photon emission dynamics and explore strategies to enhance the purity of emitted single photons in future applications.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Photonics / 493

Light-harvesting protein aggregation studied by real-time feedback-driven single-particle tracking spectroscopy.

Author: Bertus van Heerden[1]

Co-author: Tjaart Krüger [1]

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Single-molecule spectroscopy (SMS) has significantly advanced our understanding of the properties and dynamics of biomolecules. However, the environment used in SMS experiments is a poor representation of the natural cellular environment, and therefore the results of these studies may be of limited physiological relevance. One limitation of conventional SMS experiments is the need to immobilise the particles via surface attachment. This limitation is overcome by real-time feedback-driven single-particle tracking (RT-FD-SPT), a technique that allows spectroscopic measurements on individual, freely diffusing particles, with the added benefit of diffusion information. We employed RT-FD-SPT to study the aggregation of plant light-harvesting complex II (LHCII). Such aggregation is thought to be related to non-photochemical quenching (NPQ), an important photoprotective process. We combined spectroscopic and diffusion information to disentangle the interplay of aggregate size, detergent concentration, fluorescence intensity and lifetime, variables that are often overlooked in ensemble experiments.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Theoretical and Computational Physics / 494

Testing $f(Q)$ gravity as a solution for the H_0 and S_8 tensions

Author: Dumiso Mithi[None]

Co-authors: Shambel Akalu [1]; Amare Abebe [1]

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The persistent discrepancies between early and late universe cosmological measurements of the Hubble parameter (H_0) and the matter clustering parameter (S_8) pose significant challenges to current physics. In this study, we take into account such discrepancies to solve through the modified theory of gravity known as $f(Q)$ gravity (a symmetric teleparallel) framework where gravity is described by non-metricity Q, which offers a promising alternative to resolve these tensions. We will investigate the viability of $f(Q)$ gravity confronting the theory with recent cosmological data sets from both early and late measurements. Our analysis determines whether $f(Q)$ gravity can simultaneously reconcile the tensions of the H_0 and S_8 parameters while providing a theoretically compelling alternative to the ΛCDM model. The results provide crucial insights into modified gravity's capacity to address fundamental challenges in modern cosmology.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Applied Physics / 495

Reconfigurable Payload Power Management System for Rockets

Author: Marco Mariola[1]

Co-author: Tyrone Swanepoel [2]

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In general, a rocket's onboard systems, including payloads, must be harmonized within the overall system. In some cases, payloads with an autonomous power system, including batteries, must be activated shortly before or after launch to keep the mission active for the required time. The sizing of power switches must be done according to the power requirements of the payloads, and it is also necessary to size the connections between the parts to limit issues related to ground loops. If the payload specifications change, reconfiguring or resizing the Power Management System (PMS) board may be necessary, but it is not strictly required.

The proposed system has been designed to be reconfigurable and geometrically symmetric to maintain the center of mass on the rocket's symmetric axis. Once inserted into the rocket's nose cone, the system is completely powered off and can be activated remotely using a wireless system. Once activated, the Payload Power Management System (PMS) will be able to receive RF instructions and activate or deactivate payloads according to mission requirements.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Astrophysics & Space Science / 496

Bispectrum correlations of HI intensity mapping and large-scale structure surveys

Authors: Kavilan Moodley[1]; Moumita Aich[2]; Warren Naidoo[1]

[1] *UKZN*

[2] *University of Witwatersrand*

Corresponding Author: moumita.aich@wits.ac.za

Neutral hydrogen (HI) intensity mapping (IM) experiments probe the large-scale structure of the universe through the integrated redshifted 21-cm line emission from unresolved sources of neutral hydrogen. Optical surveys also probe the large-scale structure of the universe with much higher precision and depth by mapping the galaxy distribution. In this article, we study the cross-correlations of the HI IM field from HIRAX (Hydrogen Intensity and Real-time Analysis eXperiment) with the galaxy density and cosmic shear fields from the Rubin observatory large-scale structure survey, laying down the tools to do parameter forecasts and study constraints on the neutral hydrogen fraction, galaxy bias, and cosmological parameters. Astrophysical foregrounds limit the long-wavelength line-of-sight HI modes, reducing the constraining power of these cross-correlations. We introduce bispectrum estimators, specifically HI-HI-galaxy density and HI-HI-shear cross bispectra estimators, to recover modes lost in the foreground subtraction process and improve the parameter constraints.

Apply for student award at which level::

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Yes, I ACCEPT

Physics for Development, Education and Outreach / 497

An Approach to Using Arduino in University Practicals

Author: Elizabeth Hagemann[1]

Co-authors: Ernest Van Dyk [2]; Frederik Vorster [2]; Matthew Sivewright [2]

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Continuously improving students'experience of the practical component in formal education is crucial to developing a strong understanding of theoretical concepts whilst staying relevant to technologies used in industry and post-graduate studies. Previous work, within the Nelson Mandela University Physics Department, has shown that innovative practicals can improve and add another dimension to all educational environments.
The focus of this paper is the adaptation and modernization of a 2nd-year practical programme to incorporate an Arduino-based environment. The ease of access to Arduino components and software allows students to interact with a wider range of sensors and components. The affordability of the Arduino kits allows one kit to be assigned to a pair of students, thus enhancing student engagement with the practical. Further advantages of this adapted practical programme include the ability to improve student understanding of electrical diagrams, coding, sensor sensitives and report writing skills.
The programme is run as three structured practical sessions where the students are introduced, under supervision, to Arduino technology including the Arduino UNO, LED's, push buttons, an LCD, a temperature and humidity sensor and the software, Arduino IDE. Students are then required to complete a 'Coding Challenge'which requires them to build an Arduino-based system to solve a supplied scenario. The 'Coding Challenge'uses the knowledge covered in the practical sessions and as well as requiring independent learning skills to incorporate a component not covered in the structured sessions. Finally, students are required to demonstrate their systems and write a comprehensive report.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics of Condensed Matter and Materials / 498

Development of cellulose nanocrystal sheet embedded with carbon nanotubes for sensor application

Authors: AIME Diakanwa Diantantu[None]; Daniel Wamwangi[1]; Ibrahim Usman[None]; Somnath Bhattacharyya[2]

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Cellulose is an important natural material, which is biocompatible and hydrophobic, and can form strong and stable stiff-chain monomolecular structures with film and hydrogel-forming properties. The focus of this investigation was to develop a mixed nano-materials sheet, which can be used as a gas sensor system. The Microcellulose sheet was treated with TEMPO (2,2,6,6-tetramethylpiperidine-1-oxyl) oxidation to prepare TEMPO-Oxidised Nanocellulose (TONC). However, nanocellulose is not electrically conductive which is necessary for energy device applications. Therefore, the TONC was blended with various concentration of Multi-Walled Carbon nanotubes (MWCNTs) to get conductive nanocomposites, which are oven dried at various temperatures to determine the effect on the conductivity. The optimum drying temperature was determined to be 60℃, with conductivity increasing with MWCNTS loading. The extent of the oxidised cellulose (TONC) was characterised by field emission scanning electron microscopy (FE-SEM) to determine the morphology and the Fourier-transform infrared spectroscopy (FT-IR) to identify the functional groups in the neat TONC paper. The SEM showed an increasing porosity with increasing oxidation time. The carboxyl groups also increase with increasing oxidation time.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Applied Physics / 499

Characterization of a Talbot-Lau X-ray phase contrast system at the Wits Micro-CT Facility

Author: Gideon Chinamatira[1]

Co-authors: Anton Du Plessis [2]; Hilary Masenda [1]; Kudakwashe Jakata [3]

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Grating-based X-ray phase contrast imaging using a Talbot-Lau interferometer has emerged as an effective laboratory-based method to visualize specimens with low absorption contrast 1. This technique enables simultaneous extraction of absorption, phase contrast, and dark-field images from a single dataset. Characterization studies were undertaken to validate and optimize the performance of the Talint-EDU 2. phase contrast imaging system installed at the Wits Micro-CT laboratory. Firstly, visibility [3] measurements were conducted through phase-stepping experiments enabling the quantification of fringe contrast across the imaging field. A maximum visibility of 30% was achieved at 40 keV, however, a reduction in visibility was observed towards the grating edges, attributed to minor grating misalignments. Secondly, sensitivity [4] evaluations were performed by varying the sample position relative to the phase grating. The results demonstrated enhanced phase contrast detail when the sample was positioned closer to the phase grating, highlighting the importance of sample-grating proximity in achieving optimal imaging performance. Finally, system stability 2 was assessed through repeated phase-stepping measurements, confirming high reproducibility and consistent imaging performance under identical experimental conditions. Validation experiments were carried out on two biological specimens: a ground beetle and a preserved Myosorex varius foetus. The imaging results successfully illustrated enhanced visibility of delicate skeletal structures and soft tissues via phase and dark-field modalities, surpassing traditional absorption-based imaging capabilities. This study demonstrates the imaging capabilities and identifies the limitations of the Talint-EDU phase contrast imaging system at the Wits X-ray CT laboratory, providing a basis for future applications and system improvements.

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Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 500

Structural and upconversion properties of Er3+/Yb3+ doped zinc titanate for potential applications in bio-imaging

Author: Nolufundo Sintwa[1]

Co-authors: BM Mothudi [2]; Langutani Mathevula [3]; MS DHLAMINI [2]; Malik Maaza [2]; Tsholo Talane [1]

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[2] *Supervisor*

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ABO3 perovskite materials are gaining interest due to their applications in materials, electronics, and photovoltaics 1. One type of ABO3 is ZnTiO3, this material is highly favored because of its outstanding mechanical, optical, and insulating properties [2, 3]. It has been applied in various applications such as paint pigments, sorbents, microwave dielectrics, catalysts, dielectric materials, solar cells, photocatalysis, antibacterial agents, and gas sensors [4, 5, 6, 7]. Upconverting nanomaterials are used in a variety of applications, mostly in displays, the visualization of biological objects, data storage, lasers, sensors, optical imaging, and photodynamic therapy or in the development of solar panels, to name a few [8, 9, 10].
In this study, the host material zinc titanate and Yb3+/Er3+ doped ZnTiO3 was synthesized using the Hoodia Gordonii ethanoic extract.
The XRD showed that hexagonal Ecandrewsite structure was synthesized with the most intense peak corresponding to ZnTiO3 at around 2θ=35° [110], the intensity of the peaks reduced with doping concentration, and a peak shift was observed indicating incorporation of dopant. Raman results confirmed the production of ZnTiO3 and the peak shift due to dopant atoms occupying the lattice sites. The most intense vibrational mode at 350 cm-1 corresponds to the Ag mode of ZnTiO3; this agrees with the XRD phase analysis. The SEM micrographs showed a mixture of highly agglomerated morphologies ranging from platelets to rods, this is consistent with the formation of mixed-phase particles. The upconversion measurements showed a green emission centered around 550 nm, and this was confirmed by the CytoViva microscope. The upconversion properties of this material show that it has a potential use in bio-imaging and photodynamic therapy.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Photonics / 501

Temperature-dependent single-molecule spectroscopy of plant protein aggregates

Author: Tjaart Krüger[1]

Co-authors: Alexander Ruban [2]; Danhong Li [2]; Jürgen Köhler [3]

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Plants live with a continuous paradox: while light is the lifeblood for their growth, too much light can be extremely harmful. Their photosynthetic machinery, therefore, regulates the amount of absorbed energy in a photoprotective process known as non-photochemical quenching (NPQ). Aggregation of the main light-harvesting complex of plants, LHCII, is considered an excellent model system for the major component of NPQ. We performed a temperature-dependent (down to 4 K) single-molecule spectroscopy study of two types of LHCII aggregates to resolve their spectroscopic heterogeneity. We discovered that exciton annihilation is severely underestimated in steady-state bulk studies of LHCII aggregates and explains the varying spectral shapes in different time-resolved bulk studies.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 502

Radiation contamination in gold mine tailings soil samples using HPGe spectrometry

Authors: B.V. Kheswa[1]; L.P. Masiteng[1]; M.J. Mvelase[None]; P.P. Maleka[2]; S.S. Ntshangase[3]; Siyabonga Majola[1]

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[2] *iThemba Labs*

[3] *University of Zululand*

Corresponding Author: emjay.mvelase@gmail.com

An assessment of the radiation concentration in abandoned mines located near settlements in the west of Johannesburg was carried out, and the corresponding radiological indices were determined. In this study, a gamma spectrometer was used to measure the activity concentrations of radionuclides in the soil samples. The activity concentrations for ²²⁶Ra, ²³²Th, and ⁴⁰K were 338.44±3.48, 10.06±0.68, and 126.15±10.90 Bq/kg, respectively. The results revealed that the average activity concentrations at some locations exceeded the world average for some of these nuclides.

Apply for student award at which level::

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Astrophysics & Space Science / 503

Investigating the photospheric and chromospheric response of a C-class solar flare on 1 July 2012 using Swedish Solar Telescope and SDO observations

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Co-authors: Calmay Lee [2]; Eamon Scullion [3]; Gert Botha [3]

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The C-class solar flare event of 1 July 2012 13:08 UTC was observed in multiple wavelengths by the 1-m Swedish Solar Telescope (SST), providing information about the state of the photosphere, chromosphere and corona. In this study, focus is placed on the changes in sheared photospheric flow pre and post flare. Magnetic features inside the flow pattern are tracked, the borders between several counter flows and the location of different polarity inversion lines are identified, while the spatial evolution over time of the magnetic features is monitored for changes in magnetic field line tension. The magnetic flux is calculated for each magnetic feature and the velocity flow vectors are determined to show the degree of shearing pre and post flare. The SST results are combined with results from the Atmospheric Imaging Assembly (AIA) and the Helioseismic and Magnetic Imager (HMI) instruments on board the Solar Dynamics Observatory.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Nuclear, Particle and Radiation Physics-1 / 504

Theoretical studies of chiral systems described within particle-rotor model

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[2] *iThemba LABS*

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Chirality in nuclear systems requires an aplanar orientation of the total angular momentum and stable triaxial nuclear shape is needed [1-2]. It is expected that the angular momenta of an odd particle and an odd hole (both occupying high-j orbitals) are aligned predominantly along the short and the long axes of the nucleus respectively, whereas the collective rotation occurs predominantly around the intermediate axis of a triaxially deformed nucleus to minimize the total energy of the system. Experimentally one observes $\Delta I = 1$ rotational partner bands built on two- or multi-quasiparticle configuration. Multiple chiral bands (MχD) with different or same nucleon configuration can indeed form in a single nucleus, as theoretical calculations show (e.g., 3-5]), and experimental data suggest (e.g., [6-8]).
Investigations using the particle-rotor model have shown that the fingerprints of chirality in the two-quasiparticle system can occur in an idealised model description, where an odd proton and an odd neutron are restricted to one orbital each located at the lowest- and highest-energy orbitals or vice versa of a high-j shells [9-10]. For systems with many-quasiparticles, the calculations showed that nuclear chirality can also persist [11-13].
The present work reports on the review of theoretical studies of chiral systems performed using two-quasiparticle-rotor [14] and many-particle-rotor [15] models in different mass regions.

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Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics of Condensed Matter and Materials / 505

Effect of substrate geometry on microstructure and biological response of air plasma-sprayed hydroxyapatite coatings

Authors: Johan Malherbe[1]; Thabsile Theodora Thabethe[1]; Tshepo Ntsoane[2]; Unaisa Dockrat[1]

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This study investigates the influence of substrate geometry on the microstructural evolution, phase stability, and biological response of air plasma-sprayed hydroxyapatite (HAp) coatings on Ti-6Al-4V alloy substrates. Coatings were applied under atmospheric conditions onto three geometrically distinct substrates: flat disks, thick cylinders, and cylindrical rods, followed by immersion in simulated body fluid (SBF) to simulate physiological conditions.
X-ray diffraction and microscopy techniques were employed to evaluate phase composition, crystallinity, residual stresses, and surface morphology. All coatings exhibited characteristic plasma-sprayed features, including pancake splats, glassy regions, and cracks. Initial residual stresses were small and tensile, decreasing over 56 days of immersion. For instance, the average normal stress on flat disks dropped from 36.0 ± 3.0 MPa to 27 MPa. Similar trends were observed on the other geometries.
Immersion in SBF promoted ion dissolution, surface roughening, and precipitate formation, with growth occurring through a 3D network of channels. Energy-dispersive spectroscopy (EDS) confirmed increasing oxygen and decreasing phosphorus content across all samples after immersion. The Ca/P ratio declined in all geometries, most notably in thick cylinders (2.38 to 0.99).
XRD results confirmed HAp as the dominant phase, with minor tetra calcium phosphate, tricalcium phosphate and calcium oxide phases. HAp content increased within the first 7 days and slightly declined thereafter. For example, flat disks showed a rise from 70 wt% to 85 wt%, decreasing to 82 wt% by day 56. The findings underscore the significance of substrate geometry in tailoring coating performance for biomedical applications.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 506

Computational study on interaction of S-allyl-N-diethyl-dithiocarbamate (ADEDTC) and s-triazine collectors on (311) surface of pentlandite (Fe5Ni4S8)

Author: Peace Mkhonto[1]

Co-authors: Nontobeko Nondumiso Zavala [2]; Phuti Esrom Ngoepe [3]

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Nickel reserves are expected to run out by 2030 which contribute to various industrial applications such as stainless steel, coinage, and rechargeable batteries. Pentlandite is the primary source of nickel as well as a major carrier of platinum group elements (PGEs). The flotation of pentlandite and nickel ore has always been performed using traditional xanthates, dithiophosphate and dithiocarbamate collectors which are not so effective due to their low selectivity. Therefore, there is a need for finding a best collector that will possess both flotation power and selectivity performance. This study adopted that density functional theory (DFT) with dispersion correction by Grimme to investigate the adsorption of S-allyl-N-diethyl-dithiocarbamate (ADEDTC) and sodium dithio-butyl-amino-triazine (SDTBAT) collectors on dry Fe5Ni4S8 (311) surface. The adsorptions were performed on Ni and Fe atoms as preferred adsorptions sites. It was found that ADEDTC gave the most exothermic adsorption energy of (–460.58 kJ/mol) compared to s-triazine (–352.48 kJ/mol). Most significantly these collectors preferred to bind on Ni atoms than Fe atoms, which indicated their selectivity towards the pentlandite mineral. These suggested that ADEDTC is the best co-collector compared to s-triazine collector for utilization in the flotation of pentlandite minerals.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 507

Exploring enhanced titanium (Ti) nanoclusters doped with osmium (Os) and ruthenium (Ru): A DFT study

Author: Ramalebana Moeti[None]

Co-authors: Hasani Richard Chauke [1]; Phuti Esrom Ngoepe [2]; Tshegofatso Phaahla [1]

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Doped transition metal nanoclusters have gained significant interest for essential scientific research and various application purposes in catalysts, electronic and biomedicine. Elemental alloying of nanoclusters is considered as an efficient way to improve their stability, electronic properties, and reactivity. However, few studies comprehensively evaluating the effects of alloying Os and Ru on Ti nanoclusters are available. In this study, structural and electronic properties of TiN-1M (N = 2-20, M = Os, Ru) nanoclusters have been investigated using density functional theory technique. The calculations showed that osmium impurity prefers to be encapsulated and ruthenium mostly prefers the apex of titanium nanoclusters. The Os and Ru impurities are observed to enhance the binding energy of pure titanium nanoclusters with Os impurity having the least binding energy. The relative stability and the dissociation energy revealed that the doping of Os and Ru enhances the stability of N = 13 nanocluster. The HOMO-LUMO gap shows the same energy gaps for Ti and Os doped Ti nanoclusters and all the impurities are observed to have a similar gap at N = 17. The is a correlation between relative stability, dissociation energy and the HOMO-LUMO at N = 13 and 17.

Keywords: Binding energy, relative stability, dissociation energy, HOMO-LUMO

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 508

FLUKA Simulations of Gamma Irradiation Effects on Dynode Materials for the ATLAS TileCal

Authors: Cameron Baldwin[1]; Elias Sideras-Haddad[1]; Gaurav Lall[1]; Othmane Mouane[1]

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Understanding the impact of radiation on detector components is essential for ensuring the sustained long-term performance of the ATLAS TileCal, particularly in the high-luminosity phase of the LHC. This study details a variety of FLUKA Monte Carlo simulations investigating the effects of gamma irradiation on selected materials used in the dynode chain of photomultiplier tubes, a vital detector component of the TileCal. These materials include aluminium oxide, gallium arsenide, thallium-doped caesium iodide, and magnesium oxide. FLUKA's features are used to evaluate both the absorbed dose and the displacement per atom for each material, providing insight into radiation induced structural damage under conditions simulating Co-60 gamma radiation. The average photon energy of 1.25285 MeV was used to represent the decay spectrum of Co-60, with a beam fluence corresponding to 5 kGy, 50 kGy, and 100 kGy absorbed dose levels. This study aims to support the selection of radiation-hard materials for use in photomultipliers for the high-luminosity upgrade of the LHC, while also providing predictions to support ongoing experimental measurements.

Apply for student award at which level::

Consent on use of personal information: Abstract Submission:

Poster Session / 509

Theoretical study of defect structures in pure and C, Mg-doped aluminum oxide (Al2O3)

Authors: Chithambo M.L.[1]; Steephenraj A[1]

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Abstract
The stimulated luminescence features of aluminum oxide (Al2O3) regulated by defects and impurities within the structure are well-known. Examples of resultant applied materials include Al2O3:C and Al2O3:C,Mg. This study examines the basis for the experimental observation that doping Al2O3 with Mg and C improves its thermoluminescence (TL) sensitivity. In order to study the electronic structures and formation energies of point defects in pure and C, Mg doped Al2O3, first principles plane wave pseudopotential calculations were carried out. Using density functional theory as a tool, we systematically investigated the geometry and electronic structure of Al2O3 both in the presence and absence of individual dopant elements as well as in the presence of defect combination. According to the current study, the chemical environment has an important effect on the relative defect formation energy for doping with individual elements or in combination. We find that when an individual dopant element is present, the requirements for a good TL dosimetry material such as electron trapping, hole trapping and luminescent centers are satisfied. Interestingly, a simultaneous presence of the two dopant features also satisfies this need. It is observed that each dopant element contributes differently to the formation of several kinds of trapping centres. The underlying mechanism of the TL process in (Mg, C) doped Al2O3 was also investigated.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Applied Physics / 511

Design of an INVELOX based wind delivery system for low wind speed application.

Author: Anesu Chitura[1]

Co-authors: Ngwarai Shambira [1]; Patrick Mukumba [1]

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Features such as the omni directional intake, the nozzle-diffuser section as well as the diffuser section of the Increased velocity (INVELOX) wind delivery system augment incident air to a cut in wind speed of most small-scale wind turbines systems. Despite these properties, the INVELOX delivery systems suffers from adverse pressure gradient leading to flow separation within the throat section. This significantly reduces the suction capacity of the intake thus diminishing aerodynamic performance of the system. Amid other scholars that have researched to improve it, this study modified the original INVELOX setup by employing a multi-element diffuser section. The aim is to improve the expansion area and subsequently avoid flow separation on the diffuser wall. The geometry was developed and simulated in an OPEN FOAM environment where the effect to the performance of the INVELOX system as well as the extractable power is then observed. The results show an improved pressure gradient leading to the flow attaching for longer periods within the diffuser. A good value of H/D was shown to improve the speed up ratio of the throat thus emphasizing the importance of a careful design of the diffuser vanes.

Apply for student award at which level::

PhD

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics for Development, Education and Outreach / 512

The role of laboratory demonstrators in the learning and understanding of physics and chemistry concepts

Authors: Buyisiwe Sondezi[1]; Orpah Zinyemba[2]

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It is almost a common practice in institutions of higher learning that most experimental modules are well executed and understood by students if laboratory demonstrators are actively involved. This involvement is designed to assist students in understanding the practical aspects of their experiments before and during the laboratory session. This work reports on the vital and multifaceted role of laboratory demonstrators at the South African university in making learning effective for the students attending physics and chemistry practical sessions. The roles extend beyond the supervision of practical sessions. Demonstrators serve as key intermediaries between theory and experimental practices, assisting students to grasp abstract concepts through hands-on engagement.

Apply for student award at which level::

None

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 513

Optimizing the Geometry of an Empty Concentrator-Diffuser Augmented Wind Turbine Using Genetic Algorithm

Author: Ngwarai Shambira[1]

Co-authors: Golden Makaka [1]; Patrick Mukumba [1]

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The growing demand for electricity in off-grid regions, combined with rising global energy needs driven by population growth, underscores the urgent need to explore renewable energy alternatives to fossil fuels key contributors to carbon emissions and climate change. Wind energy offers a sustainable option but is challenged by its variability and low-speed performance in certain regions. This study investigates a performance enhancement strategy using an empty concentrator-diffuser augmented wind turbine (CDaugWT) to boost wind speed at the rotor, enabling continuous operation in areas with average wind speeds below 4 m/s.
A velocity augmentation model served as the objective function, correlating the augmentation ratio with six geometric parameters. A Genetic Algorithm (GA), an evolutionary optimization method, was used to determine the optimal design. Results showed that wind speed at the throat could be increased by up to 1.981 times. These findings closely aligned with results from response surface methodology (RSM), with only a 1.4 % deviation, validating the accuracy of the GA approach.
The optimized geometric values included a diffuser angle of 10.1°, concentrator angle of 20.0°, concentrator length of 396.3 mm (0.66 Rth), diffuser length of 994.8 mm (1.65 Rth), throat length of 74.5 mm (0.12 Rth), and flange height of 104.4 mm (0.17 Rth), where Rth is the throat radius. Computational Fluid Dynamics (CFD) simulations further validated these results, showing only a 0.58 % difference.
The study confirms that integrating optimization algorithms such as GA into the design process of CDaugWT systems can significantly enhance wind turbine performance making wind energy more viable for low-wind-speed regions.

Apply for student award at which level::

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Physics of Condensed Matter and Materials 2 / 514

Dft-based evaluation of Li_2MnO_3 as a promising cathode coating material for lithium-ion batteries

Author: MOGAU KGASAGO[1]

Co-authors: Katlego Phoshoko [2]; Phuti Esrom Ngoepe [3]; Raesibe Ledwaba [4]

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An ideal cathode coating material must exhibit excellent chemical stability, adequate electronic and ionic conductivity, a wide electrochemical stability window, and strong mechanical integrity to protect the electrode from degradation while ensuring efficient battery performance. Li_2MnO_3 has previously been used as a coating material due to its stabilizing effect on the core, but other beneficial properties it may offer as a coating material are still underexplored. In this study, these ideal coating properties of Li_2MnO_3 were investigated using Density Functional Theory (DFT). Given that the accuracy of DFT is highly dependent on the exchange-correlation functional, calculations were performed using meta-GGA, GGA+U, and GGA-PBE functionals to determine which provides the most accurate results compared to experimental data. To improve accuracy further, spin configurations were also considered. Among the tested methods, GGA+U combined with antiferromagnetic ordering produced results that were in closer agreement with experimental observations. The findings show that Li_2MnO_3 is thermodynamically stable, mechanically robust, and a semiconductor with a band gap of 2.17 eV. These results affirm Li_2MnO_3 as a promising cathode coating material, possessing the key attributes which are thermodynamic, electronic, and mechanical stability needed to enable durable, high-performance lithium-ion battery systems.

Apply for student award at which level::

MSc

Consent on use of personal information: Abstract Submission:

Yes, I ACCEPT

Poster Session / 515

Enhancement of the magnetic and mechanical performance of L10 MnPt-Ru alloys using ab initio techniques

Author: Thabang Kombesi[None]

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The rapid advancement of high-performance computing and spintronic technologies demands the development of novel materials that combine high magnetic anisotropy, thermal stability, and mechanical robustness. $L1_0$ ordered MnPt is a promising rare-earth-free candidate due to its large magnetocrystalline anisotropy and strong spin polarization. However, its practical application is hindered by brittleness, mechanical instability and phase segregation at elevated temperatures. In this study, we investigate the impact of Ru on the structural, thermodynamic, electronic, magnetic, and mechanical properties of $L1_0$ MnPt alloy using first-principles calculations. The lattice parameters and magnetic moments of binary $L1_0$-ordered MnPt alloy agree well with experimental and theoretical data to within 5 %. Heats of formation , elastic constants and thermophysical properties were determined to check the stability of L 10 Mn50Pt50-xRux alloys (0≤x≤25). The findings will contribute to the design of high-performance MnPt-based alloys, providing a pathway toward rare-earth-free magnetic materials with improved thermal and mechanical performance.

Keywords: Mn50Pt50-xRux alloys, DFT, Magnetic strength, Mechanical properties

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Nuclear, Particle and Radiation Physics-1 / 516

Exciting the Hoyle state in 12C selectively populated using the 10B(6Li,4He)12C reaction

Author: John Carter[1]

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An excited state in 12C close to the 3-alpha breakup was predicted by Fred Hoyle in 1954 and was identified in 1962 by Cook et al. as the 0+ state lying at an excitation energy of 7.65 MeV. It was the key to understanding the production of 12C and heavier elements in the Sun (stars) up to iron. In the Sun's core, fusion of two alpha-particles leads to the production of excited 8Be*and then the capture of another alpha-particle a + 8Be* produces excited 12C*close to the Hoyle state. Subsequently, gamma-decay from the Hoyle state to the 4+ (4.43 MeV) state and down to the 12C ground state 0+ (0.0 MeV) results in the production of stable 12C, as opposed to 3-alpha breakup. However, the observed enhanced 12C production rate in stars is speculated to be achieved through excited states of the Hoyle state. The existence of broad excited Hoyle states at 12C*(2+, 9.8 MeV) and 12C*(4+, 13.3 MeV) have been reported, previously not identified because of other nearby strongly excited states in 12C.

The 10B(6Li,a)12C* reaction selectively excites 2+ states in 12C and because of the high Q-value of Q = +24.6 MeV the high energy alpha-particles are easily identified with good energy resolution. Measurements were taken at the EN Tandem Van de Graaff accelerator of iThemba LABS (Gauteng) using 6Li beams at E_Lab = 20 MeV incident on thin 10B targets. Results will be presented for the observed high energy alpha-particles corresponding to states excited in 12C up to and above the Hoyle state. In addition, preliminary results will be shown for coincidence measurements between the outgoing high energy alpha-particle and the 12C reaction partner.

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None

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Yes, I ACCEPT

Poster Session / 518

An assessment of biogas production from food wastes

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ABSTRACT
Electricity usage and demand has risen tremendously over the years and so has its price. This has resulted in the need for less expensive, viable and ecologically acceptable means of producing energy for electricity. Currently, the primary source of electricity and power in South Africa is sourced from fossil fuels which has impacts on global warming. Bongumusa Secondary School in Mpumalanga province uses about 500kg of firewood weekly for preparing the school nutrition and this contributes to global warming; so is the dumping of these wastes in the landfills. This study is aimed at designing and constructing two low-cost pilot biogas digesters and assess their performances when fed with food wastes obtained from the school nutrition programme. The main objective of the study is to measure biogas produced from the two 〖0.21m〗 ^3 volume biogas digester setups which were designed from a polyethylene plastic drum. One digester setup was placed on surface and temperatures recorded were fluctuating; the other plant was buried underground and the fluctuations were kept minimal hence produced the most biogas. The composition of methane and carbon-dioxide were 〖4.0796m〗 ^3; 62% and 〖2.5004m〗 ^3; 38% respectively for maximum biogas of 〖6.58m〗 ^3 produced and was obtained between day 15 and 16 of the retention period at a pH of 6.9 and temperature of 35^0 C. 11.2112 total solids/day per 〖0.21m〗 ^3 and 53.3867 volatile solids per 〖0.21m〗 ^3.
Keywords: Biogas Digester, Biogas, Methane yield, temperature,

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Astrophysics & Space Science / 519

Trends of Thermal Structure in the MLT Region Using SABER Observations Over Sutherland, South Africa

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Co-authors: Makhosonke Dubazane [1]; Nkanyiso Mbatha [2]; Sifiso Ntshangase [1]

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The Mesosphere and Lower Thermosphere (MLT) region of the upper atmosphere is an essential atmospheric layer that significantly influences energy exchange, atmospheric dynamics, and space weather interactions. Comprehending the temperature of the MLT is essential, as this region acts as a critical interface between Earth's atmosphere and outer space, with its temperature directly affecting several physical and environmental processes. Moreover, the MLT temperature data interprets the vertical transfer of energy and momentum in the atmosphere. The Thermosphere Ionosphere Mesosphere Energetics Dynamics/Sounding of the Atmosphere using Broadband Emission Radiometry (TIMED/SABER) instrument is a crucial observational tool for examining the MLT area, offering long-term temperature observations to analyze trends and fluctuations in atmospheric parameters. The primary objective of this research is to examine the trend and variability of the thermal structure in the MLT region utilizing data collected by the TIMED/SABER satellite in Sutherland, South Africa. The TrendRUN model simulates and elucidates the long-term thermal structure trends in the MLT, employing realistic external forcings such as solar cycle variability, El Niño-Southern Oscillation, Quasi-Biennial Oscillation (QBO), yearly cycle, and semiannual cycle. The Mann-Kendall and Sequential Mann-Kendall nonparametric trend test methods are employed to extract trends. This research demonstrates that SABER data imply prolonged cooling trends, especially in the mesosphere, along with increasing CO_2 concentrations.

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Poster Session / 521

Track Matching Using ML Techniques in the ALICE Muon Forward Tracker

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Accurate track matching is vital for reconstructing particle trajectories in high-energy physics. In ALICE at the LHC, the upgraded muon tracking system combines data from the Muon Spectrometer with the new Muon Forward Tracker (MFT), a highly segmented silicon pixel detector positioned near the interaction point before the hadron absorber. With the MFT recording orders of magnitude more tracks than the spectrometer, we developed a refined machine learning-based matching method trained on Monte Carlo data. A subsequent data-driven approach will be explored to address potential limitations of Monte Carlo training. These enhancements aim to improve muon track reconstruction in ALICE, thereby supporting more precise physics analyses.

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Poster Session / 522

Influence of Surface Terminations (–F, –OH, –Cl) on the Structural and Electrochemical Behavior of $Ti_3C_2T_x$ MXene

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The rapid evolution of electrochemical energy storage and the growing environmental concerns demands advanced materials. MXenes, particularly Ti3C2 have been targeted to meet these demands due to their exceptional conductivity, layered structure, and tunable surface terminations. Generally, MXenes acquire surface terminations such as -OH, -O, -Cl, and -F after the etching process, which can be modified by post-synthesis treatment such as cleaning with ammonia solution (NH4OH). Herein, we study the effects of ammonia post-synthesis treatment on the structure and electrochemical performance of Ti3C2 MXene synthesized via in-situ HF etching. The aim is to understand how ammonia treatment influences the surface terminations, structure, and resulting electrochemical properties in both batteries and supercapacitors applications. Structural analysis using the SEM, EDX, and XRD revealed that ammonia hydroxide treatment effectively removes the residual fluoride (-F), chloride (-Cl), and aluminum (-Al) while preserving the layered structure of the MXene. XRD patterns further showed the eradication of (104) peak at ~39.0° 2θ for all samples, indicating the full conversion of Ti3AlC2 to Ti3C2, with no significant impurity signals as seen on the EDX data, corroborating SEM and EDX analyses. Electrochemical testing for supercapacitor application revealed that the CV curves of ammonia-treated MXene exhibited reduced current response and charge separation compared to the untreated sample, suggesting diminished pseudocapacitive behaviour and hence, lower capacitance. The GCD evaluation of both ammonia-treated and untreated samples showed nearly symmetrical curves, indicating good electrochemical reversibility. However, the ammonia-treated MXene had lower specific capacitance and decreased charge-discharge efficiency. On the contrary, it is reported that for battery systems the ammonia-treated MXene exhibits superior performance due to reduced -F termination that leads to enhanced ionic intercalation and lower charge-transfer resistance that benefits Li-ion insertion/extraction. NH4OH treatment also offers increased -O and -OH terminations promoting stronger chemical bonding while boosting capacity and cycling stability. The study has shown that ammonia treatment of Ti_3C_2 MXene detrimentally affects its electrochemical properties for supercapacitor application.

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Poster Session / 523

Circular Economy Strategies for End-of-Life Solar Panels

Author: Khathutshelo Madzivhandila[1]

Co-authors: David Tinawro [1]; Joseph Kirui ; SOPHIE MULAUDZI [1]; Shandukani Muronga

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The rapid expansion of the solar photovoltaic (PV) sector has brought increasing attention to the sustainable management of decommissioned solar panels. This study investigates circular economy strategies for addressing the environmental and material recovery challenges associated with end-of-life (EoL) PV modules. Drawing on a review of current practices and policy frameworks, the paper examines the potential of reuse, refurbishment, and advanced recycling technologies to minimize waste and enhance resource efficiency. The analysis highlights the critical need for regulatory harmonization, design-for-disassembly principles, and investment in recycling infrastructure to close material loops within the solar industry. Findings contribute to the ongoing discourse on circularity in renewable energy systems and offer actionable insights for policymakers, manufacturers, and sustainability practitioners.

Keywords: circular economy, solar panel recycling, end-of-life photovoltaics, resource recovery, sustainable materials management

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None

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Poster Session / 524

Enhancing Rural Electrification: An In-depth Analysis and Optimization of PV/Hydrogen Fuel Cell/Battery-Powered Microgrids

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Co-authors: Avhatakali Ramalata [1]; David Tinawro [1]; Ipfi Mnandi [1]; Khathutshelo Madzivhandila [1]; SOPHIE MULAUDZI [1]

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Corresponding Author: murongashandukani8@gmail.com

The global shift towards sustainable energy highlights the importance of supplying electricity to rural regions through renewable energy microgrids. Community development centres, such as the Masia Development Centre in Limpopo, South Africa, play a crucial role in community development and local economic growth. However, they often face challenges related to unreliable or insufficient power supply. This study comprehensively evaluates and enhances a hybrid microgrid powered by PV, hydrogen fuel cells, and batteries to improve energy availability in rural areas. Demand on energy consumption was analyzed to identify daily fluctuations in demand and determine peak usage times. The study examined critical energy requirements, such as lighting, appliance operation, and water pumping. Multiple hybrid configurations and dispatch methods were modelled using the Hybrid Optimization Model for Electric Renewables (HOMER) to identify the most viable technical and economical solution. Instead of analyzing existing systems, this study looks into the possibilities for optimized system design and demand-side management that cater to rural energy requirements. The results provide vital benchmarks for creating resilient and sustainable microgrids, furthering efforts to enhance energy access in off-grid rural communities.

Keywords: Rural Electrification,Hybrid Microgrid, Hydrogen Fuel Cell, PV/Battery Optimization

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Poster Session / 525

Impact of Morphology on Lithium Transport and Structural Evolution in Li2MnO3 Cathode Materials

Author: Tshidi Mogashoa[1]

Co-authors: Phuti Esrom Ngoepe [2]; Raesibe Ledwaba [1]

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Li₂MnO₃, a promising cathode material for high-performance energy storage, was synthesized in nanosphere, nanoporous, and bulk morphologies using the amorphization and recrystallization technique. The influence of morphology on the structural evolution and electrochemical behavior of Li₂MnO₃ was investigated focusing on its impact on lithium-ion mobility and structural stability during delithiation. All structures exhibited intrinsic defects, which intensified with delithiation, affecting lithium-ion transport. X-ray diffraction (XRD) analysis revealed progressive peak broadening accompanied by a slight rightward shift of the peak at 38°, suggesting cation mixing and increasing structural disorder as lithium content decreased. These changes reflect the challenges in maintaining structural integrity during cycling. Further analysis showed that delithiation led to pore size enlargement in the nanoporous morphology, while a structural transformation from the layered phase to a spinel-like configuration occurred, particularly from the Li_{1.25}MnO_{2.25} compositions onward. This transition, along with significant lattice disruption, points to complex degradation mechanisms that impact material stability. Among the morphologies, the nanosphere exhibited the highest radial distribution function (g(r)) values, indicating improved local ordering favorable for ion movement. Diffusion coefficient analysis further confirmed enhanced lithium-ion transport in the nanosphere structure. These results suggest that morphology plays a critical role in determining the structural stability and electrochemical behavior of Li₂MnO₃-based cathodes, offering insights that can inform the design of improved nanostructured materials for lithium-ion battery applications.

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Physics of Condensed Matter and Materials 2 / 526

Magnetic Properties of Carbon Nanospheres Synthesized by the Chemical Vapour Deposition Technique

Author: Othmane MOUANE[1]

Co-authors: Elias Sideras-Haddad [2]; Daniel Wamwangi [3]; Gerrard Peters [2]; Rudolph Erasmus [4]; Deena Naidoo [2]; Neil J. Coville [5]

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In this study, the magnetic properties of two different sets of carbon nanospheres synthesised by chemical vapour deposition are reported. The morphological and structural features of the carbon nanospheres are characterised by scanning electron microscopy and Raman spectroscopy. The magnetic measurements are performed by a state-of-the-art Physical Property Measurement System. For carbon nanospheres of diameters larger than 400 nm, the results reveal diamagnetic behaviour at high temperatures, and superparamagnetism at very low temperatures. However, ferromagnetic behaviour is observed for carbon nanospheres of diameters lesser than 400 nm. This unusual behaviour in carbon nanomaterials is revealed intrinsic. This is confirmed by the results obtained from both Induced Coupled Plasma Mass Spectrometry and Mössbauer spectroscopy,as well as the calculated saturation magnetisation.

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Poster Session / 527

THE EFFECT OF PHYSICS PRACTICALS ON THE FIRST YEAR PHYSICS STUDENTS AT THE UNIVERSITY OF LIMPOPO IN UNDERSTANDING PHYSICS CONCEPTS.

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Research on the efficiency of physics practicals in enhancing student grasp of physics ideas is rare. This study looks into how physics practicals affect students' knowledge of physics concepts at the University of Limpopo. Students who had attended a physics course with a laboratory component were polled using a questionnaire. The results of this study indicate that physics practicals improve students' knowledge of physics concepts. Students who took part in physics practicals reported having a more positive attitude towards physics, a better knowledge of physics concepts, and a higher level of confidence in their ability to solve physics problems. Physics practicals are therefore a useful method for enhancing student understanding of physics concepts.

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Physics of Condensed Matter and Materials 2 / 528

Assessing the Freysoldt, Neugebauer & van de Walle (FNV) and Kumagai–Oba (KO) finite-size corrections for Ce-vacancy complexes in diamond

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Lanthanide-doped diamond couples the ultra wide band gap, high thermal conductivity and radiation hardness of the host with the rich $4f$ electron physics of the dopant, promising solid-state qubits, single-photon emitters and spin-memory elements. Supercell density functional theory treatments of the charged Ce-vacancy complexes that underlie these functionalities suffer from spurious image–image interactions and an ill defined electrostatic zero energy; post processing finite-size corrections are therefore mandatory for quantitative defect thermodynamics.

We benchmark the two principal correction schemes—the reciprocal space potential alignment/monopole method of Freysoldt, Neugebauer & van de Walle (FNV) and the real space multipole expansion of Kumagai &Oba (KO)—for $\mathrm{Ce_{V2}}$, $\mathrm{Ce_{V3}}$ and $\mathrm{Ce_{V4}}$ in a 216-atom diamond supercell. Uncorrected neutral formation energies agree with literature to within 0.5 eV for $\mathrm{Ce_{V2}}$ and $\mathrm{Ce_{V3}}$ and confirm $\mathrm{Ce_{V3}}$ as the most stable neutral complex. Introducing positive charge exposes limitations of FNV: once the anisotropic Ce $4f$ charge density departs from the isotropic monopole assumed in that formalism, FNV corrections fail to converge. In contrast, KO, which accounts for higher multipoles, remains numerically stable and delivers consistent corrections.

Our results show that KO is indispensable for heavy-atom defects with non-spherical charge distributions, while FNV is reliable only for nearly isotropic cases. This enables accurate assessment of rare-earth dopants in diamond and other wide-gap semiconductors.

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Applied Physics / 529

Amplitude transformation in a qubit register

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In quantum computing a diagrammatic representation of a code is conventionally displayed as a vertical column of qubits that feed from left to right into a network of wires and gates. An alternative view is an array with qubits as a header row for all register eigenstates, with amplitude values as a column on the left. In this view, the action of gates on the register is seen as successive transformations of amplitude values, which allows for quantum parallelism to be seen acting on the register as a whole and for the ingenuity of various algorithms to be evident. Examples are the algorithms by Deutsch and for quantum teleportation.

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None

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530

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Poster Session / 531

Spectroscopy of HD 68695 with The Southern African Large Telescope

Authors: Lobone Dire[1]; Thebe Rodney Medupe[1]

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The target star of this research, HD68695, has characteristics of a young star with its age estimated to be about 7.3 million years by Arun et al. 2019. Murphy et al. 2020 observed strong emission in H-β, concluding that HD 68695 did not appear to be a λ-Böotis star and therefore its membership in the class was uncertain. Furthermore, Murphy et al. 2020, and Medupe et al. (2019) using Mahikeng Astronomical Observatory (MAO) data and Kilodegree Extremely Little Telescope (KELT-South) data have shown that HD 68695 pulsates with a period of 23 min. This is on the longest part of the roAp star pulsation period range, and on the shorter part of the δ-Scuti range. Murphy et al. 2020 claims this star is a pulsating λ-Böotis star. A criterion for the λ-Böotis classification is that a star must be within a spectral type range A, to F with metal deficiencies. Stars with weak Mg II (at 4481 Å) lines, such that the ratio of Mg II (at 4481 Å)/Fe II (at 4383 Å) is significantly smaller than in normal stars. Murphy, Corbally et al. 2015; Cheng et al. 2019 showed that the ratio of Mg II (at 4481 Å)/ Fe II (at 4383 Å) lines for stars with an 8000K suffices as a visual classification technique
for the identification of λ-Böotis stars, as it was used to discover and confirm λ-Böotis stars in their respective studies. We obtained high resolution spectrum of HD 68695 using SALT HRS in October 2024. We present an analysis of this spectrum to show you some interesting features and some spectral fitting to some of the lines. We aim to perform detailed abundance analysis so that we can confirm if classifying this star as a pulsating λ-Böotis star is correct.

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Applied Physics / 532

NON-SPECIALIST LECTURE: Characterising Photovoltaic Modules for Performance, Reliability, and Sustainability

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Photovoltaic (PV) module characterisation plays an important role in understanding and optimizing the performance of solar PV energy systems. By rigorously analysing various parameters such as power output, efficiency, temperature dependence, spectral response, degradation mechanisms and failure rates researchers can fine-tune PV modules and systems for maximum energy output and durability. This characterisation process not only ensures reliable operation under diverse environmental conditions but also facilitates the development of more efficient, cost-effective and location appropriate PV technologies. In addition, it supports standardisation in efforts across the industry to facilitate comparisons between different module types and different deployment locations. Ultimately, robust characterisation enhances the overall reliability, performance, and longevity of PV systems. This advances their widespread acceptance, adoption and contribution to the Just Energy Transition to sustainable energy solutions globally. This paper introduces PV cell and module technology and highlights key standardised laboratory characterisation and in-field characterisation methods used on various PV systems ranging from domestic to utility-scale PV power plants.

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Physics for Development, Education and Outreach / 533

PLAYand Brain Awareness –The missing link in STEM education

Author: Petro Erasmus[None]

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This article motivates and describes how play could be implemented at school, home and during therapies to help young children not only master maths concepts, but develop a positive study orientation towards maths and science. Research findings indicate that emotional intelligence, study orientation, motivation, resilience can predict not only the mathematics achievement of middle adolescents, but are also linked to increased likelihood of taking advanced mathematics courses. Developing emotional intelligence and study orientation in mathematics may be a vital missing link in maths achievement and should start at a very young age when the brain is still developing. Children learn through play. Most of the young child's thought processes are non-verbal and pictures and images are the most effective teaching media. Young children also need to be creative when discovering the world of maths. Children must touch maths and they need a variety of activities to keep their attention, and to help them develop concentration.

Keywords: mathematics; play; emotional intelligence; mathematics achievement; mathematics anxiety; metacognition; .play therapy; puppet therapy; brain development, biblio-therapy; resilience: study orientation in mathematics.

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Theoretical and Computational Physics / 534

ID 417

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Nuclear, Particle and Radiation Physics-1 / 536

Division Meeting

Astrophysics & Space Science / 537

Update on the air quality dashboard development

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The climate crisis persists, as the global community has yet to fully embrace the actions needed to tackle it. The decade from 2010 to 2019 was the hottest on record, leading to devastating wildfires, hurricanes, droughts, floods, and other climate-related disasters worldwide. To limit global warming to 1.5℃ above pre-industrial levels, emissions must already be on the decline and need to be halved by 2030. Unfortunately, we are far from meeting this target. Sustainable Development Goal 13 emphasizes the need for urgent climate action, pointing to the rising global temperatures and increased air pollution that pose significant threats to human health. This highlights the importance
of emission monitoring. In South Africa, however, emission data remains a challenge, making satellite data especially valuable. Satellites are increasingly used to monitor air quality and track atmospheric pollution. Around the world, studies are using data from the Tropospheric Monitoring Instrument (TROPOMI) to assess emissions and air quality. However, no air quality dashboard based on satellite data has been developed in South Africa using TROPOMI-Sentinel 5p data. This project aims to compute the Air Quality Index (AQI) using the Google Earth Engine (GEE) platform. Sulphur dioxide (SO2), nitrogen dioxide (NO2), and carbon monoxide (CO) will be the first pollutants used to calculate the AQI. A functional dashboard will be created to offer users easy access to standardised satellite data, enabling quick and effortless analysis.

Astrophysics & Space Science / 538

Simultaneous multiple conjugate nighttime MSTIDs observations: 4 October 2018

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This study reports on nighttime medium-scale traveling ionospheric disturbances (MSTIDs) observed by conjugate midlatitude all-sky imagers in Sutherland (32.4◦S, 20.8◦E; magnetic latitude: ~-40.9◦) and Asiago (45.87◦N, 11.53◦E; magnetic latitude: ~40.3◦) on the 4th of October 2018. These MSTIDs had fronts elongated along the northeast-southwest (NE-SW) and northwest-southeast (NW-SE) directions in the Southern and Northern Hemispheres. The NE-SW aligned MSTIDs propagated
in the NW (SE) direction in the Southern (Northern) Hemisphere, while the NW-SE aligned MSTIDs propagated in the NE (SW) direction in the Southern (Northern) Hemisphere. This study reports the first optical observations of conjugate NE-SW/NW-SE aligned and equator-eastward propagating MSTIDs. These MSTIDs are possibly linked to gravity wave-induced polarization electric field in the Northern Hemisphere, as significant gravity wave activity in the mesosphere was detected from the OH and OI greenline observations by the Asiago imager, and mapped to the Southern Hemisphere. Their equator-eastward propagation direction was favoured by background
winds at the hemisphere of origin, which were determined from a global model and observations. The NE-SW/NW-SE aligned and equator-westward propagating MSTIDs were likely generated through the coupled Perkins and sporadic E instabilities, since they were observed in the presence of sporadic E layers and with reasonable Perkins instability growth rates. Polarization electric fields induced by the observed gravity waves and sporadic E layers resulted in two pairs of conjugate MSTIDs.

Astrophysics & Space Science / 539

Investigating the influence of Boundary Layer Dynamics on Aerosol Optical Properties Using Ceilometer and Cimel Sun Photometer

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Monitoring atmospheric conditions is crucial for understanding the behaviour of aerosols, which directly impact air quality, climate, and satellite-based remote sensing applications. In this study, we focus on the atmospheric boundary layer (ABL), which regulates the dispersion, transport, and transformation of aerosols. Ceilometers, which measure the height of the boundary layer by detecting the backscatter of laser pulses, are used to observe ABL dynamics, including variations in boundary layer height (BLH), aerosol stratification, and vertical mixing. The Cimel Sun Photometer, a ground-based instrument that measures aerosol optical depth (AOD) and radiative properties of aerosols through direct sunlight measurements, is employed to provide insights into columnar aerosol loading, size distribution, and optical properties. This study examines the correlation

between ABL height, as measured by the ceilometer, and AOD trends from the Cimel Sun Photometer over Pretoria, a region with high pollution sources such as industrial areas and significant seasonal changes. By integrating these datasets, we assess how fluctuations in BLH influence aerosol concentration and optical properties across different seasons (summer, autumn, and winter). This research contributes to improving air quality assessments, validating aerosol models, and enhancing the parameterisation of aerosol dynamics in climate models

Astrophysics & Space Science / 540

Response of Ionospheric Topside Electron Density during Solar Flares

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The topside ionosphere is highly sensitive to solar flare activity, which leads to sudden enhancements in solar X-ray and EUV flux. These enhancements can significantly alter electron density profiles, impacting satellite communication and navigation systems. This study examines the response of topside electron density (Ne) to solar flares using in-situ data from the Swarm satellites. Electron density measurements during selected solar flare events are compared against X-ray flux data obtained from the GOES satellite to quantify the degree of ionospheric response. Additionally, background Ne values from the International Reference Ionosphere (IRI) model are employed to distinguish flare-induced perturbations from normal diurnal and latitudinal variations. A global analysis is carried out to investigate the topside ionospheric electron density response across different latitude regions. Preliminary findings reveal a consistent decrease in Ne during flare events, with the magnitude of the response varying by local time, latitude, and flare intensity. The study also explores how the ionospheric response aligns or diverges from IRI predictions during solar flares.

Astrophysics & Space Science / 541

Exploring Long-term trends in total electron content over South Africa

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The ionosphere is a dynamic, inhomogeneous and conductive plasma formed from the interaction of solar Extreme Ultraviolet (EUV) and X-ray radiation with the quasi-neutral atmosphere of the Earth, found at 60 –1000 km above sea level. With different peak levels of ionization, it is predominantly
studied by determining the total number of particles that pass through a square meter
area between a ground-based station and a GPS satellite –Total Electron Content (TEC). The importance
of TEC is owed by its effect in radio communication, position, telemetry and tracking.
An abundance of free electron gas in the ionosphere causes a delay of signals in the radio band.
This study explores the long-term trends in TEC over South Africa at 2 GPS stations located 1000 km apart. TEC was computed using the IONOLAB software over SUTH and HRAO stations for a period of 25 years. The TEC trend analysis was performed using 3 solar proxies (sunspot numbers, MgII and F10.7). Preliminary results show a negative TEC trend between 1998 and 2023 over these mid-latitudes stations in South Africa. This is consistent with related global studies reported in the literature.

Astrophysics & Space Science / 542

Investigation of Altitude and Solar Cycle Variation of DDM Occurrence Using Ionosonde Observations

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The diurnal variation of plasma density in the ionosphere is largely characterized by a single peak around local noon. However, diurnal double maxima (DDM) is sometimes observed when two distinct peaks and one valley in plasma density appear during the local daytime. Understanding DDM structures is essential for studying ionospheric dynamics and their key drivers, including neutral winds, E ×B drift, and solar irradiation, as these variations impact radio wave propagation and space weather forecasting. This study investigates DDM occurrences using ionosonde observations from stations in Hermanus (34.4∘S, 19.2∘E, magnetic latitude: 42.08∘S) and Grahamstown
(33.3∘S, 26.5∘E, magnetic latitude: 41.06∘S) during solar cycle 24 (2008–2019). A robust automated algorithm was developed to detect DDMs based on the presence of two fully formed peaks separated by a depletion (valley), all occurring between local sunrise and sunset. The algorithm established the criteria using a minimum peak-to-valley ratio of at least 6% to ensure significant peak prominence, a minimum peak-to-peak interval of 40 minutes to capture the time difference between two peaks, and an extra peak prominence threshold not exceeding 5% to filter out additional peaks. These thresholds ensure that only well-defined DDM structures are identified. The method was validated through visual inspection, achieving a detection accuracy of 97%. Using this approach, we identified 1,532 and 1,270 DDM events at Hermanus and Grahamstown from a total of 3,534 and 2,835 observation days, respectively, over the whole solar cycle. This translated to an occurrence rate of 43% at Hermanus and 45% at Grahamstown. We will explore statistical trends in terms of seasonal and solar cycle variations for each ionosonde station. Comparing and contrasting the trends between the stations may provide indications about possible mechanisms influencing DDM development. Furthermore, we will explore whether there are DDMs that are common between the two stations, as this may indicate the scale size and/or propagation of these events.

Astrophysics & Space Science / 543

Modelling Earth's magnetic field over the South Atlantic Anomaly region using Swarm satellite and ground-based data

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The Earth's magnetic field plays a critical role in shielding our planet from solar and cosmic radiation,
yet the South Atlantic Anomaly (SAA) region represents a significant weakening of this protective shield. This research aims to model the temporal and spatial evolution of the SAA region using the Revised Spherical Cap Harmonic Analysis (R-SCHA) technique, providing improved regional characterization and predictive capabilities. Utilizing satellite data from Swarm, alongside ground-based observatory records, we aim to refine regional predictions of the SAA's extent and intensity. The R-SCHA technique offers an enhanced resolution of localized magnetic variations, crucial for understanding the anomaly's underlying geodynamo processes and space weather impacts. Preliminary results will be presented, showcasing advanced data selection and processing techniques, which are essential in core field modelling as external field contributions must be minimized. Additionally, an analysis of all ground-based magnetic station records within the SAA region will be discussed, to further improve modelling accuracy. These findings are evaluated
through a comparative analysis with the CHAOS-7 global magnetic field model to assess their accuracy and reliability.

Astrophysics & Space Science / 544

Statistical Interpretation of the Thermospheric Density Responding to Geomagnetic Disturbances

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Variations in thermospheric density play an essential role in satellite operations, particularly during geomagnetic disturbances, where fluctuations in atmospheric drag impact orbital stability. A significant incident on February 4, 2022, saw SpaceX lose 38 Starlink satellites due to unanticipated atmospheric drag following a geomagnetic storm. This study aims to identify high- risk periods in thermospheric density using observational data from ESA's Swarm Satellite C. By integrating key geomagnetic indices such as Kp, AE, and SYM-H, this research studies the geomagnetic activity with thermospheric density variations to assess space weather disturbances. The study uses statistical

analysis to develop a predictive framework for identifying potentially hazardous periods, ensuring future satellite missions are better equipped to prevent similar risks. Data visualisation techniques, including plotted density fluctuations, provide deeper insights into the relationship between geomagnetic activity and atmospheric variability. The findings contribute to a broader understanding of thermospheric dynamics and their implications for satellite operations, mission planning, and the long-term sustainability of space activities.

Astrophysics & Space Science / 545

Modelling and observation results for the 23-25 March 2023 geomagnetic storm

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This talk will present results of ionospheric changes during the 23-25 March 2023 geomagnetic storm using observational and modeling data over the African-European sector. Both ionosonde and Swarm observational results show that mid latitudes experienced negative storm effects which have been attributed to thermospheric composition changes. We use models to simulate the ionospheric
behavior during this storm period. Considered models were Thermosphere Ionosphere Electrodynamics General Circulation Model (TIE-GCM) and the three-dimensional storm time empirical
model (3D-NNstorm) constructed based on radio occultation and ionosonde data. For the maximum electron density of the F2 layer, TIE-GCM and 3D-NNstorm models provide correlation values ranging between 0.48-0.64 and 0.64-0.88, respectively, with lower performance observed at low latitudes.

Astrophysics & Space Science / 546

Characteristics of Nighttime Medium-scale Traveling Ionospheric Disturbances: Longitudinal Comparison of their Seasonal and Local Time Variations

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This study presents a statistical analysis of the occurrence rate of midlatitude nighttime medium scale traveling ionospheric disturbances (MSTIDs) that were detected in Swarm plasma density measurements from 2014 to 2023. Monthly and local time variations of MSTID occurrence rates are compared in four longitude sectors: America, Africa, Asia, and Pacific. The spatial distribution showed a longitudinal variation as the MSTIDs were abundant in the Pacific region and scarce in the African sector. While the MSTIDs had occurrence peaks during both solstices, the winter solstice
peak dominated in all longitude sectors, representing a seasonal asymmetry. The local time variation of the MSTIDs revealed they occur predominantly during the postmidnight hours in all longitude sectors. However, post-sunset MSTIDs observations were enhanced over the Asian and Pacific sectors during the solstices. The longitudinal variation in the occurrence of MSTIDs is probably
linked to the E–F coupling as it matched that of the nighttime sporadic E variation obtained from ionosonde measurements. While the semiannual seasonal variation may be explained by interhemispheric E–F coupling, the winter dominance of MSTIDs matches that of gravity wave activity.
This indicates that gravity waves probably play a major role in seeding the MSTIDs observed in this study. Theoretical assessments of the longitudinal variations of MSTID driving mechanisms are needed to better understand the seasonal asymmetry and how it is affected by solar activity.

Astrophysics & Space Science / 547

Investigating the latitudinal-dependent solar differential rotation rate using SDO/HMI Dopplergrams

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The solar photospheric differential rotation rate has novel implications to the structure of the heliospheric
magnetic field. The period of the solar poles is ~ 35 days, and ~ 25 days at the equator.
In this study, the Doppler shift (either blue or red) of 116 Dopplergrams from the Helioseismic and Magnetic Imager instrument on board the Solar Dynamics Observatory are investigated to experimentally determine the photospheric differential rotation rate at different solar latitudes. A model is developed to describe the variation of surface speed with solar latitude. The results are compared to well-established models in the literature and shows strong consistency in trend and behaviour. The findings confirm the latitudinal differential rotation of the Sun. The developed model shows a deviation of less than 10% when compared to established models in the literature, demonstrating its accuracy and consistency. This is particularly significant considering the difference
in time scales, with the models in the literature using data spanning more than a decade, compared to the model developed using approximately an hour and a half of collected data. This study not only confirms the theoretical expectations regarding solar rotation but also demonstrates the effectiveness of Doppler spectroscopic analysis and space-based solar observations in studying solar dynamics. The results contribute to a broader understanding of solar behaviour.

Astrophysics & Space Science / 548

Modelling the antiproton modulation related to AMS-02 observations between 2011 and 2021

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In this study, the previously established set of modulation parameters used to reproduce PAMELA and AMS-02 proton observations between 2006 and 2022 is applied in the 3D steady-state drift numerical model to simulate antiproton spectra observed by AMS-02 detector between 2011 and 2021. In this way, the only differences between galactic protons and antiprotons simulations in the model remain their local interstellar spectra (LIS) and the sign of their charges. This is a better approach to antiproton modelling, especially when novel insights into potentially new physics are sought. Surprisingly, the simulated solar modulation effects on antiprotons were found to be much less pronounced than on protons at the same rigidity. For example, the computed intensity of antiprotons at ~ 1 GV was found to increased by ~13% between 2011 and 2019, whereas for protons at the same rigidity the intensity increased by ~ 86%. This result has now been confirmed by precise AMS-02 observations done at the same position around the Earth and over a long period. In this study it will be shown how the antiprotons LIS at lower rigidities intriguingly resembles the shape of the modulated spectra, and how this greatly influences the adiabatic energy losses these particles experience deep inside the heliosphere.

Astrophysics & Space Science / 549

Simulating cosmic ray diffusion coefficients in synthetic compressive magnetic turbulence

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In order to reliably estimate cosmic ray (CR) transport effects due to turbulence in the heliospheric magnetic field (HMF), and to validate existing diffusion theories (see, e.g., Engelbrecht et al., 2022, for a review), direct simulations, which involve solving the Newton-Lorentz equation numerically, may be employed (e.g., Els and Engelbrecht, 2024). Prior work, guided by turbulence conditions observed in the inner heliosphere, has largely focused on CR transport due to turbulence transverse to the background magnetic field. However, CR transport in the outer heliosphere, including in the heliosheath (HS), where HMF turbulence has been observed to have a compressive component (e.g., Fraternale et al., 2019), has, to date, received comparatively little attention. In this work, an approach to modelling HMF turbulence with an arbitrary compressive component, based on the synthetic turbulence model of Tautz and Dosch (2013), is suggested. Furthermore, turbulence parameters which may be expected in the HS are inferred from available analyses (e.g., Fraternale et al., 2019; Zhao et al., 2024). These parameters are then used as inputs for the particle pusher code detailed by Els and Engelbrecht (2024), modified so as to account for the presence of compressive turbulence, from which estimates for CR transport coefficients due to HMF turbulence conditions in the HS are calculated.

Astrophysics & Space Science / 550

The impact of geomagnetic storms and solar proton events in May and October 2024 on South Africa's upper atmosphere, compared to the historical event of October 2003

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This study investigated the impact of solar proton events (SPE) on the upper atmosphere over South Africa during intense geomagnetic storms in May (Dst = -412 nT) and October 2024 (Dst = -333 nT). Utilizing the NRLMSISE-2.0 atmospheric model and SOHO data, we characterized storm-time atmospheric composition and energetic particle fluxes. Significant fluctuations in atmospheric
constituents were observed, with molecular nitrogen (N₂) increasing by 3.61×10⁶ cm⁻³ day⁻¹ during the May sudden storm commencement
(SSC) and by 1.40×10⁶ cm⁻³ day⁻¹ and 2.26×10⁶ cm⁻³ day⁻¹ during the two-step SSC of October. A decrease in atomic hydrogen (H) of about 3.0×10⁴ cm⁻³ day⁻¹ occurred in May, while the largest decrease of approximately 8.60×10³ cm⁻³ day<sup>-

1</sup> was noted during the October storm. These changes, driven by particle precipitation that enhances nuclear and molecular interactions at GNSS altitudes (400 –450 km), affect the total electron
content (TEC) and may compromise GNSS signal accuracy. The results are compared with the historical event of solar cycle 23 in October 2003 (Dst = -353nT). This research enhances our understanding of space weather's impact on the upper atmosphere and related technologies.

Astrophysics & Space Science / 551

An investigative numerical modelling study of galactic deuterons in the heliosphere

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The observation of galactic cosmic ray (GCR) deuteron at the Earth has been done precisely with the PAMELA and AMS02 space detectors and reported from July 2006 to September 2014 and from May 2011 to April 2021, respectively. These observations span time frames that include solar maximum and both minimum modulation conditions in the $A > 0$ and $A < 0$ magnetic field cycles at rigidities between ~ 0.75 GV and ~ 19.5 GV. A surprise from AMS02 observation was that current available GALPROP calculated deuteron local interstellar spectra (LIS) are unable to reproduce the deuteron observations at rigidities above ~5 GV, and thus challenging the status quo regarding their origin in the galaxy. In this study a comprehensive 3D numerical model and a set of diffusion and drift coefficients, previously applied to a number of cosmic ray nuclei, together with a newly estimated LIS for deuterons, are used to simulate the modulation of deuterons from July 2006 to April 2021. The modelling results will be compared to observations made by PAMELA and AMS-02 detectors. This study will illustrate and discuss the effects due to different LISs and those caused by the main modulation mechanisms on deuteron modulation at the Earth. Furthermore, differences between the modulation of protons and deuterons at the Earth will be uncovered and highlighted.

Astrophysics & Space Science / 552

Solar wind temperature anisotropy during the Ulysses Spacecraft first polar pass

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Anisotropy is a property of turbulence in solar wind plasma in which velocity and magnetic fields fluctuate along and perpendicular to the ambient magnetic field. Recent in situ measurements confirmed that the solar wind in the inner heliosphere exhibits a temperature anisotropy. The presence of this anisotropy results in magnetohydrodynamic (MHD) waves and instabilities. In this report, we analyze the proton temperature anisotropy using data from the Ulysses spacecraft during its first latitude scan. Radial and latitudinal variations of temperature anisotropy for Firehose and Mirror instabilities are discussed.

Astrophysics & Space Science / 553

Cosmic-Ray Neutron Detectors for Soil Moisture Monitoring

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Primary cosmic rays are high-energy particles that enter the Earth's atmosphere via the heliosphere, which generate cascades of secondary cosmic-ray particles when interacting with atmospheric atoms. These secondary cosmic-rays interact inversely with hydrogen atoms in soil moisture, providing a non-invasive method for monitoring moisture levels. Continuous measurements of neutron flux in soil can establish predictive models for heatwaves, droughts, and floods that significantly impact South Africa's agricultural sector. This study employs a cosmic-ray neutron sensor (CRNS) probe equipped with a Boron trifluoride (BF3) detector positioned 1-2 m above ground that is capable of measuring soil moisture across a footprint of approximately 20 hectares width and up to 0.3 m depth. We detail the calibration process relating measured neutron intensity to volumetric water content, validated against gravimetric soil sampling and point sensor data, which will assist in precision agriculture that can enhance water resource management in diverse agricultural landscapes across South Africa.

Astrophysics & Space Science / 554

Investigating the photospheric and chromospheric response of a C-class solar flare on 1 July 2012 using Swedish Solar Telescope and SDO observations

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The C-class solar flare event of 1 July 2012 13:08 UTC was observed in multiple wavelengths by the 1-m Swedish Solar Telescope (SST), providing information about the state of the photosphere, chromosphere and corona. In this study, focus is placed on the changes in sheared photospheric flow pre and post flare. Magnetic features inside the flow pattern are tracked, the borders between several counter flows and the location of different polarity inversion lines are identified, while the spatial evolution over time of the magnetic features is monitored for changes in magnetic field line tension. The magnetic flux is calculated for each magnetic feature and the velocity flow vectors are determined to show the degree of shearing pre and post flare. The SST results are combined with results from the Atmospheric Imaging Assembly (AIA) and the Helioseismic and Magnetic Imager (HMI) instruments on board the Solar Dynamics Observatory.

Photonics / 555

NON-SPECIALIST LECTURER: Two-photon Infrared Vision

Nuclear, Particle and Radiation Physics-1 / 556

[516] Exciting the Hoyle state in 12C selectively populated using the 10B(6Li,4He)12C reaction

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An excited state in 12C close to the 3-alpha breakup was predicted by Fred Hoyle in 1954 and was identified in 1962 by Cook et al. as the 0+ state lying at an excitation energy of 7.65 MeV. It was the key to understanding the production of 12C and heavier elements in the Sun (stars) up to iron. In the Sun's core, fusion of two alpha-particles leads to the production of excited 8Beand then the capture of another alpha-particle a + 8Be produces excited 12Cclose to the Hoyle state. Subsequently, gamma-decay from the Hoyle state to the 4+ (4.43 MeV) state and down to the 12C ground state 0+ (0.0
MeV) results in the production of stable 12C, as opposed to 3-alpha breakup. However, the observed enhanced 12C production rate in stars is speculated to be achieved through excited states of the Hoyle state. The existence of broad excited Hoyle states at 12C(2+, 9.8 MeV) and 12C*(4+, 13.3 MeV) have been reported, previously not identified because of other nearby strongly excited states in 12C. The 10B(6Li,a)12C* reaction selectively excites 2+ states in 12C and because of the high Q-value of Q = +24.6 MeV the high energy alpha-particles are easily identified with good energy resolution.
Measurements were taken at the EN Tandem Van de Graaff accelerator of iThemba LABS (Gauteng) using 6Li beams at E_Lab = 20 MeV incident on thin 10B targets. Results will be presented for the observed high energy alpha-particles corresponding to states excited in 12C up to and above the Hoyle state. In addition, preliminary results will be shown for coincidence measurements between the outgoing high energy alpha-particle and the 12C reaction partner.

Physics of Condensed Matter and Materials / 557

PCMM Division Meeting

Corresponding Author: terblansjj@ufs.ac.za

Physics for Development, Education and Outreach / 558

School Learners‘ alternative conceptions regarding the Chemical Reaction Rate in certain Schools in the Lepelle Circuit, South Africa

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Reaction rate is a fundamental part of chemistry which forms a basis for the comprehension of subsequent chemistry areas. A Reaction Rate Concept Test (RRCT) was developed in the form of a questionnaire and administered to a group of physical sciences learners in South Africa to collect data, and was statistically analyzed. This study was based on the conceptual change approach as the strategy which will be used in the teaching and learning contexts to minimize or eliminate misconceptions (alternative conceptions) held by most learners at the high school level. The results showed that only a few (about 34%) of the learners mastered certain concepts, while the majority (about 66%) of the learners struggled to deal with the same concepts. This means that most learners do not understand the effect of factors affecting the reaction rate. There were serious misconceptions among the learners that had a significant impact on their academic performance. These misconceptions are shown to have a high resistance to change, and the teachers should always guard against and be vigilant enough to deal with them as soon as they emerge.

Physics for Development, Education and Outreach / 559

Practitioners' understanding of integrating basic science into lessons in the early childhood development playroom

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Early Childhood Development serves as a crucial foundation for lifelong learning, with basic science education playing a key role in fostering curiosity, critical thinking, and problem-solving skills of young children. However, many practitioners looks like face challenges in integrating science concepts into playroom activities. Understanding how practitioners apply basic science in these settings is essential for improving early science education. This study aims to explores practitioners' understanding of integrating basic science into lessons in the early childhood development playroom. A qualitative research approach will be adopted, using an exploratory case study design to gain in-depth insights into practitioners'understanding and pedagogical approaches. Data will be gathered through semi-structured interviews, classroom observations, and document analysis. Interviews will provide insights into practitioners' perspectives, while observations captured real-time teaching practices. Lesson plans and activity guides will be analysed to assess curriculum alignment with science learning objectives. The study will be conducted in eight selected Early Childhood Development centers. Four from urban and four from rural settings to capture diverse teaching contexts. The population included qualified Early Childhood Development practitioners. This study grounded in Vygotsky's sociocultural theory were also used to examine how children acquire scientific knowledge through play and social interaction. The expected finding assume that while practitioners recognise the importance of science education, many lack formal training in early science instruction. Play-based strategies such as storytelling, sensory exploration, and nature-based activities will be used. Despite a willingness to integrate science into playroom lessons, gaps in training and resources hinder effective implementation. The study will conclude that addressing these gaps can improve science learning outcomes in Early Childhood Development settings. The study will recommend that encouraging knowledge-sharing among practitioners to exchange best practices in early science education is crucial to improve basic science literacy and inquiry-based learning from an early age.

Physics for Development, Education and Outreach / 560

PLAY and Brain Awareness –The missing link in STEM education

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This article motivates and describes how play could be implemented at school, home and during therapies to help young children not only master maths concepts, but develop a positive study orientation towards maths and science. Research findings indicate that emotional intelligence, study orientation, motivation, resilience can predict not only the mathematics achievement of middle adolescents, but are also linked to increased likelihood of taking advanced mathematics courses. Developing emotional intelligence and study orientation in mathematics may be a vital missing link in maths achievement and should start at a very young age when the brain is still developing. Children learn through play. Most of the young child's thought processes are non-verbal and pictures and images are the most effective teaching media. Young children also need to be creative when discovering the world of maths. Children must touch maths and they need a variety of activities to keep their attention, and to help them develop concentration.

Physics for Development, Education and Outreach / 561

The role of physics in climate science and sustainability science with special emphasis on Southern Africa

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In the Anthropocene epoch, we are at a watershed where the impact of decisions made in the next five years will have impact on the future of humanity. Physics has significant roles in multiple aspects of this existential crisis. Fundamentally, in terms of evidence-based reasoning, providing the background to the conclusion that the climate is changing significantly, and at a rate not observed in the last 10 000 years, is crucial. In this paper, some of the less frequently mentioned aspects of the role of physics will be explored.
For example, in comparison with the northern hemisphere, reliable data for local weather from Southern Africa is in short supply, but Is essential in building understanding of global patterns. The new science of attribution requires good observations of extreme events, to deduce whether a disaster is attributable to the change in climate, or would have been experienced in the natural climate as a rare event. A related concern is the state and effectiveness of early warning systems within Southern Africa, which rely not only on accurate observation, but fast interpretation.
In climate science, network modelling is being adapted from information science to complement more classical climate models; and in multiscale modelling, it has become clear that the understanding of African thunderstorm systems in terms of convection, thermodynamics and turbulence is not yet adequate. The contribution of Southern African research in physics to understanding Antarctic ice breakup and the science of the Southern Ocean, a major carbon reservoir, could become significant. Less obvious is the role of theoretical physics in identifying the behaviour of bistable and related complex systems, for example the El Niño Southern Oscillation.
Complex system behaviour also has application in the stability of power supply networks, particularly as renewable energy generation and energy storage capacity are added to national and international generation and transmission networks in Southern Africa and the risk of catastrophic outages rises.
Many more examples exist and indicate that there is potential for incorporating climate and sustainability science fundamentals into physics curricula, in improving science communication skills among physicists, and in building international physics research links in Southern Africa in the context of climate and sustainability science.

Physics for Development, Education and Outreach / 562

Division Meeting

Corresponding Author: samr@uj.ac.za

Physics for Development, Education and Outreach / 563

The role of physics in climate science and sustainability science with special emphasis on Southern Africa

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In the Anthropocene epoch, we are at a watershed where the impact of decisions made in the next five years will have impact on the future of humanity. Physics has significant roles in multiple aspects of this existential crisis. Fundamentally, in terms of evidence-based reasoning, providing the background to the conclusion that the climate is changing significantly, and at a rate not observed in the last 10 000 years, is crucial. In this paper, some of the less frequently mentioned aspects of the role of physics will be explored. For example, in comparison with the northern hemisphere, reliable data for local weather from Southern Africa is in short supply, but Is essential in building understanding of global patterns. The new science of attribution requires good observations of extreme events, to deduce whether a disaster is attributable to the change in climate, or would have been experienced in the natural climate as a rare event. A related concern is the state and effectiveness of early warning systems within Southern Africa, which rely not only on accurate observation, but fast interpretation. In climate science, network modelling is being adapted from information science to complement more classical climate models; and in multiscale modelling, it has become clear that the understanding of African thunderstorm systems in terms of convection, thermodynamics and turbulence is not yet adequate. The contribution of Southern African research in physics to understanding Antarctic ice breakup and the science of the Southern Ocean, a major carbon reservoir, could become significant. Less obvious is the role of theoretical physics in identifying the behaviour of bistable and related complex systems, for example the El Niño Southern Oscillation. Complex system behaviour also has application in the stability of power supply networks, particularly as renewable energy generation and energy storage capacity are added to national and international generation and transmission networks in Southern Africa and the risk of catastrophic outages rises. Many more examples exist and indicate that there is potential for incorporating climate and sustainability science fundamentals into physics curricula, in improving science communication skills among physicists, and in building international physics research links in Southern Africa in the context of climate and sustainability science.

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None

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Plenary / 564

Generation and detection of light at the single photon level

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We develop quantum devices to enable the implementation of quantum technologies based on controlling light at the single photon level with the aim of on-chip integration and novel instrumentation. Future quantum communication and sensing will require high-performance quantum devices able to generate and detect light one photon at a time. Schemes to manipulate light on-chip, based on integrated photonics, are carried out in our group. Single photon sources based on semiconductor quantum dots can generate single as well as entangled photon pairs at telecom wavelengths to enable implementation of long-distance quantum communication. We operate a quantum network made of deployed optical fibers in the Stockholm area and demonstrate single photon transmission and quantum key generation over 34 km.

The ability to detect single photons is crucial for quantum optics as well as for a wide number of applications. Several technologies have been developed for efficient single photon detection in the visible and near infrared. The invention of the superconducting nanowire single photon detector in 2001 enabled the development of a new class of detectors that can operate close to physical limits. Different aspects will be discussed including wavelength detection range, time resolution, dark counts, saturation rates and photon number resolution along with various applications such as Lidar, quantum communication, deep space communication, microscopy and bio-medical measurements.

Multipixel single photon detectors based on superconducting nanowires will also be discussed, including a quantum spectrometer that is based on an array of high-performance single photon By time stamping single photon detection events at the output of a spectrometer we generate data that can yield spectra as well as photon correlations such as g(2), g(3) to g (n) as well as cross correlations among different spectral lines, under pulsed excitation, transition lifetimes can also be extracted. This instrument therefore replaces a spectrometer, a streak camera, a Hanbury-Brown Twiss interferometer and operates with far higher signal to noise ratio than is possible with existing detectors that are commonly used in the infrared.

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Plenary / 565

Indications for new physics at the LHC

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The Standard Model (SM) of particle physics provides a very good description of nearly all available experimental data. Notable exceptions are Dark Matter (DM) and the Baryon asymmetry of the universe (BAU, the question why we only see matter, but not antimatter). These questions point towards physics beyond the SM (BSM). While DM points towards some new so far undiscovered symmetry, the BAU leads to models with extended Higgs sectors.

The Large Hadron Collider (LHC) at CERN is searching for BSM physics. However, no clear signal of BSM physics was discovered so far. While the need for BSM is firmly established, the LHC data nevertheless exhibits some interesting anomalies that could point towards BSM theories with new symmetries and/or extended Higgs sectors. I will review the status of the BSM searches at the LHC and discuss some promising excesses in the data. I will demonstrate how this kind of excesses can be analysed with future (High Luminosity-) LHC data, or at a future e+e- collider. The confirmation of any of the many excesses and anomalies in the LHC data would pave the way for future experimental and theoretical explorations.

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Plenary / 566

Wearable adaptive optics for the eye

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The optics of the human eye is at once simple, robust, and remarkably well adapted to the needs of the visual system. However, how different optical aberrations, whether naturally occurring or artificially induced, affect vision remains a central question in ophthalmology and visual optics. One of the most powerful approaches to investigate this involves the use of adaptive optics (AO) visual simulators. Traditionally, AO visual simulators have been developed as laboratory or clinical desktop systems. These instruments combine wavefront sensing to measure the eye's optical aberrations with phase modulation devices, such as deformable mirrors or spatial light modulators, that allow the controlled induction of specific optical profiles. This enables direct testing of visual performance under well-defined optical conditions, providing insights into the visual impact of aberrations and the design of new advanced optical corrections. In recent years, we have extended this concept into wearable devices. These emerging systems aim to bring high-resolution visual simulation and testing into real-world settings, enabling assessment under natural viewing conditions and over extended periods of time. In this presentation, I revise the evolution of adaptive optics in vision science, from retinal imaging to visual simulation. Special emphasis will be placed on the technological challenges and opportunities of miniaturizing and adapting these systems for use in dynamic, real-life environments. Wearable adaptive optics has the potential to transform both vision research and clinical care, opening new possibilities for personalized correction or myopia control strategies.

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None

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Plenary / 567

Gamma-ray Pulsars: Puzzles and Progress

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Pulsars are spectacular, enigmatic, astrophysical objects that emit regular pulsations across the electromagnetic spectrum. Moreover, they are thought to be factories of cosmic rays as well as gravitational waves upon merging events, making them true multi-messenger objects. They are Nature' s exquisitely accurate timepieces, being the super-dense remnants of supernova explosions. They are extremely stable rotators with magnetic fields that are a trillion times stronger than that of Earth. These fascinating attributes make them valuable laboratories to test theories of gravity, nuclear physics, plasma physics, beaming effects, quantum mechanical effects, and radiation physics in relativistic, strong-field regimes that cannot be replicated on Earth. In the gamma-ray energy band, there has been a number of revolutionary discoveries, including the milestone detection of 300 high-energy pulsars; the detection of pulsations from the famous Vela pulsar up to 20 TeV and the Crab pulsar up to 1 TeV; mode-changing phenomena observed in the Gamma Cygni pulsar; and the existence of a pulsar fundamental plane that relates gamma-ray luminosity, spectral cut-off energy, surface magnetic field, and spin-down luminosity, to name a few. There has also been evidence for multipolar field structures and highly efficient acceleration processes in these systems. Pulsars reveal themselves in interesting settings such as binaries, globular clusters, pulsar wind nebulae, and supernovae. Several models that attempt to capture the essence of pulsar radiation have been developed and refined over the years, involving several techniques ranging from geometrical to electrodynamical to particle-in-cell to magneto-hydrodynamics. Even 50 years after their discovery, many open questions remain. In this talk, I will review the status of the field, highlighting the major breakthroughs that we can expect with the substantial increase in the pulsar population and quality of temporal, spectral, spatial, and polarisation data with the advent of several new experiments.

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Plenary / 568

Halide perovskites and related materials: A new playground of material discovery

Author: DIPANKAR DAS SARMA[1]

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The last fifteen years have seen the most spectacular rise of a class of materials initially known as the hybrid halide perovskites, with the field quickly evolving to encompass all-inorganic halide perovskites and double perovskites, low-dimensional hybrid halide materials, and quantum dots. With intense worldwide research activities over the last decade, photovoltaic, light-emissive, and detection properties of this class of materials have reached superlative performance levels within this exceptionally short period and have taken the world by surprise. I shall discuss some historical aspects of this field of study, followed by some of our recent results to exemplify the excitement in this field in terms of discovering new materials and material properties. If time permits, I shall touch upon another exciting field comprising chiral systems where some of the systems can even be made ferroelectric.

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Plenary / 569

Shaping the Future: A Physics Journey to Groundbreaking Research in Quantum Technologies

Author: YASEERA ISMAIL[None]

Quantum communication holds the promise of ultra-secure information transfer and lays the foundation for the future quantum internet. At the heart of this vision is the ability to distribute entanglement and quantum keys over long distances, including via satellite. My research focuses on free-space quantum communication, and most recently, on implementing satellite-based quantum links. In a ground-breaking achievement, we implemented South Africa's first quantum satellite link, and the longest intercontinental quantum satellite secure link of 12900 km between China and South Africa, which was published in a recent Nature (2025) publication. This achievement establishes a critical foundation for Africa's sustained participation in and contribution to the global quantum research and innovation landscape.

As a female physicist navigating the scientific landscape in Africa, I have also been fortunate to benefit from strong mentorship, collaborative networks, and an unwavering belief in the potential of homegrown excellence. These experiences have taught me that developing scientific capacity is dependent on building collaborations.

In this lecture, I will share my journey, from the early days of navigating local constraints in quantum optics to conducting cutting-edge research. Along the way, I hope to offer a message of encouragement to young women in physics and a vision of what is possible when dedication meets opportunity.

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Plenary / 570

Practitioners' understanding of integrating basic science into lessons in the early childhood development playroom

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Early Childhood Development serves as a crucial foundation for lifelong learning, with basic science education playing a key role in fostering curiosity, critical thinking, and problem-solving skills of young children. However, many practitioners looks like face challenges in integrating science concepts into playroom activities. Understanding how practitioners apply basic science in these settings is essential for improving early science education. This study aims to explores practitioners' understanding of integrating basic science into lessons in the early childhood development playroom. A qualitative research approach will be adopted, using an exploratory case study design to gain in-depth insights into practitioners'understanding and pedagogical approaches. Data will be gathered through semi-structured interviews, classroom observations, and document analysis. Interviews will provide insights into practitioners'perspectives, while observations captured real-time teaching practices. Lesson plans and activity guides will be analysed to assess curriculum alignment with science learning objectives. The study will be conducted in eight selected Early Childhood Development centres. Four from urban and four from rural settings to capture diverse teaching contexts. The population included qualified Early Childhood Development practitioners. This study grounded in Vygotsky's sociocultural theory were also used to examine how children acquire scientific knowledge through play and social interaction. The expected finding assume that while practitioners recognise the importance of science education, many lack formal training in early science instruction. Play-based strategies such as storytelling, sensory exploration, and nature-based activities will be used. Despite a willingness to integrate science into playroom lessons, gaps in training and resources hinder effective implementation. The study will conclude that addressing these gaps can improve science learning outcomes in Early Childhood Development settings. The study will recommend that encouraging knowledge-sharing among practitioners to exchange best practices in early science education is crucial to improve basic science literacy and inquiry-based learning from an early age.

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Poster Session / 571

DFT studies of photocatalytic properties of barium titanate doped with vanadium and tungsten for hydrogen production via water splitting.

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Experimental studies have demonstrated that pure BaTiO3 can serve as a catalyst for hydrogen production via water splitting. However, its large energy band gap prevents activation under visible light. This study explores the potential of using visible light, the most abundant component of solar energy, to drive water splitting by modifying BaTiO3's electronic and optical properties through Mono-doping and Co-doping. Using first-principles density functional theory (DFT) calculations, the effects of vanadium and tungsten (W) as dopant were analyzed. Doping lowered the energy required for electronic transitions in BaTiO3. Further confirmation of impurity states generated by doping was provided by calculating the DOS and values of charge density difference. In terms of the optical properties, the doped models exhibited widening of absorption edges in comparison to pure BaTiO3, resulting in absorption peaks extending into the visible light region, thereby effectively improving the overall optical performance

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Poster Session / 572

Hilbert's Hotel paradox Using structured light

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This work explores the Hilbert's Hotel paradox, a thought experiment illustrating the counter-intuitive nature of infinity, and its modern optical analogy. Historically, infinity was a vague concept until Georg Cantor provided a mathematical foundation. The paradox describes an infinitely occupied hotel that can always accommodate new guests by shifting existing ones. Recent research has uncovered a direct optical parallel through wavefield singularities. We advance this by experimentally demonstrating Hilbert's Hotel using both phase and polarization singularities in "fractional" order optical vortex beams. Utilizing a multi-ramped spiral-phase-plate and a supercontinuum source, we generate and control these beams to implement Hilbert's Hotel in scalar and vector fields, revealing complex transitions. This generic scheme highlights the power of structured beams in visualizing abstract mathematical concepts and their significance in fundamental and applied optical research.

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Poster Session / 573

Spatially resolved spin angular momentum mediated by spin-orbit interaction in tightly focused spinless vector beams in optical tweezers

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We present an efficient method to generate spatially resolved longitudinal spin angular momentum (LSAM) in optical tweezers using tightly focused first-order spirally polarized vector (SPV) beams with zero intrinsic angular momentum. When focused into a refractive index (RI) stratified medium, the beam forms spherically aberrated intensity patterns with off-axis lobes carrying LSAM of opposite helicity to the beam center. We trap birefringent particles both at the center and off-axis lobes, observing them spin in opposite directions depending on their location and size. Large particles rotate clockwise or anticlockwise based on the beam's polarization spirality, while smaller particles spin according to spatial positioning. Numerical simulations agree with experiments, revealing a simple yet powerful route to spatial spin control in optical tweezers, opening new directions in spin-orbit optomechanics.

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