SAIP2021

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North-West University

Book of Abstracts

Contents

Physics of Condensed Matter and Materials / 19

Theoretical Modeling of High Entropy Alloys

Author: Volkmar Nolting[1]

[1] *Vaal University of Technology*

Corresponding Author: volkmarn@vut.ac.za

High entropy alloys (HEA) containing Co, Ni, Fe have recently enjoyed considerable attention in the material sciences due to their interesting mechanical and magnetic properties that are further enhanced by the additive manufacturing technique often used to process them.
HEAs are theoretically difficult to describe as they often form amorphous structures and the Bloch theorem is not applicable. In this article the method of the effective medium is used and the corresponding many body problem is solved selfconsistently within the coherent potential approximation. The mixing entropy of HEAs and their phase stability are explained using an optimization approach. The complex micro- and multi phase structure are due to many body effects that are discussed from a calculation of the quasiparticle density of states. It turns out that these many body effects are most significant if the components of the alloy are present at about equal proportions. Applications to Kondo insulators and superparamagnetism are investigated where the interaction between magnetic moments is of indirect type and mediated by the free electrons of the conduction band (RKKY interaction). In the strong coupling limit it is shown that the susceptibility has a maximum at the blocking temperature indicating a phase transition from ferromagnetism to superparamagnetism. Using alternatively a lattice gas model to represent the disordered alloy the existence of the second order phase transition is confirmed and the blocking temperature is calculated. It is shown that the results of the two model calculations are in qualitative agreement with one another and must thus be regarded as good and reliable.

Apply to be considered for a student ; award (Yes / No)?:

no

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics of Condensed Matter and Materials / 20

Nanotechnology innovation Diamond

Author: Brian Masara[1]

[1] *SAIP*

Corresponding Author: brian.masara@saip.org.za

The nanotechnology innovation diamond

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics for Development, Education and Outreach / 21

THE INFLUENCE OF LOCATION AND GENDER ON SHAPING STUDENT PERFORMANCE IN PHYSICS

Author: oluseye sadare[None]

Co-authors: Thasmai Dhurumraj ; Awelani Mudau

Corresponding Author: sadareoluseye@gmail.com

The influence of Location and Gender on Shaping Student Performance in Physics.
Oluseye Folasayo Sadare[1], Thasmai Dhurumraj2&Awelani V. Mudau3
1. Department of Science and Technology Education, University of South Africa.
2. Department of Science and Technology Education, University of Johannesburg
3. Department of Science and Technology Education, University of South Africa.
Email: sadareoluseye@gmail.com1,tdhurumraj@uj.ac.za2, , mudauav@unisa.ac.za
Abstract
The poor enrolment of females in Science subjects creates gender inequalities. This study sought to explore how location and gender shape student performance in Physics. A qualitative approach was adopted for this study that randomly selected four co-educational public secondary schools, two schools from urban areas and rural areas respectively in Nigeria. Ethical considerations were accounted for by gaining permissions from the relevant departments to conduct the study. Pseudo names have been used for all participants. Data was collected through interviews, classroom observations, and document analysis. Data was analyzed deductively. The findings revealed that the gender of the students affect their performance in Physics with male students performing better than female students. Also, urban students perform better than rural students in physics. This study will assist government in the distribution of amenities to various towns and communities and also develop the interest of female students in Physics.

Apply to be considered for a student ; award (Yes / No)?:

YES

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Applied Physics / 22

A thermo-effusion pump for air sampling: theoretical considerations.

Authors: Daniel Malan[1]; Yvette Naudé[2]

[1] *Scidat Pty Ltd*

[2] *UP*

Corresponding Author: niel.malan@scidat.co.za

The monitoring of volatile organic compounds (VOCs) in the atmosphere can yield useful information regarding environmental processes, such as the degradation of pesticides or the composition of natural gas seeps. The VOCs in air are easily monitored by trapping on silicone multi-channel traps (MCTs) followed by gas-chromatographic analysis. However, MCTs are not passive devices and require active pumping of air. Conventional electric pumps are expensive and complex, which limits the use of MCTs in environmental sampling to campaigns conducted by trained workers. But one of the characteristics of the MCT's open-tube design is a very low pressure drop (typically 20 Pa), which allows the use of very simple pumps.

When there is a temperate difference across a porous membrane of which the pores have diameters much smaller than the mean free path length of the gas molecules on either side, a flow of gas Q is generated from the cold side towards the hot side. This phenomenon can be termed thermo-effusion. Q is a function of the gas pressure P, the gas temperatures T_1 and T_2, the total area of the pores A, and the molar mass of the gas M.

$Q = \frac{PA}{\sqrt{2\pi MR}} \left(\frac{\sqrt{T_1} - \sqrt{T_2}}{\sqrt{T_2 T_1}} \right)$

Thermo-effusion offers the possibility of pumping air using no moving parts. In a suitable device sunlight could be used to generate a temperature difference across a mesoporous membrane, and the resulting flow could then be used to pump air through a sampling trap. This could allow the deployment of MCT samplers in remote areas by semi-skilled workers.

A first-order approximation from naïve theory calculates that for a porosity of 20%, a membrane with pores of 6.8 nm diameter and 5 K temperature difference across it can generate a flow of 200 ml/min using an area of only 5 mm square. While these values are certainly optimistic and a real system will not be nearly as efficient, they indicate that a useful flow can probably be obtained using practical membrane sizes and temperature differences. Membranes with suitable porosity and pore sizes are commercially available and could be used in future experimental investigations.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Theoretical and Computational Physics / **23**

Fitting the relic density with contributions from dimension-five operators

Author: Lara Mason[1]

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

[1] *University of Johannesburg*

[2] *IPNL*

Corresponding Author: lara.mason@live.com

We study the relic density and astrophysical constraints of an effective model featuring top-philic scalar dark matter and a heavy T-channel mediator. The addition of a dimension-five contact term which is common to BSM scenarios modifies the available parameter space, and the model features interplay between the associated Wilson coefficient and Yukawa parameter in producing the correct relic density. We present an analytical fit to the relic density, considering co-annihilations when relevant, and discuss the detection constraints.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Photonics / 24

Nuclear translocation of Map Kinase and release of basic fibroblast growth factor following photobiomodulation at 660 nm in diabetic wounded cells.

Author: Patricia Kasowanjete[1]

Co-authors: Nicolette Houreld [1]; Heidi Abrahamse [1]

[1] *University of Johannesburg*

Corresponding Author: jkasowanjete@gmail.com

Mitogen Activated Protein Kinase (MAPK) signalling is one of the best characterised signal transduction pathways in cell biology and is involved in wound healing processes. Photobiomodulation (PBM) has been used to induce physiological changes and has been shown to improve wound healing processes, however underlying molecular and cellular mechanisms of action remain largely unexplained. The purpose of this study was to determine the effect of PBM at 660 nm on nuclear translocation of MAPK and release of basic fibroblast growth factor (b-FGF) in diabetic wounded fibroblast cells in vitro. This was evaluated by irradiating cells at a wavelength of 660 nm with 5 J/cm2 and incubating them for 24 and 48 h. Non-irradiated cells (0 J/cm2) served as controls. b-FGF was measured by the Enzyme Linked Immunosorbent Assay (ELISA) and translocation of phosphorylated MAPK was assessed by immunofluorescence. PBM of diabetic wounded cells showed an increased release of b-FGF and translocation of MAPK in irradiated cells at 24 and 48 h as compared to non-irradiated cells. The findings of this study showed that PBM is capable of facilitating the releasing of b-FGF and activation of MAPK in diabetic wound cells in vitro, thus facilitating wound healing under diabetic conditions.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Photonics / 25

A comparison between photobiomodulation at 830 nm and 660 nm on differentiation in diabetic human skin fibroblast cells

Author: Olajumoke Oyebode[1]

Co-authors: Nicolette Houreld [1]; Heidi Abrahamse [1]

[1] *Laser Research Centre, Faculty of Health Sciences, University of Johannesburg, P.O. Box 17011, Doornfontein Campus, South Africa, 2028.*

Corresponding Author: daramzjay09@gmail.com

Different studies have proposed the efficacy of photobiomodulation (PBM) at different wavelengths (830 and 660 nm) to stimulate wound repair in diabetic cells. The TGF-β1/Smad cascade has proven to be an effective signalling pathway in differentiating fibroblasts into myofibroblasts. This study aims to compare the effects of both wavelengths on cellular viability and expression of fibroblast differentiation markers in WS1 fibroblast cells. The cells were modelled into groups; normal (N),

normal wounded (NW) and diabetic wounded (DW). At 830 nm and 660 nm, cells were irradiated at 5 J/cm2, while control cells were without irradiation (0 J/cm2). At 24 and 48 h post-irradiation cell viability was investigated using trypan blue exclusion assay while TGF-β1 and p-Smad2/3 was ascertained using ELISA. Immunofluorescence was used to observe the presence of alpha smooth muscle actin (α-SMA). There was a significant increase in cell viability in the irradiated models using both wavelengths. A wavelength of 830 nm elicited a slight increase in the expression of TGF-β1 compared to 660 nm in diabetic wounded cells, both wavelengths had no effect on expression of p-Smad2/3. Both wavelengths were successful in initiating the differentiation of fibroblasts into myofibroblasts in diabetic wounded cells with no difference between wavelengths.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics for Development, Education and Outreach / **26**

Effective remote learning

Author: Eric Mazur[1]

[1] *Harvard University*

Corresponding Author: mazur@seas.harvard.edu

The rapid transition to online teaching necessitated by the coronavirus pandemic has been a good opportunity to rethink our approach to teaching. Moving to an online format suggests that many activities that have traditionally been synchronous and instructor-paced, can be made asynchronous and self-paced. What may have seemed like a challenge, is a great opportunity to improve the quality of education.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Photonics / **27**

FACILITATING iADMSC DIFFERENTIATION INTO NEURONAL CELLS BY PHOTOBIOMODULATION USING VISIBLE AND NEAR-INFRARED WAVELENGTHS

Author: Madeleen Clasina Jansen van Rensburg[1]

Co-authors: Anine Crous [1]; Heidi Abrahamse [1]

[1] *Laser Research Centre, University of Johannesburg*

Corresponding Author: 220145280@student.uj.ac.za

The central nervous system (CNS) of mammals is limited in its repair and regeneration in the event of injury due to trauma or neurodegeneration, therefore, optimization of its regeneration capabilities is necessary. Studies have shown that this issue may be addressed through the transdifferentiation of adipose-derived mesenchymal stem cells (ADMSCs) into neuronal cells. This process has not been efficiently achieved with chemical and biological inducers; this study explored possible optimization through the addition of photobiomodulation (PBM). PBM uses low intensity light to stimulate intracellular processes and has been known to increase cell proliferation and aid in stem cell differentiation. This in vitro research aimed to differentiate ADMSCs with growth factors and chemical inducers and subsequently measure the optimization effects that PBM had on differentiation. PBM was applied as single use at a low energy density, at visible and near-infrared (NIR) wavelengths. Characterization of immortalized ADMSCs (iADMSCs) with ELISA, immunofluorescence microscopy, and flow cytometry was used in identifying specific transcription factors and neuronal markers. After this, biochemical analysis was performed to observe reactive oxygen species (ROS) production, cytotoxicity, migration abilities for homing, morphology, proliferation, and the mitochondrial membrane potential (MMP). Probable results will be effective ADMSC transdifferentiation to neuronal cells through induction with growth factors and PBM support. Moreover, an optimized protocol for in vitro differentiation of ADMSCs will be established for subsequent use in clinical application and regenerative therapy in the event of damage to the CNS.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Nuclear, Particle and Radiation Physics / **28**

The derivation of preliminary reference levels for radioactivity in drinking water surrounding authorised sites.

Author: Thato Molokwe[1]

[1] *National Nuclear Regulator*

Corresponding Author: tmolokwe@nnr.co.za

The National Nuclear Regulator's (NNR) mandate is to protect the people, property and environment from radiological damage. NNR is currently involved in projects to establish the radioactivity of drinking water in the vicinity of authorised sites. It is important that before this, preliminary reference levels which will be used to assess the radioactivity levels in collected samples are established. These reference levels will inform whether the water resource from which the samples were collected poses a radiological threat to human health if ingested. The study seeks to derive preliminary reference levels based on international best practices. Annual Limit on Intake (ALI) was calculated making use of the principles of the World Health Organisation (WHO) which is considered to be international best practice. The calculations factored in different age groups and made use of dose conversion factors provided by the International Atomic Energy Agency (IAEA) in the General Safety Regulations (GSR Part 3). Calculated ALI values for infant, child and adult age groups are presented. The results suggest an insignificant (orders of magnitude) difference in calculated ALI values across ages. Therefore it is recommended that the NNR use calculated ALI for adults as preliminary reference levels. These can be used in assessing the radioactivity status of baseline data that is currently being collected.

Keywords: Drinking water, radioactivity, reference levels

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Space Science / **29**

Solar modulation of cosmic ray proton related to observations by PAMELA from 2006 to 2014

Authors: Innocentia Ramokgaba[1]; Mabedle Ngobeni[2]; Dzivhuluwani Ndiitwani[2]

[1] *School of Physical & Chemical Sciences, North-West University, Mmabatho, South Africa*

[2] *1. Centre for Space Research, North-West University, Potchefstroom, South Africa 2. School of Physical & Chemical Sciences, North-West University, Mmabatho, South Africa*

Corresponding Author: innocentiaramokgaba@gmail.com

The global features of solar modulation of galactic cosmic ray proton in the heliosphere are studied with a comprehensive three-dimensional numerical model and compared to proton observations made by PAMELA experiment from 2006 to 20014. The results of the numerical modelling and its comparison with observations give insight into how the elements of the diffusion and drift tensor change with time from solar minimum to solar maximum conditions. We find that, in order to fit PAMELA observations, the rigidity slope of the perpendicular mean free path below 4 GV increases from 2006 to 2014, while remaining almost constant above 4 GV. This study will provide better constraints on the magnitudes and rigidity slopes of the diffusion mean free paths at the Earth.

Apply to be considered for a student ; award (Yes / No)?:

yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / **30**

SYNTHESIS AND ELECTRICAL CHARACTERIZATION OF GaN GROWN BY ELECTROCHEMICAL DEPOSITION

Authors: Abdulraoof Ali[1]; Walter Meyer[2]; Jacqueline Nel[2]

[1] *PhD student*

[2] *University of Pretoria*

Corresponding Author: abdalraof34@gmail.com

ABSTRACT
The III-Nitride semiconductor materials are wide bandgap materials and can be crystalline as the structure of wurtzite and zinc-blende types. Wurtzite InN, GaN and AlN have direct bandgap 1.9 eV, 3.4 eV and 6.2 eV, respectively [1]. GaN is an extremely promising material for the blue and white light-emitting diodes LEDs, leaser and detectors [2].
İn this study GaN thin films were deposited on Si (111) substrates at room temperature using an electrochemical technique. The deposition was done by placing the Si substrate in a solution of Ga(NO3)3 and NH4NO3 in deionized water at room temperature and applying a current density of 1 mA/cm2.

Good quality of Schottky diode was fabricated on the GaN thin films, with IV barrier height of 0.68 eV and CV barrier heights of 0.97 eV for GaN deposited using 1 mA/cm2 current density. Deep-level transient spectroscopy measurements were performed, and electron traps with an activation energy of 0.47 eV and 0.29 eV were observed in GaN thin film grown by the electrochemical deposition technique. A more detailed explanation for GaN will be discussed and related to the structural and morphological of a sample using the X-ray diffraction, scanning electron microscopy.

Keywords: GaN, electrochemical deposition, Schottky diodes, DLTS, characterization.

References
[1] Nakamura, Shuji, et al. "High-brightness InGaN blue, green and yellow light-emitting diodes with quantum well structures." Japanese journal of applied physics 34.7A (1995): L797.
[2] S.J. Pearton, C.R. Abernathy, F. Ren, Gallium Nitride Processing for Electronics, Sensors and Spintronics, Springer, London, 2006.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Poster Session / **31**

Search for tWZ production in the Full Run 2 ATLAS dataset using events with four leptons

Author: Jake Reich[1]

[1] *University of Cape Town*

Corresponding Author: jake.reich@cern.ch

Supervisor: Dr. James Keaveney (UCT)
Co-Supervisor: Dr. Sahal Yacoob (UCT)

The production of a single top quark in association with a $W^{\pm}$ and Z boson ($tW^{\pm}Z$) at the CERN LHC is sensitive to both the neutral and charged electroweak couplings of the top quark as the process involves the simultaneous production of a W boson and a Z boson in association with the top quark. Due to the very large coupling of the top quark to the Higgs boson, the electroweak couplings of the top quark are a theoretically well-motivated area in which to search for the first signs of new physics. The recent lack of signs of new physics from LHC data tells us that new physics is either very heavy, or is very weakly coupled to Standard Model particles, therefore we might only observe signs of new physics in anomalous rates of well-chosen processes. A prime example of such a process is tWZ. This has an extremely low production cross section (0.7 fb for $\sqrt{s} = 13$ TeV), meaning that it is an extremely rare process to observe and subsequently, it has never been observed by any particle physics experiment. However, the latest datasets recorded by the ATLAS experiment at the CERN LHC are sufficiently large to allow a potential observation of this rare process. We use the Full Run 2 dataset recorded by the ATLAS to search for the production of a top quark together with a $W^{\pm}$ and Z boson in the channel with four leptons (two originating from the decay of the Z boson, one from the associated W boson and one from the W boson which decays from the top quark (together with a b quark)). In this analysis, we use a kinematic reconstruction technique which aims to discriminate between tWZ and our most prominent background process, $t\bar{t}Z$. In addition to this, we implement Machine Learning techniques (Boosted Decision Trees) to further isolate our tWZ signal. The dominant source of the fake lepton background is from $t\bar{t}Z$ events containing one fake lepton. The kinematic distributions of this background are taken from simulation and its normalisation is constrained using a dedicated control region. As this work forms the basis of an official ATLAS analysis, only blinded results are shown. A maximum likelihood fit (blinded) is performed over our tWZ signal region and three control regions, resulting in an expected significance of 1.1σ and an expected limit of $2.0^{+2.8}_{-1.4} \times \sigma^{tWZ}_{SM}$. In order to increase the sensitivity of

our tWZ signal, we perform another maximum likelihood fit (blinded) over all regions defined for the tetralepton channel and the trilepton channel (an independent analysis conducted by Benjamin Warren (UCT)), resulting in an expected significance of 1.2σ and an expected limit of $1.8^{+2.6}_{-1.3} \times \sigma^{tWZ}_{SM}$. These results would be the tightest ever constraint on this process.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc Dissertation

Poster Session / **32**

Application of tagged neutron method for detecting diamonds in kimberlite.

Author: Motswakae Sebele[1]

Co-authors: Mikhail Sapozhnikov ; Yury Rogov ; Vladislav Kremenets

[1] *Botswana International University of Science and Technology*

Corresponding Author: sm19100047@studentmail.biust.ac.bw

Tagged neutron method is a non destructive technique of analysing the chemical composition of a material using fast neutron. This technique can be applied in diamond mining industry to separate diamond bearing kimberlite from the barren ores before the secondary crushing of the ore to avoid damaging diamond. It allows detecting diamond within the kimberlite without crushing the ore. The ore is irradiated with fast neutrons of energy 14.1 MeV which excites kimberlite elements. These elements de-excite through the emission of characteristics gamma rays. Diamond is mainly carbon. Carbon forms peaks at 3.9 and 4.4 MeV, therefore diamond detection is the detection of excess carbon in some regions of the ore. It can detect diamonds in an ore 10 times larger than the size of diamond.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Nuclear, Particle and Radiation Physics / **33**

An Investigation of overtraining within Semi-Supervised Machine Learning Models in the search for heavy resonances at the LHC

Author: Benjamin Lieberman[1]

Co-authors: Bruce Mellado [2]; XIFENG RUAN [3]; Thabang Lebese [4]; Joshua Choma [2]; Salah-Eddine Dahbi [2]

[1] *University of Witwatersrand*

[2] *University of the Witwatersrand*

[3] *University of the witwatersrand*

[4] *WITS University*

Corresponding Author: benjamin.lieberman@cern.ch

When utilizing semi-supervised techniques in training machine learning models in the search for bosons at ATLAS, the overtraining of the model must be investigated. In particle physics internal fluctuations of the phase space and bias in training can cause semi-supervised models to label false signals within the phase space due to overfitting. The issue of false signal generation in semi-supervised models has not been fully analyzed and therefore utilizing a toy Monte Carlo model, the probability of such situations occurring can be quantified. This investigation of Zgamma resonances is performed using a pure background Monte Carlo sample. Through unique pure background samples extracted to mimic ATLAS data in a background-plus-signal region, multiple runs enable the probability of these fake signals occurring due to overtraining to be thoroughly investigated.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Nuclear, Particle and Radiation Physics / **34**

Analysis of UOC for nuclear forensics using Scanning Electron Microscope

Author: Naomi Dikeledi Mokhine[None]

Co-authors: Vera Uushona [1]; Manny Mathuthu [1]

[1] *North-West University*

Corresponding Author: dikeledi.mokhine@gmail.com

Nuclear forensic science is a relatively young discipline that has evolved because of the need to study banned nuclear or radioactive material needed to determine its origin. Nuclear forensic science basically makes use of observable material properties, referred to as “signatures,” which provide clues on the material’s history. The work done in this research was to investigate morphological parameters for uranium ore concentrates as possible with new nuclear forensic signatures. Images were obtained in an FEI Quanta FEG 250 Scanning electron microscope (SEM) operating at an accelerating voltage of 15kV. The data analyzed by SEM showed that the samples could be differentiated by image texture. Morphological aspects of UOCs have been studied extensively, showing that these signatures can provide important clues to the material’s past.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Poster Session / **35**

Statistical properties of 133Xe from inverse kinematics Reactions extracted using the Ratio Method

Author: Teffo Seakamela[1]

[1] *University of Johannesburg*

Corresponding Author: teffoseakamela@gmail.com

T. W. Seakamela1,3, S. H. Connell1 , B. V. Kheswa2, M. Wiedeking3,12, V. W. Ingeberg4, K. L. Malatji3,6, S. Siem4, H. C. Berg4, A. Avaa3,8, D. L. Bleuel5, C. P. Brits3,6, J. W. Brummer 3,6, T. S. Dinoko10, M. Guttormsen4, P. Jones3, A. C. Larsen4, J. E. Midtbø4, L. Msebi3,7, S. H. Mthembu3,9, G. ONeil7, J. Ndayishimye3, L. Pellegri3,8, O. Shirinda3,6, F. Zeiser4, B. R. Zikhali3,7, D. Negi11
1Department of Engineering, University of Johannesburg, P.O. Box 524, Auckland Park 2006, South Africa, 2Department of Physics, University of Johannesburg, P.O. Box 524, 55 Beit Str, Doornfontein, Johannesburg, 2028, South Africa, 3iThemba LABS, P.O. Box 722, Somerset West, 7129, South Africa, 4Department of Physics, University of Oslo, N-0316 Oslo, Norway, 5Lawrence Livermore National Laboratory, 7000 East Avenue, Livermore, California, 94550-9234, USA, 6Department of Physics, Stellenbosch University, Private Bag X1, Matieland, 7602, South Africa, 7Department of Physics, University of the Western Cape, P/B X17 Bellville 7535, South Africa , 8School of Physics, University of the Witwatersrand, South Africa, 9Department of Physics, University of Zululand, Private Bag X1001,KwaDlangezwa 3886, South Africa 10NMISA, Meiring Naude Rd, Pretoria, 0184, South Africa, 11Department of Nuclear and Atomic Physics, Tata Institute of Fundamental Research, Mumbai 400005, India, 12School of Physics, University of the Witwatersrand, Braamfontein, Johannesburg, 2000.

E-mail: {"mailto:teffoseakamela@gmail.com"}
Abstract. A significant set of experimental studies over the years have revealed the presence of a Low-Energy Enhancement (LEE) in the Gamma Strength Function (GSF) in many light-to-medium as well as in some rare-earth nuclei [1,2,3,4 and references therein]. The GSF and the Nuclear level density (NLD) are critical input parameters in calculations of nuclear reaction rates within Hauser-Feshbach formalism. It has been shown that the existence of this LEE can enhance astrophysical r-process reaction rates, by up to several orders of magnitude [5] for the neutron-rich nuclei. This would be very significant for models of nucleosynthesis hence; it should be investigated further. Furthermore, experimental data on the LEE is non-existent for noble gas isotopes, such as 133Xe due to the difficulty to produce suitable targets.
To search for the LEE in the 133Xe nucleus, the 132Xe (d,p) reactions conducted at iThemba LABS, with beam energy of 530 MeV. The AFRODITE and ALBA arrays were used to measure the gamma-rays in coincidence with a silicon particle telescope which were used to measure the charged particles from the reactions. At the time of the experiments the array consisted of eight high resolution germanium, six large volume and six small volume LaBr3(Ce) detectors and two S2 silicon strip detectors, particle-gamma-gamma events were extracted and are being used obtain the GSF of 133Xe using the Ratio Method [6].

[1] A. C. Larsen et al., J. Phys. G: Nucl. Part. Phys. 44, 064005 (2017).
[2] M. D. Jones et al., Phys Rev. C 97, 024327 (2018).
[3] J. E. Midtbø, et. al., Phys. Rev. C 98, 064321 (2018).
[4] V. W Ingberg et al., Eur. Phys. J. A 56, 68 (2020).
[5] A. C. Larsen and S. Goriely, Phys. Rev. C 82, 014318 (2010).
[6] M. Wiedeking et al, Phys. Rev. Lett. 108.162503 (2012).

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Applied Physics / **36**

The development of a real-time Monitoring system for the ATLAS Tile Calorimeter Phase-II Upgrades

Author: Mpho Gift Doctor Gololo[1]

Co-author: Bruce Mellado [2]

[1] *Witwatersrand University*

[2] *University of the Witwatersrand*

Corresponding Author: mgd.gololo@gmail.com

A major upgrade to the High Luminosity Large Hardon Collider (HL-LHC) will increase the instantaneous luminosity by a factor 5 compared to the LHC. A complete redesign of the electronic system is required for new radiation levels, data bandwidth as well as the clock distribution. The upgrade of this electronic system is an integration of front-end and back-end electronics to acquire physics data. However, the large computation of data requires a healthy state-of-the-art electronic system. Numerous sensors will be used to monitor the status of the ATLAS Tile Calorimeter (TileCal) electronic system. This paper presents a real-time monitoring system that will be used to read data from the sensors of the TileCal electronic system that will be used by the Detector Control System (DCS). The real-time monitoring system includes an implementation of a server on the System-on-Chip (SoC) Zynq Field Programmable Gate Array (FPGA) known as Tile Computer-on-Module (TileCoM). This server will read data and publish it to the clients of the DCS. This test bench includes an Avnet Ultra96-V2 ZYNQ UltraScale+ MPSoC evaluation board and Tile Gigabit Ethernet switch that will serve as a basis for the TileCoM mezzanine board as part of the Tile PreProcessor (TilePPr).

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Nuclear, Particle and Radiation Physics / **37**

South African contribution towards the ATLAS Tile Calorimeter PreProcessor

Author: Mpho Gift Doctor Gololo[1]

Co-author: Bruce Mellado [2]

[1] *Witwatersrand University*

[2] *University of the Witwatersrand*

Corresponding Author: mgd.gololo@gmail.com

Four major experiments for the High Luminosity Large Hardron Collider (HL-LHC) are upgraded to accommodate an increase in luminosity. ATLAS (A Toroidal LHC ApparatuS) is part of these four major experiments and it is upgraded to investigate a wide range of physics. The detector is divided into long barrel and two extended barrels. The Tile Calorimeter (TileCal) is part of the ATLAS detector and is the central hadronic calorimeter. The main aim of the TileCal Phase-II upgrade is to completely redesign the on- and off-detector electronics. The Tile PreProcessor (TilePPr) is part of the off-detector electronics and it is responsible for storing the detector data with a total data bandwidth of 40 Tbps. University of the Witwatersrand is contributing 24 % to the total design and production of boards toward the TilePPr. The TilePPr is made up of numerous components and University of the Witwatersrand is responsible for Tile GbE Switch and TileCoM components.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics for Development, Education and Outreach / **38**

Online classes and the effects on conceptual understanding

Authors: Alan Cornell[None]; Anna Chrysostomou[1]; Emanuela Carleschi[None]; Wade Naylor[2]

[1] *University of Johannesburg*

[2] *SAIP*

Corresponding Author: alanc76@gmail.com

The Force Concept Inventory (FCI) can be used as an assessment tool to measure the gains in a cohort of students. In this study it was given to first year mechanics students pre- and post-mechanics lectures, for students at the University of Johannesburg. From these results we examine of the change from traditional classes to online classes, as imposed by the COVID-19 lockdown. Overall gains and student perspectives indicate no appreciable difference of gain, when bench-marked against previous studies using this assessment tool. When compared with 2019 grades, the 2020 semester grades do not appear to be greatly affected. Furthermore, initial statistical analyses also indicate a gender difference in mean gains in favour of females at the 95% significance level. A survey given to students also appeared to indicate that most students were aware of their conceptual performance in physics, and the main constraint to their studies was due to difficulties associated with being online. As such, the change in pedagogy and the stresses of lockdown were found to not be suggestive of a depreciation of FCI gains and grades.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Theoretical and Computational Physics / **39**

Quasinormal modes in the large angular momentum limit: an inverse multipolar expansion analysis

Authors: Anna Chrysostomou[1]; Alan Cornell[1]

[1] *University of Johannesburg*

Corresponding Author: annachrys97@gmail.com

The quasinormal modes (QNMs) of a black hole (BH) may be identified as a class of damped, classical oscillations in spacetime, emergent as part of the late-stage response to a perturbation of the compact body. In the weak-field limit, the radial behaviour of these oscillations can be modelled as a wave equation whose potential varies to represent different fields. The choice of computational method applied to solve these QNMs must accommodate the specifics of the BH spacetime and wave

equation dependencies, as a certain approach may fail under conditions where another proves more accurate. Through a novel exploitation of the null geodesics of spherically-symmetric BHs, Dolan and Ottewill recently constructed an inverse multipolar expansion method that allows for the efficient computation of BH quasinormal frequencies (QNFs). In a previous work, we have seen that this method is well suited to the exploration of the large angular momentum regime of QNFs of various spin for Schwarzschild, Reissner-Nordström, and Schwarzschild de Sitter BHs. Here, we extend this method to the computation of the QNM wavefunctions within a Schwarzschild BH spacetime, and subject the resulting expressions to the asymptotic limit of $\ell \to \infty$.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc.

Nuclear, Particle and Radiation Physics / **40**

The use of machine learning to understand the excesses of events in SS and 3 lepton events with b-jets at the LHC

Author: Thuso Mathaha[1]

Co-authors: Mukesh Kumar [2]; Bruce Mellado [2]; XIFENG RUAN [3]

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

[2] *University of the Witwatersrand*

[3] *University of the witwatersrand*

Corresponding Author: thuso.stephen.mathata@cern.ch

Top-quark is the known heaviest elementary particle of the Standard Model (SM) and it is said to have large couplings to hypothetical new physics in many models beyond the SM. With the mass and spin correlations of the top-quark together with W-boson helicity fractions already being measured, interesting characteristics of the top-quark are accessible due to the large center-of-mass energy and luminosity at the LHC. Based on a number of publications in leading journals, our team predicted emergence of multi-lepton anomalies at the LHC. One of these anomalies in the excess production of two same sign leptons (electron or muon), three leptons in association with b-quarks. The ATLAS and CMS experiments have reported sustained excesses in these final states. The main backgrounds for these final states is the production of top pairs in association with a W boson and the production of four tops. Here we are applying Machine Learning techniques to understand the subtle differences between SM and BSM production mechanisms is a 12 dimensional space.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Theoretical and Computational Physics / **41**

Generating function approach to open quantum walks

Author: Ayanda Zungu[1]

Co-authors: Ilya Sinayskiy [2]; Francesco Petruccione

[1] *Department of Physics, North-West University, Mafikeng Campus*

[2] *School of Physics and NITheP, University of KwaZulu-Natal*

Corresponding Author: arzngu@gmail.com

Open quantum walks (OQWs) have been introduced as a type of quantum walks which are entirely driven by the dissipative interaction with external environments and are defined in terms of discrete completely positive trace-preserving maps on graphs [1]. Recently, a quantum optical scheme for the experimental realization of OQWs was proposed [2]. In the proposed scheme, a two-level atom plays the role of the "walker" and the Fock states of the cavity mode correspond to the lattice sites of the OQW. Using the small unitary rotations approach and rotating wave approximation the effective dynamics of the system is shown to be an OQW. The presence of spontaneous emission in the system was an essential ingredient for obtaining an OQW. In this contribution, we solve this OQW analytically using generating functions. We used the obtained solution to construct the moments of this quantum walk explicitly. The dynamics of the observables (mean, variance) are presented for various parameters.

Keywords: Open quantum walks; quantum optics; quantum dynamics engineering.

References:

[1] S. Attal, F. Petruccione, C. Sabot and I. Sinayskiy, J. Stat. Phys. 147 (2012), 832.
[2] I. Sinayskiy and F. Petruccione, Int. J. Quantum Inform. 12 (2014), 1461010.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Theoretical and Computational Physics / 42

Solving the Schrödinger equation for Hydrogen Molecular ion (H2+) using Sinc functions and empolying both Python and Numpy

Author: OBIAGELI LOVENDA EZENWACHUKWU[1]

Co-author: Moritz Braun [2]

[1] *UNIVERSITY OF SOUTH AFRICA (UNISA)*

[2] *University of South Africa*

Corresponding Author: obbylove@gmail.com

In this contribution, we present the results of calculations for the ground state energy of H2+ employing Sinc functions as a basis set as discussed for a number of
examples in [1]. The modifications required to the basis functions to make them suitable for calculating the ground state energy of H2+ as well as the application of the cusp factor formulism [2] are outlined. Finally the resulting energies are investigated as a function of the number of basis functions and double-logarithmic fits are performed. It is found that they converge with an order of at least six.
[1] Proceedings of 64th SAIP Conference 2019, ISBN: 978-0-620-88875-2, edited by Prof. Makaiko

Chithambo, p 347
[2] Eur. Phys. J. B. (2019) 92: 230

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Nuclear, Particle and Radiation Physics / **43**

Looking at overfitting within semi-supervision with Generative Adversarial Networks for physics searches at the LHC

Author: Thabang Lebese[1]

Co-authors: Bruce Mellado [2]; XIFENG RUAN [3]

[1] *WITS University*

[2] *University of the Witwatersrand*

[3] *University of the witwatersrand*

Corresponding Author: thabang@aims.ac.za

The technique of semi-supervision can be used in searches for new physics where the signal plus background regions are not labelled. We employ semi-supervision but this technique has over-fitting issues. We resort to GANs to mimic a Monte Carlo (MC) simulation which is very expensive computationally in order to perform toy MC studies. We propose Generative Adversarial Networks (GANs) as our main framework. GANs are powerful, but often suffer from number of issues including training instability or failure to converge. We henceforth go beyond vanilla GANs, by implementing a wasserstein GAN with gradient penalty (WGAN-GP) to achieve performance stability. We demonstrate the effectiveness of WGAN-GP on MC generated data and show that WGAN-GP achieves a better performance and is capable of generating perfect fakes with a good accuracy on a single GPU.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Nuclear, Particle and Radiation Physics / **44**

The use of Semi-Supervision in the search for heavy resonances with the Zγ final state

Author: Nalamotse Joshua Choma[1]

Co-authors: Bruce Mellado [2]; Salah-Eddine Dahbi [2]; XIFENG RUAN [3]

[1] *Wits University*

[2] *University of the Witwatersrand*

[3] *University of the witwatersrand*

Corresponding Author: nalamotse.choma@students.wits.ac.za

Unlike supervised learning which is known to assume a full knowledge of the underlying model, semi-supervised learning, weak supervision in particular allows with partial knowledge to extract new information from the data. The objective of this study is to set up the search for heavy resonances at the electroweak scale with topological requirements. These resonances could be produced with different production mechanisms. In this case we will be focusing on the searches for new resonances in the Zɣ final state using weak supervised learning approach. This will then be compared to the performance of the full supervision approach.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Nuclear, Particle and Radiation Physics / **45**

Background decomposition in $Z\gamma$ events used in the search for high-mass resonances.

Author: Phuti Ntsoko Rapheeha[1]

Co-authors: Gaogalalwe Mokgatitswane [1]; Salah-Eddine Dahbi [1]; XIFENG RUAN [2]; Bruce Mellado [1]

[1] *University of the Witwatersrand*

[2] *University of the witwatersrand*

Corresponding Author: ntsoko.phuti.rapheeha@cern.ch

The study present the measurement of the contribution, purity, of $Z + \gamma$ and $Z+$ jet background events in the search for high-mass $Z\gamma$ resonances. The study uses events were the Z boson decays into a pairs of oppositely charged electrons or muons. The events used consist of 139 fb^{-1} of proton-proton, pp, collisions data at $\sqrt{s} = 13$ TeV, recorded by the ATLAS detector at the CERN Large Hadron Collider.
The measured purity of $Z + \gamma$ background events depends on the parameter R that gives the correlation between the isolation and identification criteria for jets faking photons in $Z+$ jet events. A data-driven method that uses $\gamma\gamma$ events collected in the same detector conditions as the $Z\gamma$ events is used to determine R in various bins of the photon transverse momentum or the invariant mass bins. The results are compared against results that are obtained using the R computed using a $Z+$jet Monte Carlo sample and a data-driven method that uses $Z + \gamma$ events to estimate R.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Nuclear, Particle and Radiation Physics / **46**

Search for Zγ high-mass resonances using the ATLAS Detector

Author: Gaogalalwe Mokgatitswane[1]

Co-authors: Salah-Eddine Dahbi [2]; Phuti Ntsoko Rapheeha [2]; XIFENG RUAN [3]; Bruce Mellado [2]

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

[2] *University of the Witwatersrand*

[3] *University of the witwatersrand*

Corresponding Author: 2331751@students.wits.ac.za

This study presents a search for the high-mass resonances in $Z\gamma$ final states. The search is performed using the Monte Carlo simulated signal samples of mass up to 5 TeV, corresponding to an integrated luminosity of 139 fb^{-1} dataset recorded by the ATLAS experiment in proton-proton collisions during the LHC Run-2. Only leptonic decay of the Z boson to a lepton-antilepton pair ℓ^+ ℓ^-, $\ell = e$, μ is considered, and the analysis search for a localized excess in the invariant mass distribution of reconstructed final state over a smoothly-falling background emanating from Standard Model processes. The characterization of signal shape for the mass spectrum from gluon fusion (ggF) production mode is modelled by a double-sided crystal ball function form and the background shape modelling is performed using analytic functions of different order. The systematic uncertainties are incorporated, which arise from uncertainties on the energy scale of the reconstructed final states and on the possible bias (spurious signal) on the fitted signal yield due to the choice of background function.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Space Science / **47**

Solar modulation of Helium isotopes from minimum to maximum activity

Author: Donald Ngobeni[1]

Co-authors: Marius Potgieter [2]; O.P.M. Aslam [3]; Driaan Bisschoff [3]; Innocentia RAMOKGABA [4]; Dzivhuluwani Ndiitwani [1]

[1] *1. Centre for Space Research, North-West University, Potchefstroom, South Africa 2. School of Physical & Chemical Sciences, North-West University, Mmabatho, South Africa*

[2] *Institute for Experimental & Applied Physics, Christian-Albrechts-University in Kiel, Germany*

[3] *Centre for Space Research, North-West University, Potchefstroom, South Africa*

[4] *School of Physical & Chemical Sciences, North-West University, Mmabatho, South Africa*

Corresponding Author: donald.ngobeni@nwu.ac.za

The solar modulation of Helium isotopes (Helium-3 and Helium-4) is studied and compared to observations at the Earth. This is done from the period of minimum solar activity from 2006 to 2011, up to the period of solar maximum activity from 2012 to 2015. Computed spectra are compared to the precise measurements of Helium-3 and Helium-4 fluxes measured by the PAMELA and AMS-02 space missions between July 2006 and December 2015, spanning time frames that include the solar magnetic field reversal epoch. Insight gained from this comprehensive modeling, with a three-dimensional drift model, about the relative roles of the four main modulation processes over the mentioned period will be shown and discussed.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics for Development, Education and Outreach / **48**

Teaching measurement and uncertainty the SI way

Authors: Aletta Karsten[1]; Andy Buffler[2]; Nuraan Majiet[2]; Tanya Hutton[2]; Tom Leadbeater[2]; Wynand Louw[1]

[1] *National Metrology Institute of South Africa*

[2] *University of Cape Town*

Corresponding Author: andy.buffler@uct.ac.za

In May 2019 a very significant event in the world of metrology occurred whereby all seven of the SI base units were refined in reference to seven "defining" constants. Among them are fundamental constants of nature such as the Planck constant and the speed of light, and thus the definitions are based on and represent our present understanding of the laws of physics. The new self-consistent approach offers a unique opportunity to make useful impact on physics education both at high school and university level.

The present project is developing a set of teaching materials for use by educators and students which introduce the fundamentals of measurement and uncertainty in ways which are aligned to the ISO-recommended framework for measurement 1.

The work is being informed both by our research into students' understanding of measurement [2], and our experience in teaching measurement and uncertainty to university students [3]. It has been shown [4] that students are able to develop a more robust understanding of the nature of scientific measurement when the measurement result is understood to be a statement of knowledge. Uncertainty is then associated with the quality of this knowledge.

We present the development of posters which are freely available for download [3], and progress towards a set of worksheet-based materials which are aimed to be distributed to schools and universities throughout South Africa and beyond. The teaching materials will be designed to be used within a wide range of contexts, with few additional resources, and will also introduce the new definitions of the SI base units in a way which promotes an improved philosophy of scientific measurement.

1 BIPM, IEC, IFCC, ISO, IUPAC, IUPAP and OIML (1995) *Guide to the Expression of Uncertainty in Measurement* (GUM) (Geneva: ISO)
[2] A. Buffler et al. (2001) *Int. J. Sci. Educ.* **23**, 1137.
[3] [http://www.measure.uct.ac.za/msr/education]1
[4] A. Pillay et al. (2008) *Eur. J. of Phys.* **29**, 647.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Space Science / 49

Climatology of the nighttime thermospheric winds over Sutherland, South Africa.

Author: Taiwo Ojo[1]

Co-author: Zama Katamzi-Joseph [1]

[1] *South Africa National Space Agency (SANSA)*

Corresponding Author: tojo@sansa.org.za

We present first observation of climatology of nighttime thermospheric neutral winds between February 2018 and January 2019 measured by a Fabry-Perot interferometer (FPI) located in Sutherland, South Africa (32.2◦S, 20.48◦E; geomagnetic latitude: 40.7◦S). This FPI measures the nighttime oxygen airglow emission at 630.0 nm, which has a peak emission at an altitude of roughly 250 km. The annual meridional and zonal winds at this location vary between -100 and 150 m/s and show typical midlatitude nocturnal and seasonal variations. During local summer months (December-February), the meridional wind is predominantly equatorward from dusk to predawn. During the winter months, the meridional wind is poleward from dusk, turns equatorward around midnight, and either remains in this direction for the rest of the night (June) or turns poleward again after just before dawn (July and August). The zonal wind velocity is generally eastward during the evening until just before midnight, changing westward post-midnight. The zonal wind peaks at higher velocities during the winter months compared to the summer months. The eastward-to-westward transition occurs later during the winter months compared to the summer months. We compared HWM14 with the FPI measurements and found a better agreement between FPI measured winds and HWM14 predicted winds for the meridional component compared to the zonal component.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Applied Physics / 50

Integration of the ALTI module in the ATLAS Tile Calorimeter system

Author: Humphry Tlou[1]

Co-author: Bruce Mellado [1]

[1] *University of the Witwatersrand*

Corresponding Author: humphry.tlou@cern.ch

The Tile Calorimeter (TileCal) is currently preparing for the Run 3 data-taking period. As part of the ongoing Phase I upgrades, TileCal is replacing a part of the Timing, Trigger and Control (TTC) system. The legacy TTC system is being replaced with a new advanced electronic board, designed for the ATLAS experiment at CERN. The new ATLAS Local Trigger Interface (ALTI) module, is a 6U VME board which integrates the functionalities of four legacy modules, currently used in the experiment: Local Trigger Processor, Local Trigger Processor interface, TTC VME bus interface and the TTC emitter. ALTI module will provide the interface between the Level-1 Central Trigger Processor and the TTC optical broadcasting network, to the Front-End electronics for each of the ATLAS sub-detectors. The implementation and validation of the data acquisition software for the

ALTI module in a TileCal test station is complete. The TileCal Back-End electronics consists of four legacy TTC partitions, and the integration of the ALTI module in the Tile Calorimeter requires the insertion of four new ALTI modules in the TTC crates. Calibrations and data quality validations, are performed before certifying the TileCal ALTI system ready for the Run 3 data-taking period in early 2022.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics of Condensed Matter and Materials / 51

Cost effective sol-gel synthesis of mesoporous TiO2 nanoparticles: Reaction temperature and calcination effects for perovskite solar cells application

Authors: Dieketseng Glara Tsotetsi [1]; Pontsho Mbule[2]

[1] *Student*

[2] *Senior Lecture(Supervisor)*

Corresponding Author: dieketsengklara96@gmail.com

Abstract

We explore the synthesis of mesoporous titanium dioxide (mp-TiO2) nanoparticles using cost effective method, sol-gel. mp-TiO2 films are existing electron transport layers in perovskite solar cells (PSCs) and the material development is encouraged for their commercialization . Different synthesis approaches give rise to different morphologies, mesostructures, pore size and crystallization of mp-TiO2 nanoparticles. In our current work we emphasize the sol-gel synthesis of mp-TiO2 at room temperature and at 60 oC reaction temperature while incorporating polyethylene glycol (PEG) in the system. The sol-gel dispersion is then drop-cast on the glass substrate to make films and subsequently calcined at 350 oC, 450 oC and 550 oC for 4 hours. The structure, morphology and the optical properties of the films were controlled by the calcination and the correlation between the calcination and film properties were investigated for possible application in PSCs. The 95% rutile and 5% anatase phases of mp-TiO2 were optimized at calcination temperature of 550 oC for sample synthesized at room temperature, while the sample synthesized at 60 oC was optimized at 450 oC. Similarly, the pore size in the TiO2 material was optimized at calcination temperature of 550 oC. Relatively higher transmittance (˜87%) of the films towards the near infrared region showed improved optical properties for their use in PSCs application. The mesoporous nature was determined by Brunauer-Emmett-Teller (BET) method using the Barrett-Joyner-Halenda (BJH) model. From this work, mp-TiO2 prepared at room temperature showed better morphological, BET, BJH and optical properties indicating a better chance for possible application in perovskite solar cells.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Nuclear, Particle and Radiation Physics / 52

Re-designing a radiation-tolerant low voltage power supply for the ATLAS Tile Calorimeter Phase-II Upgrade

Author: Edward Nkadimeng[1]

Co-authors: Ryan Mckenzie [2]; Thabo Lepota [1]; Nkosiphendule Njara [2]; Roger van Rensburg [3]; Bruce Mellado [1]

[1] *University of the Witwatersrand*

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

[3] *Wits*

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

Power Electronics used in high-energy physics experiments at the Large Hadron Collider (LHC) more specifically the ATLAS detector, which are custom built and have to work reliably in the presence of ionizing radiation and an ever present magnetic field. In many such applications, owing to cost constraints, Commercial Off-The-Shelf (COTS) components are often used instead of components that are radiation-hard by design. Moreover, design complexity, verification effort, and scalability issues in centralized structures can impede performance improvement in monolithic designs. This talk presents the steps followed for upgrading and re-designing a radiation tolerant low voltage power supply for a large scale operation and the considerations made for such a design. This includes measurements taken at component level, system level, and radiation tests done using the newly upgraded low voltage power supply

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

53

Quality control software development for testing the next generation of upgraded low voltage power supplies for the ATLAS Tile Calorimeter

Author: Edward Nkadimeng[1]

Co-authors: Ryan Mckenzie [2]; Nkosiphendule Njara [2]; Thabo Lepota [1]; Roger van Rensburg [3]; Bruce Mellado [1]

[1] *University of the Witwatersrand*

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

[3] *Wits*

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

In several areas of Nuclear and Particle Physics research, the size of the detectors have become exceedingly large and quite complex. The ATLAS Hadronic Tile Calorimeter (TileCal), was designed 25 years ago using the technologies available at the time. The switch to a three (3) stage powering scheme necessitates the upgrade of all detector electronics. The Low Voltage power supply (LVPS) brick, which powers the front end electronics is being redesigned and in this talk we provide details on the development of quality assurance test benches that use custom-built software packages to interface, monitor and verify parameters for check-out of the LVPS bricks. The strict procedure required for brick checkout during production constitutes of a series of highly automated tests that

provides information about the general conditions of the brick and subsequently would thus ensure the reliability and quality of the new LVPS brick which will power the next generation of the upgraded hardware system of ATLAS at CERN.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Nuclear, Particle and Radiation Physics / **54**

Search for heavy resonances in the $\ell^+\ell^-\ell^+\ell^-$ final state in association with missing transverse energy using pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector

Author: Humphry Tlou[1]

Co-authors: Abdualazem Fadol [2]; XIFENG RUAN [3]; Onesimo Mtintsilana [2]; Bruce Mellado [1]

[1] *University of the Witwatersrand*

[2] *University of Witwatersrand*

[3] *University of the witwatersrand*

Corresponding Author: humphry.tlou@cern.ch

Search for the presence of a new heavy resonance, produced via gluon-gluon fusion and decaying to the four-lepton (4ℓ) final state, in association with missing transverse energy ($E_{\mathrm{T}}^{\mathrm{miss}}$), with ℓ = e, μ. The search uses 2015–2018 proton–proton collision data at $\sqrt{s}$ = 13 TeV, corresponding to an integrated luminosity of 139 fb^{-1}, collected by the ATLAS detector at the Large Hadron Collider at CERN. The data is interpreted in terms of two models, firstly the $R \to SH \to 4\ell + E_{\mathrm{T}}^{\mathrm{miss}}$, where R is a scalar boson, which decays to two lighter scalar bosons (S and H). The S decays to a pair of neutrinos ($E_{\mathrm{T}}^{\mathrm{miss}}$) and the H decays into 4ℓ, through ZZ bosons. The second model is the $A \to ZH \to 4\ell + E_{\mathrm{T}}^{\mathrm{miss}}$, where A is considered to be a CP-odd scalar which decays to a CP-even scalar H, and the Z boson. The Z boson decays to a pair of neutrinos, and the H decays to the 4ℓ final state.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Applied Physics / **55**

Programming the load readout board micro-controllers used in the development of a Burn-In test bench for the ATLAS TileCal Phase-II Upgrade

Author: Nkosiphendule Njara[1]

Co-authors: Thabo Lepota [2]; Ryan Mckenzie [3]; Edward Nkadimeng [2]; Bruce Mellado [2]

[1] *School of Physics University of the Witswatersrand*

[2] *University of the Witwatersrand*

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

Corresponding Author: nkosiphendule.njara@cern.ch

The University of the Witwatersrand will be producing over 1200 Low Voltage Power Supplies (LVPS) to power the on-detector electronics of the Tile Calorimeter (TileCal) ATLAS detector in preparation for the Phase II upgrade. Two burn-in type test stations are currently being developed in the high-throughput electronics laboratory. The Load readout board is used to read and control/adjust parameters of four channels electronic dummy load board, and several parameters. In this talk, we discuss how different commands for each PIC micro-controller are written and used to shift bits into the register of the Digital to Analog converter (DAC) contained on the dummy load to control the load current. A hexadecimal source file is thus generated and typically used by programmable logic devices which provides general information of the configured functions.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Photonics / 56

Targeted photodynamic treatment of colorectal cancer

Author: Nkune Nkune[1]

Co-authors: Cherie Ann Kruger [2]; Heidi Abrahamse [3]

[1] *Laser Research Centre, University of Johannesburg*

[2] *Laser Research Centre, Faculty of Health Sciences, University of Johannesburg*

[3] *Laser Research Centre, Faculty of Health Sciences, University of Johannesburg.*

Corresponding Author: nkune.williams@gmail.com

Abstract. Colorectal cancer (CRC) is a fatal malignancy with limited therapeutic options and its incidence is on the rise in recent years. Photodynamic therapy (PDT) has emerged as a promising minimally invasive therapeutic modality that employs three fundamentals to induce tumour damage: a photosensitizer (PS), light of a specific wavelength and molecular oxygen. However, PDT has shown undesirable lack of specificity for tumour cells. The aim of this study was to develop a targeted PDT multicomponent nanoparticle-antibody (ZnPcS4 – AuNP-PEG5000-SH-NH2 - Anti-GCC Ab) based system that is capable of enhanced and targeted ZnPcS4 PS delivery within in vitro cultured CRC cells (CaCo-2) for improved PDT treatment. The final conjugate was successfully synthesized and characterized to confirm the efficient binding of the antibody and PS to functionalized gold nanoparticle surfaces. Immunofluorescent results noted that the final actively targeted PS nanoconjugate was able to actively and specifically localize in target CRC cells only. Thus, the increased bioavailability of ZnPcS4 PS in CaCo-2 cells elicited significant cytotoxic responses, suggesting that through nano active targeting the enhanced PDT treatment of CRC can be achieved.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Photonics / 57

Targeted photodynamic diagnosis of colorectal cancer

Author: Nokuphila Simelane[1]

Co-authors: Cherie Anne Kruger [2]; Heidi Abrahamse [3]

[1] *Laser Research Centre*

[2] *Laser Research Centre, Faculty of Health Sciences, University of Johannesburg,*

[3] *Laser Research Centre, Faculty of Health Sciences, University of Johannesburg*

Corresponding Author: lelopearl@gmail.com

Abstract. Colorectal cancer (CRC), currently remains a challenge to diagnose and is the third most diagnosed cancer worldwide. Photodynamic diagnosis (PDD) is a promising early diagnostic approach which uses photosensitizers for fluorescence detection of malignant cancer cells without inducing tumour damage. In this study, ZnPcS4 a photosensitizer with pronounced chemical properties due to its tetra sulphonation was incorporated with specific CRC targeting antibodies (Anti-GC-C) on the surface of heterobifunctional amine-functionalized and PEG stabilized gold nanoparticles (AuNPs), to form a final actively targeted PS nanoconjugate (ZnPcS4 – AuNP-PEG5000-SH-NH2 – Anti-GCC Ab). The final actively targeted PS nanoconjugate was successfully synthesized and characterized using spectroscopic techniques. Immunofluorescent photodiagnostic results confirmed that the final actively targeted PS nanoconjugate was able to localize within in vitro cultured CRC cells more specifically, due to its active targeting biomolecule (Anti-GCC Ab) than PS alone. The final targeted PS nanoconjugate offered highly specific and sensitive absorption of the PS in CRC cells and so allowed for the successful photodynamic diagnosis of CRCs in vitro.

Apply to be considered for a student ; award (Yes / No)?:

yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Applied Physics / 58

The characterization and functionality of the interface boards used on the burn-in test station for the ATLAS Tile Calorimeter Low Voltage Power Supplies phase II upgrade

Author: Thabo Lepota[1]

Co-authors: Edward Nkadimeng [1]; Ryan Mckenzie [2]; Nkosiphendule Njara [2]; Bruce Mellado [1]

[1] *University of the Witwatersrand*

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

Corresponding Author: james.lepota@gmail.com

With University of the Witwatersrand responsible for producing 50% of the Low Voltage Power Supplies (LVPS) bricks for powering on-detector electronics of the Handronic Tile Calorimeter (TileCal).

The Burn-in testing station is used to detect early failures in components of the LVPS bricks, thereby increasing component reliability, detect early failures in components. The LVPS bricks that passes this test are then shipped to CERN, for installation on the detector. Here we describe the significance and functionality of the brick interface board on the burn-in station, and the process to programme PIC16f883 microcontroller, which is used to send commands and act as a multiplexer to main board, brick interface boards on the burn-in test station and enables the LabView software programme to interface with the hardware of the Burn-in to successfully carryout its functions.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Space Science / 59

Statistical analysis between Travelling Ionospheric Disturbances (TIDs) and SuperDARN Near Range Echoes (NREs)

Author: Judy Stephenson[1]

Co-authors: Alicreance HIYADUTUJE [2]; Michael Kosch [3]

[1] *University of KwaZulu Natal*

[2] *South African national Space Agency*

[3] *South African Space Agency*

Corresponding Author: ahiyadutuje@sansa.org.za

The Super Dual Auroral Radar Network (SuperDARN) forms a global network of coherent high frequency (HF) radars located at mid- to high latitudes. Atmospheric gravity waves (AGWs) are ubiquitous throughout the atmosphere and can transport enormous energy and momentum from above or below into the mesosphere. AGWs are readily detected by HF radars as Travelling Ionospheric Disturbances (TIDs) (Oinats et al., 2015). Different mechanisms cause SuperDARN Near Range echoes (NREs) around 100 km altitude. By using cross-correlation and statistical significance analysis, a moderate correlation between the two phenomena was found (Rauf et al., 2019). TIDs amplitudes, wavelengths and velocities are estimated to be 5-15 km, 15-75 km, and 30-70 m/s, respectively (He et al., 2004). The cross-correlation between the TID-perturbed electric field and SuperDARN backscatter power shows a good correlation.
References
(1) Oinats, Alexey V., Vladimir I. Kurkin, and Nozomu Nishitani. “Statistical study of medium-scale travelling ionospheric disturbances using SuperDARN Hokkaido ground backscatter data for 2011.” Earth, Planets and Space 67.1 (2015)
(2) Rauf, Abdur, et al. “Investigation of PMSE dependence on high energy particle precipitation during their simultaneous occurrence.” Advances in Space Research 63.1 (2019): 309-316.
(3) He, L-S., et al. “Studies of medium-scale travelling ionospheric disturbances using TIGER SuperDARN radar sea echo observations.” Annales Geophysicae. Vol. 22. No. 12. Copernicus GmbH, 2004.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Nuclear, Particle and Radiation Physics / 60

Photons in Darkness

Authors: Karien du Plessis[1]; Deepak Kar[2]

[1] *University of the Witwatersrand*

[2] *University of the Witwatersrand*

Corresponding Author: kduplessis609@gmail.com

Several astronomical observations have revealed the existence of larger matter quantities which are thought to occupy 27% of the universe. Many hypotheses exist about the nature of these elusive dark matter particles. One of these hypotheses predicts the existence of a hypothetical dark photon. The unique signature of this particle can be searched for at the Large Hadron Collider (LHC) at CERN. A study is performed to determine the feasibility of this search in ATLAS. A theoretical model containing a vector-like quark is considered which decays into a top quark and a dark photon. The focus will be on the decay channel containing a leptonic top consisting of either an electron or muon. Signal and several background distributions for some key variables of this decay mode will also be presented. This proposed search could lead to detectable dark matter whilst simultaneously expanding our limited understanding thereof.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Poster Session / 61

The replacement and refurbishment of Gap Scintillator Counters for the ATLAS Tile Calorimeter Phase-I Upgrade

Author: Gaogalalwe Mokgatitswane[1]

Co-authors: Bruce Mellado [2]; Thabo Lepota [2]

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

[2] *University of the Witwatersrand*

Corresponding Author: 2331751@students.wits.ac.za

We report on the replacement of E3E4 (Crack) and refurbishment of Minimum Bias Trigger Scintillator (MBTS) counters as part of phase-I upgrade during the long shutdown 2 (LS2) at CERN. Crack and MBTS counters, situated between the central and extended Tile Calorimeter barrels, are used for correcting the electromagnetic energy responses and for providing inputs to the trigger, respectively. During the LHC Run-2 data-taking period in 2015-2018, Crack and MBTS scintillators were deteriorated by radiation and had to be replaced with more radiation-hard scintillators and optimised geometry prior to High-Luminosity LHC Run-3. The phase-I upgrade has been ongoing since the beginning of the LHC LS2. The upgrade activities which were finalized with a strong contribution from South Africa consisted of the re-design of the crack and MBTS detector modules, their assembly, qualification and characterization using radioactive sources (strontium-90 and cesium-137), as well as their installation on the ATLAS detector. The University of the Witwatersrand was previously involved in the radiation qualification and selection of the scintillator material to be used in the counter production.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Nuclear, Particle and Radiation Physics / **62**

Quality assurance testing of the ATLAS Tile-Calorimeter Phase-II upgrade low-voltage power supplies

Authors: Ryan Mckenzie[1]; Edward Nkadimeng[2]; Roger van Rensburg[3]; Bruce Mellado[2]

Co-authors: Thabo Lepota [2]; Nkosiphendule Njara [4]

[1] *University Of the Witwatersrand*

[2] *University of the Witwatersrand*

[3] *Wits*

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

Corresponding Authors: ryan.peter.mckenzie@cern.ch, edward.khomotso.nkadimeng@cern.ch

The start of the operation of the High Luminosity LHC (HL-LHC) is planned for the year 2027. The planned increase in luminosity provides the opportunity for further scientific discoveries within the field of particle physics as well as many technical challenges associated with the new HL-LHC environment. Due to these environmental changes the ATLAS Tile-Calorimeter (TileCal) is to undergo its Phase-II upgrade in 2025 in order to ensure peak performance in the coming years. To this end the University of the Witwatersrand Institute for Collider Particle Physics, iThemba Labs, and SA-CERN, in collaboration with the University of Texas at Arlington, are currently undertaking the development and production of approximately 2300 Low-Voltage Power Supply (LVPS) Bricks. In order to ensure the reliable operation of these Bricks on-detector an extensive quality control procedure is to be implemented. This procedure is two-pronged in its approach. Firstly, initial testing is undertaken to ensure various performance metrics such as the Bricks output voltage are met. After which, the Bricks undergo Burn-in testing which functions to improve the reliability of the components via accelerated aging. Both of these processes require custom test apparatus which take the form of the Initial and Burn-in test stations. This presentation will provide an overview of these test stations including their hardware, software, and the certification of the Bricks before installation within TileCal.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Applied Physics / **63**

A Burn-in test station for the ATLAS Phase-II Tile-calorimeter low-voltage power supply transformer-coupled buck converters

Authors: Ryan Mckenzie[1]; Edward Nkadimeng[2]; Bruce Mellado[2]; Roger van Rensburg[3]

Co-authors: Thabo Lepota [2]; Nkosiphendule Njara [4]

[1] *University Of the Witwatersrand*

[2] *University of the Witwatersrand*

[3] *Wits*

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

Corresponding Authors: ryan.peter.mckenzie@cern.ch, edward.khomotso.nkadimeng@cern.ch

The upgrade of the ATLAS hadronic tile-calorimeter (TileCal) Low-Voltage Power Supply (LVPS) falls under the high-luminosity LHC upgrade project. This presentation serves to provide a detailed overview of the development of an endurance (Burn-in) test station for use on an upgraded LVPS component known as a Brick. These Bricks are radiation hard transformer-coupled buck converters that function to step-down bulk 200 VDC power received from technical cavern USA15 to 10 VDC on-detector. This 10 VDC is then converted again by Point-of-Load (POL) regulators to the voltages required by the front-end electronics of TileCal. To ensure the reliability of the Bricks, once installed within TileCal, an electronic accelerated aging (Burn-in) test station has been designed and built. The Burn-in test-station functions to shift newly produced electronics out of the infant-mortality failure region, thereby improving the reliability of the components once installed. This is achieved by exposing the Bricks to
operating conditions that exceed those of typical use. This results in components that would fail prematurely within TileCal failing instantly thereby allowing for their replacement. The Burn-in station is of a fully custom design in both its hardware and software. Both of these topics will be explored in detail with the presentation culminating in a discussion of the Burn-in test procedure.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Photonics / **64**

Photobiomodulated Differentiation Of Adipose Derived Stem Cells Into Osteoblasts.

Authors: Daniella Da Silva[1]; Anine Crous[1]; Heidi Abrahamse[1]

[1] *Laser Research Centre*

Corresponding Author: da4ni7@gmail.com

Osteoporosis is a progressive, metabolic bone disease affecting millions across the globe. Stem cell regenerative therapy has demonstrated potential in treating osteoporosis, particularly when using Adipose Derived Mesenchymal Stem Cells (ADMSCs). Photobiomodulation (PBM) has gained international momentum due to its ability to aid in the proliferation and differentiation of stem cells. Additionally, PBM when combined with differentiation growth factors has revealed enhanced proliferation and ADMSC differentiation into osteoblasts. This in vitro study combined the use of osteogenic differentiation inducers and PBM at visible light wavelength of 525 nm using a single fluence of 5 J/cm2 to determine the proliferation and differentiation effectivity of ADMSCs into osteoblasts. The cells were characterised using both early and late osteoblast protein markers identified via the use of flow cytometry, spectroscopy and morphology. Results were analysed via morphology and biochemical analysis investigated through, viability, proliferation, Mitochondrial Membrane Potential and cellular migration rate. The successful outcome of this in vitro study will be to provide relevant scientific knowledge for osteogenic differentiation. Moreover, this study may reach clinical trials for use in the treatment of osteo-degenerative diseases like osteoporosis.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Nuclear, Particle and Radiation Physics / **65**

Search for a heavy pseudo-scalar decaying into a Z boson and another heavy scalar boson leading to four lepton final states in pp collisions at $\sqrt{s}$ = 13˜TeV with the ATLAS detector

Author: Onesimo Mtintsilana[1]

Co-authors: Bruce Mellado [2]; Mukesh Kumar [2]; Humphry Tlou [2]; Abdualazem Fadol [1]; XIFENG RUAN [3]

[1] *University of Witwatersrand*

[2] *University of the Witwatersrand*

[3] *University of the witwatersrand*

Corresponding Author: onesimo.mtintsilana@cern.ch

A search for a heavy resonance pseudo-scalar, A, decaying into a Z boson and another heavy scalar boson, H, is carried out at the LHC using a data sample corresponding to an integrated luminosity of 139 fb^{-1} from proton-proton collisions at $\sqrt{s}$ = 13 TeV. In these studies, the scalars H will decay to two scalars S or an S and a Standard Model Higgs boson H via an effective model. The $A \rightarrow Z(\rightarrow \ell\ell)$ and $H(H \rightarrow SS$ or $Sh)$ production in at least four leptons final state will be examined in this search.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Nuclear, Particle and Radiation Physics / **66**

Electronics Research Laboratory at University of Zululand: Contributing towards the ATLAS Experiment at CERN

Author: Betty Kibirige[1]

Co-author: Bruce Mellado [2]

[1] *University of Zululand*

[2] *University of the Witwatersrand*

Corresponding Author: kibirigeb@unizulu.ac.za

In December 2017, the Executive Board of the SA-CERN Consortium approved an investment in the local research infrastructure at the University of Zululand. As a result, an Electronics Research

Laboratory was developed and completed in 2019. The laboratory host state of the art electronics test equipment and it was enhanced when the Centre for High Performance Computing (CHPC) in Cape Town deployed a High Performance Cluster (HPC) to the institution. While it services members of the ATLAS team in South Africa who are heavily involved in the TileCal Instrumentation upgrades at CERN, the laboratory goes beyond just the ATLAS group to accommodate other research groups. This presentation focuses on possible projects that can be dealt with in this laboratory. It is to create an awareness to the Physics community, especially the Nuclear and High Energy Particle Physics groups, on what the laboratory offers.

Key words: Electronics Research Laboratory, State of the Art Test Equipment, High Performance Computing.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Space Science / **67**

Pitch-angle Scattering vs. Magnetic Confinement in Flare Loops

Author: Jabus van den Berg[1]

Co-authors: Du Toit Strauss [1]; Frederic Effenberger [2]

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

[2] *Institut für Theoretische Physik, Ruhr-Universität Bochum, Germany*

Corresponding Authors: fe@tp4.rub.de, jabus.vandenberg1@gmail.com

Accelerated particles in flaring loops are confined by both pitch-angle scattering and the converging of magnetic fields to the loop endpoints, i.e. magnetic mirroring. This confinement, together with the initial pitch-angle distribution of the injected particles, govern the average escape time of particles from the loop. The escape time can give an estimate of the particle spectrum as it indicates how much time is available for acceleration and energy losses to occur. Pitch-angle scattering is caused by both Coulomb collisions and magnetic turbulence, but the two processes have different pitch-angle and energy dependencies, and could therefore yield different escape times. The hard X-rays produced by escaping particles are sensitive to the temporal profile and pitch-angle distribution of escaping particles and not the average escape time. We investigate the effect of a spatially varying magnetic field and anisotropic scattering on the escape time. We find that these considerations only yield a factor two difference in the escape time compared to isotropic scattering in an uniform magnetic field with a loss cone specified at the endpoints. The temporal profile and pitch-angle distribution of escaping particles is also investigated. We find that the time when the bulk of the particles escape can be quite different from the average escape time and that periodic 'waves' of escaping particles are found under weak scattering conditions. The pitch-angle distributions of escaping particles are found to be generally neither isotropic nor beamed, and critically depend on either the scattering regime or the injected distribution.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Nuclear, Particle and Radiation Physics / 68

Single Leptoquark Search in ATLAS

Authors: Lawrence Davou Christopher[1]; Deepak Kar[2]

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

[2] *University of Witwatersrand*

Corresponding Author: lawrence.davou.christopher@cern.ch

The recent anomalous magnetic moment of the muon (muon g-2) result presents a pattern of deviation from the standard model prediction in the interaction of muons with a surrounding magnetic field. A similar deviation from the standard model prediction is seen in the LHCb results on rare B-meson decay. Plausible explanations of these anomalies are leptoquarks. Leptoquarks when coupled with a chirality flip interaction to a heavy quark can boost the muon's anomalous magnetic moment. This study presents a search for leptoquark in single production in ATLAS, with the leptoquark decaying into a one-light jet (b-tagged) and one lepton accompanied by an oppositely charged lepton in the final state.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Theoretical and Computational Physics / 69

Towards discrimination and improved modelling of dark-sector showers

Author: Sukanya Sinha[1]

Co-author: Deepak Kar [2]

[1] *The University of Witwatersrand*

[2] *University of Witwatersrand*

Corresponding Author: sukanya.sinha@cern.ch

One of the biggest problems in particle physics today, is understanding the nature of dark matter. If dark mesons exist, their evolution and hadronization procedure are currently little constrained. They could decay promptly and result in a very SM QCD like jet structure, even though the original decaying particles are dark sector ones; they could behave as semi-visible jets; or they could behave as completely detector-stable hadrons, in which case the final state is just the missing transverse momentum. In a recent work, we have shown that the dark sector can potentially be probed with jet-substructure observables, however, the modelling of these scenarios is somewhat an unexplored area, owing to the existence of only Pythia Hidden Valley dark shower module. An alternate dark shower model is becoming more necessary, in order to gauge the theory systematics and the extent of model dependence. In this talk, I will cover the proposed idea of having a Herwig hidden valley dark shower and hadronisation module, as well as our published work on jet-substructure studies for semi-visible jets.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Nuclear, Particle and Radiation Physics / **70**

Search for dark-sector showering in ATLAS using semi-visible jets

Author: Sukanya Sinha[1]

Co-author: Deepak Kar [2]

[1] *The University of Witwatersrand*

[2] *University of Witwatersrand*

Corresponding Author: sukanya.sinha@cern.ch

Recent studies in particle physics have shown that there are myriad possibilities for strong dark sector studies at the LHC. One signature is the case of semi-visible jets, where parton evolution includes dark sector emissions, resulting in jets overlapping with missing transverse energy. Owing to the unusual MET-along-the-jet event topology, this is yet an unexplored domain within ATLAS. In this talk, I will discuss my ongoing ATLAS search, focussing on the performance and optimisation challenges associated with such a unique final state, specifically looking at the angle difference between the hardest jet and the missing transverse energy, and targeting a cut-and-count strategy.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Nuclear, Particle and Radiation Physics / **71**

The anatomy of the multi-lepton anomalies at the LHC and the potential connection with other anomalies

Author: Bruce Mellado[1]

Co-authors: Mukesh Kumar [1]; XIFENG RUAN [2]

[1] *University of the Witwatersrand*

[2] *University of the witwatersrand*

Corresponding Author: bruce.mellado@wits.ac.za

In this presentation an account of the multi-lepton (electrons and muons) anomalies at the LHC will be given. These include the excess production of opposite sign leptons with and without b-quarks, including a corner of the phase-space with a full hadronic jet veto; same sign leptons with and without b-quarks; three leptons with and without b-quarks, including also the presence of a Z. Excesses emerge in corners of the phase space where a range of SM processes dominate, indicating that the potential mismodeling of a particular SM process is unlikely to explain them. A procedure is implemented that avoids parameter tuning or scanning the phase-space in order to nullify potential look-else-where effects or selection biases. The internal consistency of these anomalies and their

interpretation in the framework of a simplified model will be presented. Implications on the SM Higgs boson measurements, the muon g-2, astrophysics and other potential deviations from the Standard Model will be discussed.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Astrophysics / **72**

Probing Dark Matter in the Madala Model using MeerKAT

Author: Ralekete Temo[1]

Co-authors: Geoff Beck [1]; Elias Malwa [2]; Mukesh Kumar [2]; Bruce Mellado [2]

[1] *School of Physics and Centre for Astrophysics, University of the Witwatersrand*

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

Corresponding Author: 1497117@students.wits.ac.za

The Madala model was introduced to explain several anomalies observed at the Large Hadron Collider. This model introduces a dark matter candidate through the extension of the standard model's Higgs-sector, i.e. heavier scalar bosons are introduced, which can couple to dark matter. The cosmic ray spectra and galactic centre's gamma-ray flux excesses have been observed in the AMS-02 and Fermi-LAT experiments, respectively. Assuming the Madala model can explain these excesses, the aim is to make synchrotron emission predictions for MeerKAT observations. The region of interest for the predictions is the nearby satellite Reticulum II. The MeerKAT predictions will instigate the validation of our assumption and otherwise allow us to constrain the particle properties of the Madala model from an astrophysical standpoint. In essence we are able to describe the multi-lepton anomalies at the LHC and the anomalies in astrophysics simultaneously.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Nuclear, Particle and Radiation Physics / **73**

Quark versus Gluon Jet Tagging

Author: Tasnuva CHOWDHURY[1]

[1] *University of the Witwatersrand, Johannesburg*

Corresponding Author: ch.tasnuva@gmail.com

Classifying a jet initiated from quarks or gluons based on its substructure is one of the most challenging problems at the LHC. The difference in the color structure of quarks and gluons can reflect

in the amount of energy loss or the pattern of radiated energy of a jet originated from quarks or gluons. The low-level detector output can be used to identify parton jets using Machine learning techniques. Here we will present the performance of the existing quark versus gluon jet tagger in the ATLAS experiment for RUN 2 data with a 60% efficiency for selecting a quark-initiated jet. We will also present preliminary studies for a new forward tagger using the ATLAS calorimeter where the granularity is coarse.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics for Development, Education and Outreach / **74**

Classification of Sound Conceptions

Author: Derek Fish[1]

Co-authors: Nancy Pelaez [2]; Saalih Allie [3]; Trevor Anderson [4]

[1] *University of Zululand*

[2] *Department of Biological Sciences, Purdue University*

[3] *UCT*

[4] *Department of Chemistry, Purdue University*

Corresponding Author: thefish@iafrica.com

Experience and other studies show that students come to our Science Centres with pre-existing ideas of how the world works (often called prior-, naïve- or mis-conceptions). When confronted with conflicting ideas from science they are forced to make a "border crossing" (Aikenhead, 1999) from the familiar territory of their cherished beliefs into the "unknown country" of science. How difficult this crossing is and how comfortable a student feels to remain in this new country depends on many factors both internal and external to the student. The challenge for our Science Centres is to assist students to cross these borders more easily and to remain in their new country without feeling threatened. An example will be given of student prior conceptions with regard to sound and waves: a brief literature survey will outline pre-existent conceptions noted around the world. The 4 level framework of (Grayson et al, 2001) is used to classify these conceptions and modify them in the light of data gathered. Student responses to a questionnaire provide multiple mode (MCQ, written and drawings) feedback into this process. The result is a modified table of local students' prior conceptions with regard to sound and waves. This is a useful resource when designing (and improving) science shows, exhibits and other programme materials in this area. While the specific example of sound and waves will be the focus of this presentation, suggestions will be made of how this resource can be used in other subject areas.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Astrophysics / **75**

Diffusing assumptions in astroparticle physics

Authors: Michael Sarkis[1]; Geoff Beck[2]

[1] *University of the Witwatersrand*

[2] *University of Witwatersrand*

Corresponding Author: michael.sarkis@students.wits.ac.za

Previous calculations of diffuse radio emissions from dark matter annihilations have made use of Green's function approximations to solve the diffusive cosmic ray transport equation. Some notable astrophysical code packages, including GALPROP and DRAGON, take a numerical approach to this calculation that involves the use of the Crank-Nicolson finite-differencing scheme. In this work we analyse the physical accuracy of the analytic approximations and directly compare the computational efficiency of the two solution methods. We also incorporate full spatial dependence into the diffusion and energy-loss coefficients, and compare this to the approach of using spatially-averaged values of the magnetic field strength and thermal electron population.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Photonics / 76

Intelligent and efficient dual-wavelength ghost imaging

Authors: Chané Simone Moodley[1]; Bereneice Sephton[2]; Valeria Rodríguez-Fajardo[1]; Andrew Forbes[3]

[1] *University of the Witwatersrand*

[2] *CSIR National Laser Centre; Wits Physics Department*

[3] *U. Witwatersrand*

Corresponding Author: chane13.m@gmail.com

Entangled photon pairs are employed in quantum ghost imaging to facilitate an alternative image acquisition method. Individually, the information contained in each photon does not allow for image reconstruction, however, the image can be reconstructed by harnessing the power of the correlations that exist between the entangled photon pair. Interestingly, these photon pairs can be either degenerate or non-degenerate in nature. Non-degenerate, or dual-wavelength, ghost imaging offers the ability to image with wavelength bandwidths where spatially resolving detectors are impractical or ineffective. Due to the scanning nature of the technique and the inherent low light levels of quantum experiments, imaging speeds are rather unsatisfactory. To overcome this limitation, we propose a two-step deep learning approach to establish an optimal early-stopping point for the experiment while preserving all necessary object information. Step one enhances the reconstructed image after each measurement and employs a deep-convolutional autoencoder, while step two recognises the image after each measurement by a neural classifier. We achieved a recognition confidence of 75% at 20% of the image reconstruction time, hence reducing the time 5-fold while preserving the image information. This, therefore, leads to a faster, more efficient image acquisition method. We tested our method on a dual-wavelength imaging system however, our procedure can be extended to many such systems that are of quantum nature. We believe that this novel deep learning approach will prove valuable to the community who are working towards real-time ghost imaging.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics of Condensed Matter and Materials / **77**

Effect of Er doping on structure, optical and electrical properties of the fabricated Schottky diodes based on ZnO thin films prepared by sol-gel spin coating

Author: Mohammed Ahmed[1]

Co-authors: Walter Meyer [2]; Jacqueline Nel [2]

[1] *Physics department, University of Pretoria*

[2] *University of Pretoria*

Corresponding Author: elagib.2030@gmail.com

Er-doped ZnO thin films (0, 2, 4 and 6 at.% Er) were prepared using the sol-gel spin coating technique. The morphology of the thin films was studied using scanning electron microscopy (SEM). The structure was investigated by X-ray diffraction (XRD). It was found that the films have hexagonal wurtzite structure with randomly orientated particles and the crystallite size decreased from 32 nm to 8 nm as the Er increased from 0 at.% to 6 at.%. The optical properties were studied using UV-Vis spectroscopy. The films exhibited good transmittance in the visible region and a sharp absorption peak in the UV region. The optical band gap of the films calculated from Tauc plot was found to increase from 3.024 eV to 3.157 eV as the Er increased from 0 at.% to 6 at.%. Schottky diodes were produced by resistively depositing Pd contacts onto the Er-doped ZnO thin films. The electrical properties of Schottky diodes based on Er-doped ZnO thin films were characterized using I-V measurements. All the diodes exhibited good rectification behavior. The calculated Schottky barrier height at room temperature was found to be 0.649 eV, 0.738 eV, 0.714 eV and 0.723 eV for Er 0 at.%, Er 2 at.%, Er 4 at.% and Er 6 at.%, respectively. The I-V characteristics were studied at room temperature under the dark and illumination conditions using a solar simulator with 1000 mW/cm-2. All the diodes exhibited a high response to the light. This is probably due to the Er in the ZnO.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Applied Physics / **78**

Heat Transfer Improvement of a Thermal Interface Material for Heat Sink Applications Using Carbon Nanomaterials

Author: Othmane Mouane[None]

Co-authors: Edward Nkadimeng [1]; Roger van Rensburg [2]; ELIAS SIDERAS-HADDAD [1]; Bruce Mellado [1]

[1] *University of the Witwatersrand*

[2] *Wits*

Corresponding Authors: 1356959@students.wits.ac.za, edward.khomotso.nkadimeng@cern.ch

A functional material of carbon nano-composite is investigated to be utilised as a Thermal Interface Material (TIM) in the Low Voltage Power Supply (LVPS) bricks as part of the upgrade of the large Hardron Collider (LHC) accelerator at CERN. The TIM is a composite in a pasty form, based on carbon nanomaterials (CNMs) and Silicone heat transfer compound. The goal behind the implementation of the carbon nano-material in the TIM was to increase the thermal transfer from the electronics to the heat sink by the intermediary of the aluminium oxide (Al2O3) posts. The temperature of the thermal posts was aquisite by the means of an automated test stand built in house and monitored hourly with a Labview interface. The composite of CNMs and silicone compound were dissolved in acetone, then annealed at high temperatures in atmospheric air in order to achieve a homogeneous mixture. The CNMs investigated in this research work are Carbon Nanotubes (CNTs) and Carbon Nanospheres (CNSs) which were synthesised by Chemical Vapor Deposition. Also, the study included the investigation of the weighting of the CNMs in the nano-composite.

Apply to be considered for a student ; award (Yes / No)?:

yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Astrophysics / **79**

Using Asymptotic Matching to Study Accretion Disks

Author: Justine Tarrant[1]

Co-author: Geoff Beck [2]

[1] *University of the Witwatersrand*

[2] *University of Witwatersrand*

Corresponding Author: tarrant.justine@gmail.com

Generally, one expects to find accretion disks around massive objects since their gravity is able to pull in surrounding gas, dust, etc. toward themselves. Such astrophysical objects include black holes and their binaries. However, as of yet, no circumbinary disks have been found around inspiralling stellar-mass black hole binaries related to LIGO events. Our aim is to try find a mechanism to explain why this is the case. We start by assuming that these binaries do indeed possess a circumbinary disk initially but that they, through some as yet-to-be-determined mechanism, lose their disk by the time the LIGO-observable inspiral begins. We perform a computational study of a Kerr binary black hole system, for masses in the LIGO regime. We do this to derive some properties of the circumbinary accretion disk. This is possible using a novel approach to numerical relativity calculations where the disk dynamics are studied with the help of recently developed analytical spacetime models. In this talk we discuss two types of analytical models which may be used to study the geodesics relating to two different metrics. That is, we compare asymptotic patching vs. asymptotic matching, which is used to build a global metric from subdivided metric pieces. We discuss preliminary results.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Theoretical and Computational Physics / 80

Constraints on Dark Matter Models using current LHC Measurements

Author: Danielle Wilson[1]

Co-author: Deepak Kar [2]

[1] *University of the Witwatersrand*

[2] *University of Witwatersrand*

Corresponding Author: daniellewilson1305@gmail.com

In an era where high energy particle physics is having to transition from a theory-driven to a data-driven approach, the traditional method of performing specific searches off of theory models may be inefficient. Contur (Constraints On New Theories Using Rivet) was designed as a means to quickly exclude BSM models based off the many LHC measurements currently contained in Rivet. Focusing on track based measurements, the sensitivity of Contur to some Dark Matter models was explored. The exclusion potential of soft unclustered energy patterns (SUEP) and different dark sector jets scenarios will be presented.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / 81

Effect of 6.25 at.% Ta on TiPtCo Shape Memory Alloy

Authors: Mphamela Enos Baloyi[1]; Hasani Chauke[1]; Rosinah Modiba[2]; Phuti Ngoepe[1]

[1] *University of Limpopo*

[2] *CSIR*

Corresponding Author: mphamela.baloyi@ul.ac.za

In this study, the phase stability of B2 and B19 Ti50Pt43.75-xCoxTa6.25 structures using ab initio density functional theory approach was investigated. Their structural, vibrational and mechanical properties were determined to show their stability. The supercell approach was employed to substitute Pt with Ta on the TiPtCo and evaluate the stability of the structures. The calculated heats of formation predicted Ti50Pt37.50Co6.25Ta6.25 to be the most stable structures as compared to other concentrations for both B2 and B19 systems. The calculated elastic properties show that TiPtCoTa is mechanically stable at different concentrations of Co. Moreover, the temperature dependence was also calculated to predict the possible transformation.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics for Development, Education and Outreach / 82

The effects of global radical changes on students' attitudes in the new mode of teaching and learning

Author: Mphiriseni Khwanda[1]

Co-authors: Paul Molefe [2]; Buyi Sondezi [2]

[1] *UJ*

[2] *University of Johannesburg*

Corresponding Authors: bmsondezi@uj.ac.za, pmolefe@uj.ac.za

One of the challenges facing Physics Education worldwide is the improvement of learning outcomes. These have been intensified by the known attitudes of many, towards this subject. The Global Corona Pandemic also added fire to the challenge by shifting the teaching and learning from face-to-face to online. Based on this radical change to online teaching and learning platforms, it is necessary to assess if students' attitude towards their learning of Physics has changed or not. To achieve this an attitude test called Epistemological Beliefs about Physical Sciences was deployed. The current study reports preliminary results of the EBAPS questionnaire administered at UJ to first-year extended and pre-service teachers' students.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Poster Session / 84

VALIDATION OF THE MONTE CARLO MODEL FOR 6 AND 15 MV PHOTON BEAMS OF VARIAN CLINAC IX LINAC

Authors: Khombo Eunice Dumela[1]; Iyabo Usman[2]; Oluwaseyi Micheal Oderinde[3]

[1] *Netcare Medical Physics CoE, Netcare Ltd and University of the Witwatersrand*

[2] *University of the witwatersrand*

[3] *RefleXion Medical, inc and University of the Witwatersrand*

Corresponding Author: khomboeunice.dumela@netcare.co.za

The purpose of this study is to validate the Monte Carlo model of the Varian Clinac IX linear accelerator (Linac). Using the BEAMnrc package, the Linac head was modelled and simulated with 3 x 3 cm2, 6 x 6 cm2, 10 x 10 cm2 and 15 x 15cm2 for 6 MV and 15 MV photons beams based on the manufacturers' specification. For dose distribution, the scored phase-space file was used as an incident on a 60 x 60 x 24 cc virtual water phantom. The accuracy of the MC model was evaluated by comparing the central axis percentage depth dose (PDD), lateral dose profile (off axis ratio) and output factor with the beam commissioning data. The MC model dose parameter agreed measurement within 2%. This model shows the potential to be used for further dosimetric studies.

Apply to be considered for a student ; award (Yes / No)?:

YES

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Astrophysics / 85

Simulating the enrichment of cosmological gas

Author: Renier Hough[1]

Co-authors: Arif Babul [2]; Romeel Davé [3]; Ilani Loubser [1]; Douglas Rennehan [2]

[1] *North-West University*

[2] *University of Victoria*

[3] *The University of Edinburgh*

Corresponding Author: renierht@gmail.com

Large, state-of-the-art cosmological simulations allow us to follow the evolution of various galaxies, and since it contains detailed knowledge of e.g. the metal content of the stars in each galaxy, it can be used to compare to galaxies in the real Universe. In our work, we are improving the implementations of the stellar feedback model within the GIZMO-Mufasa cosmological simulation. This particular simulation is the merged product of GIZMO's public available code and Mufasa/SIMBA to create realistic large-scale enviroments. Specifically, we are improving the current simplistic instantaneous recycling of the metals model, with a more accurate Cosmic Chemical Enrichment model developed by Kobayashi et al (2007) and updated in Kobayashi et al (2020). This will improve the time delay due to the star's evolution and the time delay for the local enrichment to occur, as well as add new metals to the evolutionary tracks of stars tracked by simulations. We added a probability distribution to determine if a specific region will be enriched (rather than a fixed distance distribution) into the mechanical feedback process. This distribution can be found in the thermal feedback process in the main GIZMO simulation. This will lead to more realistic black hole seedings. Ultimately, we can compare the new model to the old simplistic model using various different well-tested scenarios (e.g Mass-Metallicity relation) and interpret any differences.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Theoretical and Computational Physics / 86

Looking for Lorentz invariance violation (LIV) in the latest long baseline accelerator neutrino oscillation data

Author: Ushak Rahaman[1]

[1] *University of Johannesburg*

Corresponding Author: ushakr@uj.ac.za

In this paper, we have analysed the latest data from NOνA and T2K with the Lorentz invariance violation along with the standard oscillation hypothesis. We have found that the NOνA data cannot distinguish between the two hypotheses at $1\,\sigma$ confidence level. T2K data and the combined data analysis excluded standard oscillation at $1\,\sigma$. All three cases do not have any hierarchy sensitivity

when analysed with LIV. There is a mild tension between the two experiments, when analysed with LIV, as θ_{23} at NOνA best-fit is at higher octant but the same for T2K is at lower octant. NOνA has a new degeneracy over $\sin^2\theta_{23}$ value, when analysed with LIV.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Astrophysics / **87**

The multi-wavelength behaviour of PSR B1259-63 during the 2021 periastron passage

Authors: Brian van Soelen[1]; Maria Chernyakova[2]; Denys Malyshev[3]; Samual Mc Keague[2]; itumeleng Monageng[4]; Charlotte Sobey[5]; Shane O'Sullivan[2]

[1] *University of the Free State*

[2] *Dublin City University*

[3] *Universität Tübingen*

[4] *University of Cape Town*

[5] *CSIRO*

Corresponding Author: vansoelenb@ufs.ac.za

Gamma-ray binaries are a rare class of high mass binary system (less than 10 sources) that emit most of their non-thermal emission in the gamma-ray regime. The gamma-ray binary PSR B1259-63/LS 2883 consists of a young pulsar in a 3.4 year orbit around a Be star. Observations around previous periastron passages have shown increased non-thermal emission associated with the pulsar crossing the Be star's circumstellar disc, as well as flares at gamma-ray energies around inferior conjunction, which exceed the pulsar's spin-down luminosity. We undertook an extensive multi-wavelength campaign to observe the source at radio (ATCA), optical (SALT), X-ray (Swift) and gamma-ray (Fermi-LAT) energies during the most recent periastron passage in February 2021. We present the first results from this observational campaign and discuss their possible implications.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics of Condensed Matter and Materials / **88**

Charge transfer mechanism and recombination process of hybrid perovskite solar cell

Author: Akin Olaleru[1]

Co-authors: Bonex Mwakikunga [2]; Daniel Wamwangi [3]; Joseph Kirui [4]; Kittessa Roro [5]; Lordwell Jhamba [6]; NM Thantsha [7]; Olasoji Adekoya [8]

[1] *University of venda, South Africa*

[2] *CSIR National Laser Centre*

[3] *wits university*

[4] *UNIVERSITY OF VENDA*

[5] *NLC-CSIR*

[6] *UNIVEN & WITS*

[7] *Tshwane University of Technology*

[8] *Yaba college of Technology, Lagos Nigeria*

Corresponding Author: akinolaleru@gmail.com

Perovskite-based solar cells (PSC) is the rapidly emerging solar technology up to the present since its introduction in 2009, hence invigorating the photovoltaic (PV) zone. To reach the maximum potential of hybrid perovskite solar cell performance, analyses of the dominant mechanisms in a perovskite material, together with interfacial properties of contact materials and their impact on the performance and stability of the device become imperative. Understanding the interface properties of the contact materials is the primary strategy for harnessing the full potential of perovskite-based solar cells. In this study, we focused on the charge transfer process and interfacial recombination within solar cell devices with n–i–p architecture. The motivation for this paper is to investigate the impact of recombination mechanisms that exist within the interface in order to quantify their effects on the performance and stability.
To achieve our objective, we firstly provide a rationale for the photoluminescence and UV-vis measurements on perovskite thin film to allow for disentangling of different recombination pathways. Secondly, we use ideality factor measurements (I-V curve) and impedance spectroscopy to access information about recombination mechanisms in full device. Our findings suggest that charge loss in PSC is dependent mainly on the configuration of the cell and morphology of the layer, with insignificant dependence on the material preparation of the perovskite itself. This is based on result of the individual analyses of the perovskite film and device, which suggest that major recombination losses are most likely located at the interface.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Theoretical and Computational Physics / 89

Generation of GHZ states via projected squeezed states

Author: Byron Alexander[1]

Co-authors: Bollinger John [2]; Tame Mark [1]

[1] *Stellenbosch University*

[2] *National Institute of Standards and Technology (NIST)*

Corresponding Author: alxbyr001@myuct.ac.za

Emerging quantum technologies rely principally on quantum phenomena such as superposition and entanglement for their unique capabilities. To this end, it is essential to develop well-defined and efficient protocols to produce and further exercise control over states of quantum bits that exhibit desired quantum mechanical traits. From a pure separable multipartite state, a control sequence, which includes rotation, spin squeezing via one-axis twisting, quantum measurement and post-selection, generates a highly entangled multipartite state, which we refer to as a *Projected Squeezed* (PS) state. Through an optimization method, we then identify parameters required to maximize the overlap

fidelity of the PS state with the maximally entangled Greenberger-Horne-Zeilinger (GHZ) state. The method leads to an appreciable decrease in the state preparation time of n-qubit GHZ states when compared to preparation through unitary evolution. The efficiency of the PS state protocol is studied in non-ideal experimentally relevant settings by simulating decoherence channels using numerical methods.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Poster Session / **90**

Assessment of NORM in fruits and vegetables from local markets in Hartbeespoort, Mahikeng and Pretoria

Author: Veronica Gouws[1]

Co-authors: Manny Mathuthu [2]; Risimati Mavunda [3]

[1] *Tomsk Polytechnic University*

[2] *NWU*

[3] *Necsa*

Corresponding Author: veronika3@tpu.ru

Abstract
This study's aim was to determine the gamma activity concentration of NORM of (238U, 234U, 235U and 232Th); the gross alpha and gross beta activity concentration; estimation of absorbed dose rate; annual ingestion dose rate and the excess lifetime cancer risk (ELCR) in fruits and vegetables collected from Hartbeespoort, Mahikeng, and Pretoria markets. The measured results will help the regulators to formulate guidelines and regulations to ensure that fruits and vegetables were safe for human consumption. For this purpose, the agricultural sample types: 4 fruits and 7 vegetables were collected. The samples were prepared and analysed at the South African Nuclear Energy Corporation (Necsa) RadioAnalysis Laboratory using different techniques. Gross alpha and gross beta activity concentration measurements were performed using the Oxford series 5 proportional gas-flow counter in fruit and vegetables. The neutron activation analysis (NNA) was used to identify naturally occurring radioactive materials (NORMs) in fruits and vegetables using a combination of high-resolution gamma-ray spectrometry and a high purity germanium HPGe) detector. The study also showed that the gross alpha and gross beta activity concentrations obtained were higher than WHO reference of 0.1 Bq.g-1 and 1.0 Bq.g-1, respectively 1. The activity concentrations of 238U, 234U and 232Th in fruits and vegetables were lower than the world values of 35 Bq.kg-1 and 30 Bq.kg-1 [2]. The calculated absorbed dose rates from this study were lower than the world safety limit of 59 nGyh-1 [3]. The current study showed lower annual ingestion doses of 238U and 232Th which are lower than the world annual ingestion dose of 290 μSv.y-1 [2] and the recommended values of 250-400 μSv.y-1 [4]. The calculated excess lifetime cancer risk in fruits and vegetables from Hartbeespoort, Mahikeng and Pretoria were lower than the world safety limit of 2.9 × 10−4 mSv.y-1 [2]. Therefore, it can be concluded that consumption of fruits and vegetables from Hartbeespoort, Mahikeng and Pretoria markets may not pose any health threats.
Keywords: Fruits and vegetables; activity concentration; neutron activation analysis; high-resolution gamma-ray spectrometry; Excess Lifetime Cancer Risk
References
1. WHO (2008). Guidelines for drinking water quality and other screening levels of various categories of foods. 6th ed.World Health Organization, Geneva, Switzerland.
2. UNSCEAR (2000). Effects of ionizing radiation: 2000 report to the general assembly, with scientific annexes (Vol. I). Effects. United Nations, New York.
3. ICRP (1993). International Commission of Radiological Protection ICRP Publication 65, Annals of

the ICRP (23). Pergamon Press, Oxford.
4. WHO (2011). International Food Safety Authorities Network, Information on Nuclear Accidents and Radioactive Contamination of Foods. 20 Avenue Appia Vol. 30. World Health Organization, 1211 Geneva 27, Switzerland, pp.159-165.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Photonics / **91**

Dicoma anomala enhances the zinc phthalocyanine tetrasulphonic acid (ZnPcS4) mediated photodynamic therapy in breast cancer cells

Author: Alexander Chota[1]

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

[1] *Laser Research Centre, Faculty of Health Sciences, University of Johannesburg, John Orr Building, Doornfontein Campus, PO Box 17011, Doornfontein, 2028.*

Corresponding Author: chotatimzy@gmail.com

Breast cancer is a form of cancer that affects women and is regarded as the second leading cause of cancer-related deaths. Phyto photodynamic therapy is a promising therapeutic approach adopted in cancer research, which uses plant-derived bioactive compounds in combination with photosensitizers to induce apoptosis in cancer cells. *Dicoma anomala* is an African medicinal plant, that is widely used in the treatment of various diseases. In this research, *D. anomala* extracts were used in combination with zinc phthalocyanine tetrasulphonic acid (ZnPcS4) to induce cell death in MCF-7 breast cancer cells. The cells were treated with different concentrations (25, 50 and 100 µg/mL) of methanolic root extract and the dose response results were used to calculate the IC50 value.(85 µg/mL). Morphological changes were observed using inverted microscope. The lactate dehydrogenase (LDH) cytotoxicity and ATP proliferation assays were performed to determine the cytotoxic effect of the extract and ZnPcS4 after 24 h of treatment. The morphological results showed a significant decrease in cell population while LDH level was increased and ATP levels were decreased in dying cells.. The outcome of this research suggests the potential medicinal benefits of *D. anomala* and ZnPcS4 in breast cancer treatment.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Photonics / **92**

Effects of photodynamic therapy on A375 Melanoma cells using aluminium phthalocyanine photosensitizer

Author: Bridgette Mkhobongo[1]

Co-authors: Rahul Chandran [1]; Heidi Abrahamse [1]

[1] *Laser Research Centre*

Corresponding Author: bbmkhobongo@yahoo.com

Metastatic Melanoma (MM) is highly aggressive and is among cancers causing major global deaths annually. It is imperative to find therapies that can eliminate MM and has become a major concern due to the potential for cancer relapse and metastasis, as well as the disease being accounted to be resistant to multiple forms of therapy. This *in vitro* study explores the effect of Photodynamic Therapy (PDT) using an Aluminium Phthalocyanine Photosensitizer (AlPcS4Cl) at 673 nm and a fluency of 5 J/cm2, in targeting Melanoma cells (A375). Dose dependent response of AlPcS4Cl was studied on both A375 and fibroblast (WS1) cell lines and the IC50 calculated from this. Significant post-irradiation signs of cell death were detected using microscopy and biochemical assays. Cell viability testing showed increased damaged cells taking up Trypan Blue Dye. A decrease in cell proliferation was observed through the measurement of Adenosine Triphosphate (ATP) content. An increased release of Lactate Dehydrogenase (LDH) content due to cytotoxicity with increasing doses of AlPcS4Cl was measured. The study suggested an effective treatment against Melanoma cells. Enhanced capabilities of PDT for MM could possibly be achieved through gold nanoparticle (AuNP) activated increased uptake of AlPcS4Cl photosensitizer, targeting their quiescent cancer stem cells.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Theoretical and Computational Physics / **93**

Investigating New Computational Techniques for Solving Black Hole Perturbation Equations.

Author: Anele Ncube[1]

Co-authors: Alan Cornell [1]; Gerhard Harmsen [2]

[1] *University of Johannesburg*

[2] *University of Witswaters Rand*

Corresponding Author: ncubeanele4@gmail.com

Physics-informed neural networks (PINNs) have recently emerged in machine learning as a tool for solving differential equations governing various physics phenomena. The present research will apply them specifically to solving black hole perturbation equations – differential equations describing quasinormal modes (QNMs) induced on the surface of a black hole by perturbing fields. Generally, these equations are difficult to solve by algebraic means owing to the nature of the effective potential in them, and thus they have no known exact, closed-form solutions. Several approximation techniques have been applied throughout the literature to compute the complex-valued quasinormal frequencies (QNFs) corresponding to black hole QNMs for different perturbation scenarios. The same will be attempted with PINN models constructed with the DeepXDE library in Python (created by Lu et al. (2021)); however, this full-fledged study of black hole QNMs will follow after an ongoing preliminary project focused on implementing PINNs to solve a one-dimensional Schrödinger equation with a symmetric Pöschl-Teller potential. For this problem, the exact solutions given by Legendre functions have been used to gauge the accuracy of PINN approximations. 5-digit accuracies were achieved for the first energy level. Given that a black hole effective potential is closely approximated by an upside-down Pöschl-Teller potential (as was shown by Ferrari & Mashhoon (1983)), these results indicate that PINNs have the potential to solve black hole perturbation equations. After the

pilot project, PINNs will be implemented to solve the perturbation equations of Schwarzschild and Reisnerr-Nordström black holes. An empirical search for optimal PINN set-ups will be conducted to maximize their performance. The computation of QNFs with PINNs will then be compared, in terms of accuracy and efficiency, with previously implemented approximation techniques.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Astrophysics / **94**

A dynamical systems analysis of interacting dark energy models

Author: VUYANI MOLOSI[1]

Co-author: AMARE ABEBE [1]

[1] *North-West University*

Corresponding Author: vuyani33g@gmail.com

We investigate, using dynamical system analysis, the impacts of various interaction models whereby dark energy is coupled with dark matter. Phase space analysis of each interaction is conducted where we obtain the cosmological consequence of each choice of interaction, with all components of the universe considered, namely; the radiation, matter, and dark energy dominated universes. We show that linear models breakdown at the early stages of the universe thus introduce product-like models to resolve for the breakdown. A thorough analysis on the nature of critical points was conducted, from which we found the existence of unstable radiation epoch; unstable dark matter epoch; and stable dark energy epoch. An upper limit on the coupling constant for interactions between dark matter and dark energy was found. This limit is crucial for producing cosmologically acceptable results of the matter dominated epoch, that is, the instability and deceleration of this epoch.

Apply to be considered for a student ; award (Yes / No)?:

YES

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Applied Physics / **95**

Development of a digital data acquisition system for neutron metrology

Author: Chloé Sole[1]

Co-authors: Andy Buffler [1]; Tanya Hutton [1]; Tom Leadbeater [1]; Vincent Gressier [2]; Richard Babut [2]

[1] *University of Cape Town*

[2] *IRSN*

Corresponding Author: slxchl001@myuct.ac.za

Fast neutron fields are found in a wide variety of contexts, for example at accelerator and medical radiation facilities, around nuclear power plants, in aviation and space flight. The essence of neutron metrology is to quantify both the fluence and energy of these fields, which is complicated by the large range of energies, intensities and directional characteristics in each unique scenario 1. Neutron metrology and spectrometry communities are beginning to adopt modern digital pulse processing systems to complement, and eventually replace, the existing analogue data acquisition systems [1,2]. Digital pulse processing electronics offer several distinct advantages over the existing analogue systems, with a need to rigorously benchmark against the current metrology standards prior to deployment [3].

The standard analogue data acquisition system at the AMANDE fast neutron metrology facility [5] at the IRSN, is compared to a new digital system comprised of a CAEN DT5730 digitizer and the open source QtDAQ software [4]. Measurements were made using a BC-501A scintillator detector for neutron fields with energies between 1.2 MeV and 20.0 MeV over the full range of available beam currents at AMANDE. Uncertainty budgets were constructed and compared for the measurements of energy dependent neutron fluence. The results of the comparison are presented along with recommendations for measurements with a fully digital acquisition system in contexts where metrological considerations are critical.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Theoretical and Computational Physics / **96**

On the advantages of relative Toffoli gates

Author: Unathi Skosana[1]

Co-author: Mark Tame [1]

[1] *Stellenbosch University*

Corresponding Author: 19790457@sun.ac.za

Many of the quantum algorithms that make theoretical guarantees on computational speedups are well beyond the capabilities of currently existing noisy intermediate-scale quantum (NISQ) hardware. The requisite resources (qubits, quantum gates) demands of these algorithms make their implementation impractical on such hardware. For some algorithms, various approaches exist to reduce these demands. We consider one such approach here. This approach uses relative phase Toffoli gates, advantageous over regular Toffoli gates due to their smaller circuit size. As a proof-of-concept demonstration of the utility of relative phase Toffoli gates, we have used a configuration of these gates in constructing the compiled quantum phase estimation routine to achieve a complete factoring of $N = 21$. This demonstration builds on the demonstration of Martín-López et al. in Nature Photonics 6, 773 (2012) and going beyond this work by improving the accuracy of the algorithmic output by a further bit, which is necessary for the complete factorization of $N = 21$. We implemented the algorithm on IBM quantum processors using only 5 qubits. The use of relative phase Toffoli gates as demonstrated and characterized here may be useful in carrying out Shor's algorithm for larger integers, or other algorithms in systems with a limited number of noisy qubits.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Nuclear, Particle and Radiation Physics / 97

A search for a high-momentum high-mass neutrino in pp collisions with the ATLAS detector

Author: Mvelo Dhlamini[1]

[1] *University of the Witwatersrand*

Corresponding Author: mvelo.d@cern.ch

One indication that the Standard Model of particle physics is incomplete lies in the unanswered question of neutrino mass generation. Most popular among the possible explanations of this mystery is the see-saw mechanism which postulates that small neutrino masses arise from the exchange of heavy force-carriers. Additionally, a framework for this mechanism is the so-called Left-Right Symmetric Model (LRSM) which is favoured since it offers a number of advantages such as explanations for violation of parity in the Standard Model, generation of mass in both heavy and light neutrinos, and accounts for parity symmetry at high energies. This model can be analysed through studying lepton-number violation, of which the Keung-Senjanovi\'c process is a culprit. The search herein investigates the decay of a heavy right-handed gauge boson W_R into a heavy neutrino N_R via the aforementioned process, with keen focus on regions where the gauge boson W_R is much heavier than the boosted neutrino N_R. The basis of the search is Run 2 data collected during the years 2015 to 2018, from the ATLAS detector at the Large Hadron Collider (LHC). For such a search, muon and electron channels result in different topologies; in the former, a unique method of large-radius jets containing electrons is employed.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Applied Physics / 98

The Physics of Vacuum Arc Propulsion Systems

Authors: Paul Stansell[None]; phil ferrer[1]

[1] *wits*

Corresponding Author: prstan2@gmail.com

The Vacuum Arc Thruster (VAT) is an unconventional plasma propulsion system with unique advantages for small satellite applications. The relevant literature and figures of merit were presented. An inductive energy storage pulsed power circuit was built which delivered triangular submillisecond current pulses to a coaxial VAT. The dense copper plasma, the expansion of the macroparticle plume, high velocity luminous micro-droplets and cathode ablation were documented among other plasma phenomena. A pulse forming network was built to deliver square pulses with higher current to the VAT. Thruster performance differences between the two circuits are discussed. The fractal and explosive ecton models of the arc are considered. The retrograde motion of the cathode spots is

discussed with special attention given to the balance of plasma and magnetic pressure. Finally, ion current density measurements are presented.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

Msc

Applied Physics / **99**

Development of 18F Radiochemistry for Positron Emission Particle Tracking (PEPT)

Authors: Ameerah Camroodien[1]; Tom Leadbeater[1]; Shankari Nair[2]

Co-author: Michael van Heerden [1]

[1] *University of Cape Town*

[2] *iThemba LABS*

Corresponding Author: cmrame001@myuct.ac.za

Positron Emission Particle Tracking (PEPT) is a radioactive tracer technique used to determine the trajectory of a positron emitting macroscopic particle used as a flow follower. The nearly collinear 511 keV gamma ray pairs resulting from positron annihilation are detected in dedicated arrays. The tracking efficiency and performance is dependent on the physical properties of the tracer, particularly the achievable positron activity. The primary application of PEPT is to study dynamic flow systems under varying conditions; including a wide range of particle size distributions, physical, and chemical properties (e.g. densities, shapes, surface chemistry, friction coefficients, etc.), with applications across the science disciplines.

We are developing tracer particles for PEPT applications based on the radioisotope 18F. Radiochemical and physical methods are being explored to produce tracer particles representative of the system under study with respect to size, density and shape. In radiochemical tracer particle production, we extract 18F from commercially available 18-fluorodeoxyglucose (18FDG) and implement ion-exchange techniques to label small phase-representative resin particles (diameter < 1mm). For physical activation we utilise the novel reaction 16O(alpha,pn)18F using 100 MeV alpha particles produced by the iThemba LABS separated sector cyclotron (SSC) to produce 18F in-situ for larger particles (>5mm diameter).

This work will develop iThemba LABS specific tracer particle production mechanisms using 18F for the first time. The effects of tracer particle properties in PEPT applications, including optimisation of the PEPT technique and enhanced tracer production mechanisms, will be discussed.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / **100**

Heavy Ion Beam Induced Sputtering of Thin Film Indium Tin Oxide at MEV SIMS Energies.

Author: Grant Tshepo Mafa[1]

Co-authors: Mandla Msimanga [1]; Thulaganyo Phillip Sechogela [2]

[1] *Tshwane University of Technology & iThemba LABS TAMS*

[2] *iThemba LABS TAMS*

Corresponding Author: granttshepo02@gmail.com

Ion beam induced sputtering in matter is of interest for fundamental ion-atom interaction studies. It is also important for practical applications such as ion beam materials analysis techniques like Secondary Ion Mass Spectrometry at MeV ion energies (MeV SIMS). Theoretical descriptions of nuclear sputtering yields due to keV projectile ions are generally in good agreement with experimental data, but this is not the case for electronic sputtering yields using heavy projectile ions There is thus a need for experimental data to improve existing theoretical models that describe electronic sputtering due to MeV ions. This work presents results of thin film sputtering yield measurements carried out using the Elastic Recoil Detection Analysis technique (ERDA). Measurements were carried out to determine the electronic sputtering yield in Indium Tin Oxide (ITO) due to 29 Cu q+ and 79 Au q+ MeV ion beams at an ion velocity range of 0.1 MeV/u - 0.6 MeV/u. The UV-Vis characterization technique was also used to determine the changes in the optical properties of the conducting oxide films due to heavy-ion beam irradiation. Results show that reduction in thickness of the ITO film is attributed to the preferential sputtering of oxygen from the surface. The measured sputtering yield data were found to decrease with increasing ion fluence in the ITO target material for both Au and Cu ion beams. The optical band gap was found to decrease only slightly from 3.99 eV (for pristine) to 3.93 eV with increasing ion fluence. The results, in general, indicate that heavy ion beams irradiation can be used as an effective tool to induce surface modifications in thin films by dense electronic excitation.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / 101

Surface, structural, and optical investigations of heavy ion-irradiated polyaniline thin films

Authors: Ingrid Kutlwano Segola[1]; Mandla Msimanga[2]; Christopher Mtshali[3]

[1] *TUT/iThemba LABS*

[2] *Tshwane University of Technology*

[3] *iThemba LABS*

Corresponding Author: kutlwanosegola@gmail.com

In this study, polyaniline thin films with thickness of approximately 100 nm were spin-coated on a silicon substrate. The films were then irradiated at normal incidence and room temperature by 150 keV Ar+ ions to fluences ranging from 1 × 10ˆ12 to 5 × 10ˆ16 ions/cm2. According to the Monte Carlo simulation code, Stopping and Range of Ions in Matter (SRIM), the approximate penetration depth of the Ar+ ions in the thin films was found to be 279 nm. The surface morphology and roughness of the irradiated films was investigated by atomic force microscopy (AFM), while the optical properties and bandgap determination of the thin films were investigated by ultraviolet-visible spectrophotometry

(UV–Vis). Rutherford backscattering spectrometry (RBS) and elastic recoil detection analysis (ERDA) were used to study the effects of irradiation on the film thickness and compositional changes. AFM analysis showed that the roughness of the films decreases from about 33 nm to 19 nm as the ion fluence increases. The optical band gap of PANI film also decreased from 1,9 eV at 1 × 10ˆ12 ions/cm2 to 1,4 eV at 5 × 10ˆ16 ions/cm2 signifying the presence of new defect states within the bandgap as fluence increases. RBS results showed that there is a decrease of the thickness with increasing fluence while ERDA showed a decrease in hydrogen atoms of the film.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / **104**

Heav Ion Beam Analaysis of Ion Implanted Polymer Nanocomposites

Authors: Dakalo Mashamba[1]; Mandla Msimanga[2]; Phillip Sechogela [3]

[1] *Tshwane University of Technology*

[2] *Tshwane University of Technology-iThemba LABS*

[3] *iThemba LABS*

Corresponding Author: dakalorollet@gmail.com

Ion Beam Analysis (IBA) is a suite of techniques used to determine elemental composition and depth profiles of thin film materials. Ion beam induced damage in soft insulating materials like polymers can be a limiting factor to the accuracy of IBA especially when using heavy ions. The usability of Heavy Ion Elastic Recoil Detection Analysis (ERDA) at iThemba LABS for analysis of polymeric films is presented in this work. The primary aim of the work was to optimize the applicability of the technique towards depth profiling ion implanted species in polymer films using different heavy ions of Au7+ and Cu5+. The films were implanted with different ion fluences of 80 keV Ti+ ions ranging from 5 x 1015 to 5 x 1016 ions/cm2 at liquid nitrogen temperature. Effects of ion implantation on the optical properties of polymers were investigated using Ultraviolet-Visible (UV-Vis) spectroscopy. Comparative Rutherford Backscattering Spectroscopy (RBS) analysis confirmed the implanted ion doses and increase in carbon concentration in the polymers. Ion implantation induced loss of hydrogen in the near surface of the polymers has been observed using Time of Flight-ERDA. The analysis efficacy of and ion beam induced damages due to Au7+ and Cu5+ beams have been investigated comparatively. UV-Vis analysis shows an increase in absorption intensity and a decrease in optical energy band gap as the ion fluence increases. The observed changes in UV-Vis have been correlated with RBS and Time of Flight-ERDA results. Possible ways of minimizing beam induced damage while improving efficacy of the analysis have been suggested.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

Msc

Physics for Development, Education and Outreach / **106**

Cascade Outreach model

Author: Carolina Odman[1]

[1] *Inter-University Institute for Data Intensive Astronomy, University of the Western Cape*

Corresponding Author: codman@uwc.ac.za

We present an approach to outreach that is based on developing scientist communicators, more than it is focused the audience and the contents. Indeed, outreach has three aspects - both the people carrying it out and the audience, and the content itself. While there has been a lot of work on outreach content creation and audience engagement, the relatability and role modelling of the ambassadors of the field who carry out the outreach have been less of a focus. In the Cascade Outreach model, we emphasise the development of relatable role models and stimulate a cascading effect of the outreach, similar to near-peer mentoring. While doing so, we explicitly ensure that the scientist communicators themselves are empowered and gain in communication and teaching skills, as well as confidence to navigate their professional environment. Challenges that are faced by scientist communicators often relate to their professional situation and personal exposure. This has so far not been seen as priority in outreach, but is a natural area of concern when focusing on the scientist communicators. We discuss how we approach this, especially in the context of social media.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics for Development, Education and Outreach / 107

The impact of the field model on pre-service students' qualitative understanding of basic DC circuits.

Author: Mphiriseni Khwanda[1]

[1] *UJ*

Corresponding Author: mkhwanda@uj.ac.za

The electron transport model is one of the consensus models currently used to teach DC circuits worldwide. The model explains current in terms of the flow of electrons. Regardless of its frequent use in high schools to explain DC circuits, the model was ineffective in helping students to understand the topic of DC qualitatively. The electron transport model also fail to provide a complete and coherent account of how electrons are involved in the transportation and distribution of energy around the circuit. As an alternative to the electron transport model, the field model was used during intervention to teach DC circuits to pre-service teachers at the University of Johannesburg. The current study reports the impact of the field model on preservice students' qualitative understanding of DC circuits as measured by the international DIRECT concept test instrument.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

Phd

Physics for Development, Education and Outreach / 108

DOING DIGITAL OFFLINE – THE COVIDEO PROJECT

Author: Derek Fish[1]

[1] *University of Zululand*

Corresponding Author: thefish@iafrica.com

Unizulu Science Centre (USC) has been running face to face matric workshops for 25 years, presenting practicals and sharpening skills for over 200 000 matric science students. The 2020 lockdown presented a dilemma: matrics needed assistance more than ever, but schools were closed and large gatherings impossible. Many SC's around the world went online, making digital content available through the internet. Very few of the schools in which USC works have reliable internet and almost none of the homes, so this route was not possible. USC worked to convert a 4 hour contact workshop into 8 one-hour videos, highlighting the essential skills for Matric Science Paper 1 – the physics paper. While these videos were made available on the internet for download or streaming, they were physically distributed on memory sticks to teachers, along with an accompanying 48-page workbook. Local industry funding saw provision for the King Cetshwayo district (5500 students in 180 schools) and further SAIP funding (with support from Allan Gray) saw a further 20 000 booklets printed and 500 memory sticks manufactured. These were distributed to schools in 3 other provinces and used as the basis for teacher training.
Now, in 2021, the Physics booklet and videos have been extensively rewritten and refilmed, adding about 50 % more content and updating with 2020 exams. In addition, projects are underway to make a video series for Life Science and Chemistry. Evaluation has been conducted to try to measure the effectiveness of this method and for further improvement. Valuable lessons learnt in the process will be shared.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Photonics / 109

Resonant Ionization Spectroscopy for laser isotope separation of zinc isotopes

Author: Andre de Bruyn[1]

Co-authors: Christine Steenkamp [2]; Anton du Plessis [3]; Erich Rohwer [2]

[1] *Laser Research Institute, Stellenbosch University*

[2] *University of Stellenbosch*

[3] *Stellenbosch University*

Corresponding Author: andredebruyn0@gmail.com

Resonant Ionisation Spectroscopy (RIS) refers to the selective excitation of a particular atomic isotope to an excited state by means of resonant light, followed by photo-ionisation and ion detection. ^{68}Zn and ^{67}Zn are important stable nuclides in medicine and industry. ^{68}Zn and ^{67}Zn are used to produce Gallium isotopes (^{68}Ga and ^{67}Ga) that are used in medical imaging such as Positron Emission Tomography (PET) and SPECT (single-photon emission computerised tomography) to detect inflammation, infection or cancer. The main aim of this project is to investigate, model and optimise RIS schemes for Zn isotopes (^{68}Zn and ^{67}Zn) that are suitable for laser-based separation of these isotopes

from natural Zn. RIS is used to obtain spectroscopic data on the transition wavelengths, hyperfine structure, and transition strengths of the relevant energy levels.

In this presentation, an overview is given on the successful development of a RIS system for Zn. The experimental setup for a three-level excitation system will be discussed. The results for the fluorescence measurements of the $3d^{10}4s^2\ {}^1S_o$ - $3d^{10}4s4p\ {}^1P_1$ and $3d^{10}4s4p\ {}^3P_1$ - $3d^{10}4s4d\ {}^3D_2$ transitions will be reported as well as the successful ionization of Zn. A brief overview of the implementation of the time-of-flight mass spectrometer (TOF-MS) with the RIS system for the detection of Zn ions, will be given. The TOF-MS and RIS systems were finally used to investigate the optimal conditions for photoionization of the individual Zn isotopes.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Astrophysics / 110

Galaxy Evolution in the Local Universe: Studying the Complete Local-Volume Groups Sample (CLoGS)

Author: Clinton Stevens[1]

Co-authors: Konstantinos Kolokythas [1]; Ilani Loubser [1]

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

Corresponding Author: stevens97@protonmail.com

More than half of all galaxies within the local Universe are found within group environments. Therefore, galaxy groups are excellent laboratories for studying galaxy evolution in the local Universe. The Complete Local Volume Groups Sample (CLoGS) is the first statistically complete galaxy group survey in the optical, X-ray and radio bands, consisting of 53 galaxy groups and 1427 member galaxies in total. The basic properties of the member galaxies, such as their morphologies, star formation rates, stellar masses and radio emission have been determined and studied with regards to their unique group environments. Exciting statistical relations between the properties of the member galaxies and their group environments have been found; such as trends in star formation that relate to each group's dynamical age, X-ray halo and radio emission from their brightest group ellipticals (BGEs). As a continuation of this study, a detailed optical spectroscopic study of these BGEs using data obtained on SALT (Southern African Large Telescope) is currently underway. The determined statistical relations and latest spectroscopy results will be presented.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Theoretical and Computational Physics / 111

Dark matter searches through dark photons and heavy top quark partner

Author: Hannah van der Schyf[1]

[1] *University of Witwatersrand*

Corresponding Author: 1586749@students.wits.ac.za

A exploratory study of dark photons in a search for dark matter is presented, where a dark photon is a hypothetical dark matter particle. A dark photon may be detected through its kinetic mixing with the general photon, in which it then couples weakly to electrically charged particles and allows a non-gravitational window into the detection of dark matter. We will be considering the hypothetical Maverick top quark decaying to a top quark and dark photon. The dark photon will decay to a lepton pair, and for masses up to hundreds of MeV the decay is completely to a electron and positron pair. We have focused on the hadronic decay of the top quark which gives a final state consisting of a heavy top quark jet. The search is for a large radius jet in the mass range of the top quark and a small radius jet close to the produced electron both with high transverse momenta. The mass of the small radius jet is that of the dark photon. The main backgrounds are expected to be multijet, Standard Model and semileptonic top quark pair production which will be estimated using simulation. The aim of this talk is to discuss the search strategy of this dark photon with the ATLAS detector. Such issues as the signal selection, feasible strategies to reduce and estimate background will be discussed.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Astrophysics / 112

Time-Dependent Modeling of Blazar Spectral Variability with Diffusive Shock Acceleration

Author: Markus Bottcher[1]

[1] *University of North West*

Corresponding Author: markus.bottcher@nwu.ac.za

Jets in blazars are an excellent forum for studying acceleration at relativistic MHD shocks, since this process is likely to spawn the highly-variable emission seen across the electromagnetic spectrum from radio to gamma-rays. Our recent work on combining time-dependent multi-wavelength leptonic emission models with complete simulated thermal + non-thermal particle distributions from shock acceleration theory has resulted in new insights into plasma conditions in AGN jets. This has demonstrated the ability to infer the plasma density, and suggested the interpretation that turbulence levels decline with remoteness from jet shocks, with a significant role for non-gyroresonant diffusion. Using our time-dependent two-zone construction, we are able to model together both extended, enhanced emission states from larger radiative regions, and prompt flare events in select Fermi-LAT and TeV blazars. In this contribution, I present recent applications of this simulation framework to AstroSAT and multi-wavelength observations of the prototypical VHE gamma-ray blazar 1ES 1959+650 and NuSTAR and multi-wavelength observations of the high-redshift FSRQ PKS 0537-286. A prime goal is to ascertain whether such flares are truly associated with prompt shock acceleration activity in relatively confined regions. The results illustrate how parametric degeneracies in shock acceleration conditions can lead to refined determinations of the plasma density and particle diffusion character in blazar jets.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Poster Session / **113**

A compact neutron spectrometer for neutrons produced by cosmic rays

Author: Erin Jarvie[1]

Co-authors: Tanya Hutton [1]; Andy Buffler [1]; Rendani Nndanganeni [2]; Charlot Vandevoorde [3]

[1] *University of Cape Town*

[2] *South African National Space Agency (SANSA)*

[3] *iThemba LABS, Radiation biophysics*

Corresponding Author: jrveri002@myuct.ac.za

Cosmic rays are comprised largely of high energy protons and alpha particles which create large amounts of secondary particles through spallation when they interact with our atmosphere. At aviation altitudes the radiation field is made up predominantly of neutrons in the energy range 1 - 100 MeV 1. During space weather events, such as solar flares, the number of energetic particles entering the atmosphere can increase drastically resulting in higher radiation doses to aircrew, and an increased risk of electronics malfunction on board aircraft [2]. As these events are unpredictable and short-lived, very little observational data exist.

The development and characterisation of a detector to measure cosmic ray induced neutrons with energies up to 100 MeV on board aircraft is presented. Due to the measurement environment, the detector needed to be compact and safe to operate during commercial flights. Building upon previous research at UCT [3,4,5], the prototype detector comprised of a 6 mm x 6 mm x 50 mm slab of EJ-276 plastic scintillator, a SensL C-series silicon photomultiplier, and digital data acquisition. Results from the first measurement campaign at the n-lab, UCT, are presented, utilising mixed gamma ray and neutron fields with energies up to 4.4 MeV and 14.1 MeV respectively. Overall, the detector system performed well and showed promise of being suitable for the measurement of neutrons with energies up to 100 MeV. Further development of the device is ongoing in collaboration with SANSA and iThemba LABS, with the aim to improve the design and characterise the response up to 100 MeV.

1 P. Goldhagen, et al., Rad. Prot. Dos., vol.110, p.387 (2004)
[2] W. Tobiska, et al., Space Weather, 13, 202–210 (2015).
[3] A. Buffler, et al., Int. Jour. Mod. Phys. 44, 1660228 (2016).
[4] A. Comrie, et al., Nucl. Instr. Meth. A, 772, 43–49 (2015).
[5] E. Jarvie, A new pocket-sized neutron detector, Hons. Thesis, Dept. Physics, UCT, 2020

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

Hons

Astrophysics / **114**

Kinematics and star formation histories of brightest cluster galaxies

Author: Siyabulela Andile Nkosi[1]

Co-author: Ilani Loubser [1]

[1] *North-West University*

Corresponding Author: andiles19@gmail.com

BEAMS is a spectroscopic survey of brightest cluster galaxies (BCGs) in massive clusters detected by the Advanced Atacama Cosmology Telescope (AdvACT). The goal is to trace the evolution of AGN feedback (both radio and quasar mode), stellar populations, and the growth of central galaxies in clusters over a 3.4 Gyr time period ($0.3 < z < 0.8$). Our study is focused on analyzing the new spectroscopic data of the BEAMS BCGs observed on the Southern African Large Telescope (SALT). In particular, we extract the spectra and stack them to increase the signal-to-noise ratios to get more accurate measurements. The stellar populations and star formation histories of BCGs can then be measured as a function of cluster mass and redshift. We will present our results on the kinematic properties and star formation histories measured from the stacked BCG spectra.different objects from the longslit
spectra, and the goal is to stack the spectra to increase the signal-to-noise ratios to get more accurate measurements.The stellar populations and star formation histories of BCGs can then be measured as a function of cluster mass and redshift. We will also directly fit the stacked spectra with stellar population models in order to constrain their star formation histories.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Theoretical and Computational Physics / 115

Random Number Generation using IBM Quantum Processors

Author: Conrad Strydom[1]

Co-author: Mark Tame [2]

[1] *Stellenbosch University*

[2] *University of KwaZulu-Natal*

Corresponding Author: conradstryd@gmail.com

Random numbers are used extensively in both cryptography and simulation, but are difficult to generate reliably using classical methods. We investigate random number generation on the ibmq_16_melbourne quantum processor, a 15-qubit superconducting quantum computer. By applying simple post-processing techniques to the random bits generated, we were able to extract a sample of random bits which passed the NIST Statistical Test Suite. This shows that, with some post-processing, solid-state quantum computers such as IBM quantum processors can be used to generate random numbers of sufficient quality for cryptographic applications.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Applied Physics / 116

Solar irradiance in Gauteng during the 2020 COVID-19 lock-down – can we detect decreased aerosol loading?

Author: Charles H. Fourie[1]

Co-authors: Hartmut Winkler [1]; Kittessa Roro [2]

[1] *Dept. Physics, University of Johannesburg*

[2] *NLC-CSIR*

Corresponding Author: hwinkler@uj.ac.za

During the early high-level lockdown linked to the COVID-19 pandemic in 2020 much of the South African industrial and economic sectors ground to a halt. This provided an opportunity to identify the role human activities have on the local contribution to aerosol emissions in Gauteng by comparing the 2020 atmospheric turbidity during that time of the year with the levels observed in prior years. We examine Council for Scientific and Industrial Research solar spectral irradiance, broadband irradiance and weather data for the period in question together with corresponding data from an earlier year. We categorise days and months according to the measured degree of turbidity for the period April-July for 2018 and 2020 through analysis of the relationship between the measured irradiance and the solar zenith angle on cloud-free days. Spectral data also allows an insight into the aerosol type and particle size. We discuss whether the solar irradiance data provides evidence of lower aerosol concentrations due to the COVID-19 lockdown.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Photonics / 117

Inhibition of Lung Cancer Migration and Invasion Using a Gold Nano Photosensitizer Conjugate.

Author: Anine Crous[1]

Co-author: Heidi Abrahamse [1]

[1] *University of Johannesburg*

Corresponding Author: acrous@uj.ac.za

Despite advances in cancer treatment, lung cancer remains one of the leading causes of cancer deaths worldwide. Lung cancer can spread through the blood and lymphatic systems, as well as infiltrate healthy tissues underlying the lung, resulting in both distant and local metastasis. The most common causes of death are cancer metastasis and the threat of secondary tumours. The ability of cells to invade, which is largely controlled by cell motility, is an essential aspect of metastases. Photodynamic therapy (PDT), a minimally invasive cancer treatment, is based on the concept of light stimulation

of a photosensitizing agent at a certain wavelength, which, combined with an optimum energy density of light activation, induces the photosensitizer (PS) to reach their triplet state, where oxidants causing tumour cell death can form in the presence of molecular oxygen. Due to their physicochemical and optical properties, gold nanoparticles have been shown to improve the effectivity of PDT by increasing the loading potential of the PS within cancer cells, are biocompatible and non-toxic, and give improved permeability and retention. The use of gold nanoparticles in nano-mediated PDT has been shown to cause lung cancer cell death. Several physiological studies, including migration, cell cycle analysis and the extracellular matrix cell invasion assay were carried out in this study to determine whether PDT using a gold nano sensitizer inhibits lung cancer migration and invasion. The results show that nano mediated PDT treatment of lung cancer inhibits lung cancer migration and invasion, causes cell cycle arrest, and reduces lung cancer proliferative abilities, elaborating on the efficacy of nano mediated PDT treatment of lung cancer.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Astrophysics / **118**

A Study of The Lobes of Radio Galaxy Hydra A using MeerKAT Observations

Authors: Mika Naidoo[1]; Dmitry Prokhorov[None]; Sphesihle Makhathini[2]; Paolo Marchegiani[None]

Co-authors: Andrew Chen [3]; Rozeena Ebrahim [3]; Paolo Serra ; Siphiwe Thwala

[1] *The University of the Witwatersrand*

[2] *Rhodes University*

[3] *University of the Witwatersrand*

Corresponding Author: 1678178@students.wits.ac.za

Hydra A is a type I Fanaroff-Riley radio galaxy which hosts a pair of 300-kiloparsec diameter radio lobes that are being powered by the previous powerful AGN outburst. Radio observations provide us with an excellent probe for the study of high energy particles residing in the lobes. The MeerKAT radio telescope carried out observations of Hydra A, from which we obtained radio maps at several frequencies. A spatial analysis of the radio maps reveals a pair of inner lobes and a pair of outer lobes. Using these observations, we computed the radiative flux densities and combined them with previous results from low frequency VLA observations at 74MHz and 327 MHz. We found that the spectrum in the MeerKAT frequency range is well described by a power law. We set constraints on the magnetic field strength and the age of the outer radio lobes through electron spectrum modelling which includes electron ageing.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Nuclear, Particle and Radiation Physics / **119**

Machine learning approach for the search of resonances with topological features at the Large Hadron Collider

Author: Salah-eddine Dahbi[1]

Co-authors: Benjamin Lieberman [2]; Bruce Mellado [3]; Gaogalalwe Mokgatitswane [4]; Joshua Choma [3]; XIFENG RUAN [5]

[1] *University of Wits*

[2] *University of Witwatersrand*

[3] *University of the Witwatersrand*

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

[5] *University of the witwatersrand*

Corresponding Author: salah-eddine.dahbi@cern.ch

We propose a new approach to search for new resonances beyond the Standard Model (SM) of particle physics in topological configurations using Machine Learning techniques. This involves a novel classification procedure based on a combination of weak-supervision and full-supervision in conjunction with Deep Neural Network algorithms. The performance of this strategy is evaluated on the production of SM Higgs boson decaying to a pair of photons inclusively and exclusive regions of phase space, for specific production modes at the Large Hadron Collider (LHC), namely through the gluon-gluon fusion, the fusion of weak vector bosons, in associated production with a weak vector boson, or in association with a pair of top quarks. After verifying the ability of the methodology to extract different Higgs signal mechanisms, a search for new phenomena in high-mass diphoton final states is setup for the LHC.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Astrophysics / **120**

Optical emission line properties of some little-known Narrow Line Seyfert 1 galaxies

Author: Bynish Paul[1]

Co-authors: Hartmut Winkler [2]; Stephen B. Potter [3]

[1] *Dept. Physics, University of Johannesburg & SAAO*

[2] *Dept. Physics, University of Johannesburg*

[3] *SAAO*

Corresponding Author: bynish@saao.ac.za

We analyse medium resolution optical spectra of six Active Galactic Nuclei (AGN), with strong iron emission spectra and characteristics associated with the class referred to as Narrow-Line Seyfert 1 (NLS1) galaxies. These were observed using the 1.9 m telescope at the South African Astronomical Observatory in Sutherland. The objects are among the brighter sources of that description accessible from the southern hemisphere: Fairall 265, NPM1G −15.0297, CTS J03.19, EUVE 0414−596, A 644-1, and HE 2116−3609. For each target we performed multiple integrations totalling between 1 and 2.5 hours, yielding spectra in the range $\sim$ 3700-6000 A with relatively high signal-to-noise ratios. This enabled us to locate multiple spectral emission features, including the strong Fe II bands in

the range 4000-5400 A as well as other prominent emission lines associated with the Balmer series, Helium and the [O III] nebular doublet. Our measurements include the flux, the width and peak wavelength shifts of the lines, which sometimes displayed multiple components. We describe the properties of our sample, compare these to other representatives of the NLS1 class and interpret their physical mechanism in the context of AGN theory.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Applied Physics / 121

Glancing Incidence X-ray Diffraction (GIXRD) analysis of induced nanocrystalline boron nitride (BN) on ion-implanted poly-crystalline hexagonal BN.

Authors: Lehlohonolo Lisema[1]; David G Billing[2]

Co-authors: Morgan Madhuku [3]; Trevor Derry [4]; Adam Shnier [5]; Daniel Wamwangi [6]

[1] *School of Physics, University of Witwatersrand, Johannesburg 2050, South Africa, DSI-NRF Centre of Excellence in Strong Materials (DSI-NRF CoE-SM) and) iThemba LABS (Gauteng), Private Bag 11, P.O. Wits, Johannesburg 2050, South Africa.*

[2] *School of Chemistry, University of Witwatersrand, Johannesburg 2050, South Africa*

[3] *) iThemba LABS (Gauteng), Private Bag 11, P.O. Wits, Johannesburg 2050, South Africa*

[4] *School of Physics, University of Witwatersrand, Johannesburg 2050, South Africa and DSI-NRF Centre of Excellence in Strong Materials (DSI-NRF CoE-SM).*

[5] *School of Chemistry, University of Witwatersrand, Johannesburg 2050, South Africa and DSI-NRF Centre of Excellence in Strong Materials (DSI-NRF CoE-SM).*

[6] *School of Physics, University of Witwatersrand, Johannesburg 2050, South Africa*

Corresponding Author: 1701761@students.wits.ac.za

This study examined changes in the properties of poly-crystalline hexagonal boron nitride (h-BN) samples implanted with light ions (He+, Li+, B+, and Ne+) at 150 keV and at a fluence of 1x1015 ions/cm2. We have previously reported the production of cubic boron nitride nanoparticles in a subsurface layer, accompanied by a measurable hardening. The GIXRD findings show a new peak at 46.45° characteristic of c-BN (111) on the XRD spectra of implanted samples. The as-grown h-BN lattice parameter, as determined from XRD, was 2.499 Å and the lattice parameters of samples implanted with He+, Li+, B+ and Ne+ ions were 2.581 Å, 2.514 Å, 2.508 Å and 2.509 Å, respectively. There is a transition to lower angles and expansion in the peak position, this is due to the residual stress caused by ion implantation since there is a difference in the lattice parameter ratios, i.e., one lattice parameter is shorter, the other is longer (a and c lattice parameters, respectively). This could mean a hexagonal stress-related phase change to cubic nanoparticles (nc-BN). The increase in hardness affects the attenuation of X-ray photons because the density of the material on the implanted surface is affected and the X-ray photons penetrate deep into the sample. The Scherrer equation was used to calculate the particle size of the induced nc-BN particles.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Applied Physics / 122

A Zinc Oxide(ZnO) Gas Sensor Approach To Measure Oxidizing Gases

Author: Lungisani Phakathi[1]

Co-authors: Betty Kibirige [1]; Prince Mkwae [1]

[1] *University of Zululand*

Corresponding Author: lungisani0626@gmail.com

Abstract. Selective detection of gases such as Nitrogen Dioxide (NO2), Carbon Monoxide (CO), Carbon Dioxide (CO2), and various other volatile organic gases is necessary for air quality monitoring. In this project we are focusing on Zinc Oxide (ZnO) as a gas-sensor and the test gas considered is Nitrogen Oxide, an oxidising gas. The conductivity of ZnO gas sensor increases when the sensor is exposed to an oxidising gas. The aim of this experiment is to modify an existing device with the introduction of electronic circuitry. The introduction of Wheatstone bridge circuit to the existing device was to provide an output voltage suitable to run a microcontroller. The magnitude of the output voltage resulting from the P-Spice simulation environment lies between 0 V and 3 V and it is sufficient to run a microcontroller. Simulation result compliment theory.
Keywords: ZnO Semiconductor Gas Sensor, Electronics circuitry, microcontroller

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Poster Session / 123

The physics of the fragmentation region in heavy-ion collisions

Authors: Isobel Kolbe[1]; Mawande Lushozi[2]; Larry McLerran[3]; Gongming Yu[4]

[1] *University of Cape Town*

[2] *Institute of Nuclear Theory*

[3] *Institute for Nuclear Theory*

[4] *Harbin Engineering University*

Corresponding Author: isobel.kolbe@gmail.com

The “fragmentation region”, or far forward region, of high-energy heavy-ion collisions provides an opportunity to study the quark-gluon plasma at very high densities. This region of phase space has not been studied in detail. We present a simple model to aid in the development of intuition for the physics of the fragmentation region, including the nature of both the highly boosted matter and the resultant radiation. We find that the fragmentation region contains two separate fluids during the early stages of the collision and we present preliminary thermodynamical results.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Applied Physics / **124**

ENHANCING ZINC OXIDE GAS SENSING DEVICE FOR MICRO-CRONTROLLER APPLICATION

Author: Sanele Scelo Gumede[1]

Co-authors: Lungisani Phakathi [1]; Betty Kibirige [1]

[1] *University of Zululand*

Corresponding Author: sanelescelogumede@gmail.com

Since, for some years now, with the rapid development of industrialization and urbanization, severe pollution primarily attributed to automobile exhaust and factory emission has become major threat to human survival and development. A leakage of flammable and explosive gases may end in a loss of life and property damage. Thus uplifting the concern for researchers to seek a high sensitive, durable and selective gas sensor. ZnO gas sensors have been popular for some time now, so the existing ZnO gas sensor will be modified by adding extra electronics components, in order to provide the voltage output that will lie between 0 V to 5 V, suitable for a Microcontroller device. HCHO is a reducing gas that increases the conductivity of ZnO and therefore decreases its resistivity due to the release of electrons into the ZnO metal oxide surface. The resistance of the ZnO gas sensor is inversely proportional to the concentration of a reducing gas. A design of a suitable electronics circuit that meets the requirements has been proposed. A P-Spice simulation environment has been developed for the proposed design. Results show promise to serve as an input to run a microcontroller environment. For future use we want to automate in the hardware.
Keywords: Metal oxide gas sensor, Reducing gas, Microcontroller

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics for Development, Education and Outreach / **125**

Science for Development at Honours level

Authors: Carolina Odman[1]; Christopher Arendse[None]

[1] *Inter-University Institute for Data Intensive Astronomy, University of the Western Cape*

Corresponding Author: codman@uwc.ac.za

Physics is a foundational science that lays the groundwork for scientific thinking and problem solving. South Africa has a strong Physics community in experimental and theoretical physics, but our graduates are not always given the chance to appreciate how broadly applicable physics principles and tools are. At the University of the Western Cape, we are setting up a Science for Development course to equip our graduates with a broad physics perspective on development challenges of all

kinds. In this paper, we describe the UWC Honours programme's origins and the efforts to adapt it to the needs of our students, our research capacity and pressing issues of our country. We then describe the syllabus for this Science for Development module, how it fits into a university physics curriculum and how we hope it will broaden our physics graduates' thinking.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Space Science / **126**

Obliquely propagating solitons and supersolitons in magnetized three-component plasmas with adiabatic ions and two-temperature electrons

Authors: Shivani Singh[1]; Shimul Maharaj[1]

[1] *SANSA*

Corresponding Author: ssingh@sansa.org.za

Large amplitude nonlinear soliton and supersoliton structures are investigated in three-component magnetized plasma models, consisting of inertial adiabatic ions and two-temperature electrons. We determine the existence of nonlinear structures which are propagating obliquely relative to the ambient magnetic field using the Sagdeev pseudopotential formalism in which an energy integral is derived, under the assumption of quasineutrality. We will test the plasma composition and parameter range to establish whether the system supports the existence of supersolitons. The electric fields of such structures have a characteristic wiggled appearance in comparison with regular solitons. We consider first Boltzmann distributions for the cool and hot electrons and then study the effect of nonthermal Cairns and kappa distributions for the hot electrons

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics for Development, Education and Outreach / **127**

GRADE 11 PHYSICAL SCIENCES LEARNERS' PERCEPTIONS OF SCIENTIFIC INQUIRY

Authors: Rosemary Zunga[1]; Sam Ramaila[1]

[1] *University of Johannesburg*

Corresponding Author: rosemaryzunga@yahoo.com

This study explored South African Grade 11 Physical Sciences learners' perceptions of scientific inquiry within the context of science classrooms. The study adopted a mixed method approach

as part of an exploratory descriptive survey design and involved 50 purposively selected Grade 11 physical sciences learners from 3 South African township schools. The empirical investigation is underpinned by inquiry in school science as the underlying theoretical framework. Quantitative data was collected by administering a validated Learner Perceptions of Classroom Inquiry (LPCI) instrument with the participants. Qualitative data was collected through semi-structured interviews. The study revealed that the learners held mixed conceptions about the nature of scientific inquiry. A substantial number of learners held naïve and incoherent views about the nature of scientific inquiry. Lack of practical laboratory lessons, lack of well-equipped science laboratories, inadequate teacher professional competence when conducting scientific investigations, and limited opportunities for meaningful engagement in inquiry-based learning activities were perceived to be contextual factors that serve to hinder meaningful enactment of scientific inquiry in science classrooms. The findings have profound implications for meaningful enactment of contemporary pedagogic approaches such as inquiry-based learning in diverse contexts. Theoretical implications for coherent development of scientific literacy through meaningful enactment of scientific inquiry within the broader South African educational context are discussed.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Astrophysics / 128

SALT spectroscopy of gas-rich galaxies in Fornax A

Authors: Katleho Mosia[1]; Ilani Loubser[2]

[1] *North West University*

[2] *North West University*

Corresponding Author: 27509079@nwu.ac.za

The Fornax Cluster is currently experiencing active assembly of mass. It has a lower-density group surrounding the radio galaxy NGC1316 (Fornax A) currently falling into the cluster. Infalling groups are ideal environments to study the transformation in the properties of the multi-phase gas due to e.g. tidal interactions and ram pressure stripping due to the velocity change at the boundary between the group and cluster. We have optical and H-alpha imaging of Fornax A, and also obtained MeerKAT data, which for the first time resolved HI emission in different substructures in the subgroup, often coinciding with detections in H-alpha. We then obtained spectroscopy of 11 gas-rich galaxies on SALT (Southern African Large Telescope). In this study, a combination of spectral fitting routines are used to accurately separate stellar continuum and absorption lines from the ionized gas emission in the observed SALT spectra, and to measure gas as well as stellar population properties. We will present our latest results from the SALT spectral analysis, which will ultimately be combined with the information obtained from the various other multi-wavelength observations to fully understand the physical processes and the multi-phase gas.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Nuclear, Particle and Radiation Physics / 129

Measurements of neutron energy spectra up to 200 MeV at the iThemba LABS fast neutron beam facility

Author: Kutullo Maibane[1]

Co-authors: Andy Buffler [2]; Tanya Hutton [2]; Zina Ndabeni [3]

[1] *University of Cape Town*
[2] *UCT*
[3] *UCT and iThemba LABS*

Corresponding Author: kutullo.maibane@uct.ac.za

The iThemba LABS fast neutron beam facility (D-line) is an international niche facility that can provide quasi mono-energetic neutron beams in the energy range of 30 MeV – 200 MeV using proton beams available from the separated sector cyclotron (SSC) 1. The D-line is undergoing a major upgrade and redevelopment in order for it to meet the requirements to become designated as a medium- and high-energy neutron metrology facility [2]. As part of the ongoing upgrade, a new design for the D-line vault layout was implemented in 2019 to reduce the leakage of epithermal neutrons from the target area to the experimental area and extend the 16o flight path. Further upgrades include the addition of new instrumentation and data acquisition, and improved beam monitoring and control systems [3].

To complement the upgrade of the D-line, a fast remote target handling system will be installed to transport neutron-irradiated samples in and out of the high-flux area, close to the neutron producing target, to a counting facility shortly after irradiation for spectroscopy measurements of short lived species. Accordingly, monitoring of neutrons; both in the relatively low-flux zone (after the collimators), and in the high-flux zone (before the collimators) forms a crucial part of the redevelopment of the D-line.

Here, we present time of flight (ToF) and fluence measurements of 66 MeV and 200 MeV neutron beams produced at the iThemba LABS fast neutron beam facility, using a BC501A organic scintillator detector and 238U fission ionisation chamber. The ultimate goal is to design, construct, and characterize a modern detector system relative to the existing metrological standards, utilising plastic scintillators capable of pulse shape discrimination, silicon photomultipliers and digital pulse processing. The new detector will be used in the D-line for international key-comparison studies in the area of neutron metrology for medium- to high-energy neutrons.

1 Mosconi et al., Radiation Measurements, 45, pp. 1342-1435, 2010
[2] Harano et al., Metrologia, 48, S292–S303, 2011
[3] Ndlovu et al, JACoW Cyclotrons 2019, TUP012, pp. 182 – 185, 2019

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Astrophysics / 130

Constraining the magnetic field geometry of millisecond pulsar PSR J0030+0451 using NICER and Fermi data

Authors: Anu Kundu[1]; Christo Venter[2]; Constantinos Kalapotharakos[3]; Alice Harding[4]; Zorawar Wadiasingh[5]; Demosthenes Kazanas[6]

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

[2] *North-west University, Potchefstroom Campus*

[3] *University of Maryland and NASA*

[4] *Theoretical Division, Los Alamos National Laboratory*

[5] *NASA and USRA*

[6] *NASA*

Corresponding Author: anukundu02@yahoo.com

The Neutron star Interior Composition Explorer (NICER) was installed aboard the International Space Station (ISS) in 2017 with the major aim of a better understanding of the extreme nature and composition of neutron stars (NSs). With its exceptional sensitivity, it hopes to constrain the equation of state for these compact objects to high precision. Modelling thermal X-ray light curves (LCs) of pulsars can also provide us insights into the magnetic field structure of NS which further helps in understanding the morphology of the surface hot spots.

Recently, works by Miller et al. (2019) and Riley et al. (2019) suggested strong evidence for a multipolar magnetic field of the millisecond pulsar PSR J0030+0451, constraining its mass and radius with unprecedented accuracy. Kalapotharakos et al. (2021) constrained the parameter space for an offset-dipole plus quadrupole field configuration, by calculating polar caps which accurately produce the NICER X-ray LC (and inferred surface hotspots) of J0030 making use of Markov chain Monte Carlo (MCMC) methods. This approach indicates field degeneracies for offset static vacuum and force-free configurations, meaning different configurations adequately describe the same observed LCs. Exploring the same configuration to fit the gamma-ray LCs measured by Fermi data breaks the field degeneracies – giving a more constrained model solution.

We are extending the above study by changing the static vacuum field configuration to a more realistic retarded field in terms of a multipole expansion, where we include higher multipoles, i.e. beyond quadrupole, and then including general relativistic effects and an offset configuration. Exploring the field parameter space by using MCMC for this configuration to fit the X-ray LCs and corresponding Fermi gamma-ray LCs would help us constrain the field structure, and eventually the stellar mass and radii, more robustly. In the talk, the impact of this work and future implications would be discussed.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

Post-doc

Nuclear, Particle and Radiation Physics / **131**

Unsupervised Machine Learning in the Search for Dark and Semi-visible Jets

Author: Roy Gusinow[None]

Corresponding Author: roy.gusinow@gmail.com

Much of dark matter (DM) research has focused on DM candidate particles which are heavy and have little interaction with baryonic matter. However, many theories have proposed DM candidates that do indeed interact with observable matter, particularly resulting in the formation of jets. In certain models, only a portion of dark hadrons produced in a collision will decay back to SM quarks, while the rest will pass through the detector undetected. Semi-visible jets (SVJ) occur when dark hadrons only partially decay to SM hadrons, while for dark jets, the dark hadrons decay fully. Since the final states involve unusual topologies, searches using traditional methods prove challenging to find evidence of resonant signal. New developments in recent years within machine learning community

provides a unique opportunity for high-energy particle physics research. In this work is provided a review of anomaly detection methods and its applicability to dark and semi-visible jets in order to uncover new BSM physics.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Poster Session / **132**

Measurement of the photoabsorption cross section of ^{24}Mg.

Authors: Jacob Bekker[1]; Retief Neveling[2]; Mathis Wiedeking[2]; Luna Pellegri[3]; Lindsay Donaldson[4]

[1] *Student*

[2] *iThemba LABS*

[3] *University of Witwatersrand and iThemba LABs*

[4] *iThemba Laboratory for Accelerator Based Sciences*

Corresponding Author: 1390529@students.wits.ac.za

Accurate nuclear data is a key factor in determining the suitability and reliability of many theoretical nuclear models and large scale calculations. One of the main ingredients of these calculations is how the nuclei respond to an electromagnetic field. This study investigates the total photoabsorption cross section of ^{24}Mg by excitation of the giant dipole resonance (GDR). The E1 excitation of the GDR is of particular importance in studies as this is the main mode of interaction of these cosmic rays with the extragalactic medium en route to Earth.

The GDR in ^{24}Mg was excited using the inelastic scattering of 200 MeV protons, which are produced using the Separated Sector Cyclotron (SSC) at the iThemba LABS facility. The detection system used was the K600 magnetic spectrometer in the zero degree configuration. This configuration of the spectrometer together with the high energy of the proton beam, has been demonstrated to be a powerful technique to investigate the GDR and therefore the photo absorption response in nuclei. The total photoabsorption cross section will be extracted from the data using the equivalent virtual-photon method. The results of this project can be used to supplement astrophysical calculations relating to the propagation distance of UHECRs. I will discuss the methods used to extract the cross section as well as the calculation of the E1 strength using the virtual-photon model.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Photonics / **133**

Investigating optically trapped spherical particles by Mie scattering.

Author: Anneke Erasmus[1]

Co-authors: Erich Rohwer [2]; Pieter Neethling [3]; Gurthwin Bosman [1]

[1] *Stellenbosch University*

[2] *University of Stellenbosch*

[3] *Laser Research Institute, University of Stellenbosch*

Corresponding Authors: 16529138@sun.ac.za, pietern@sun.ac.za

We investigate Mie scattering from particles in an optical trap. Optical tweezers and counter propagating optical traps allow micron sized particles to be optically trapped and investigated by scattering white light off the particles. In optical tweezers, a high numerical aperture microscope objective is used to focus a laser beam and create an optical trap for microscopic particles, such as polystyrene beads or biological cells suspended in water. The trapped particle has a higher refractive index than the medium which surrounds the particle. The light refracts through the particle and due to conservation of momentum, a net force pushes the particle towards the focus of the beam. In a counter propagating optical trap, microscope objectives with a longer working distance can be used. Using two high numerical aperture microscope objectives, two counter propagating beams create a trap where the two foci overlap in space. The design and construction of the counter propagating optical trap will be discussed. In this work, the ultimate aim is to trap microscopic water droplets suspended in air. Once trapped, the droplet's morphology can be studied using whispering gallery modes, also known as morphologically dependent resonances, formed within the particle when it is illuminated with white light. Specific wavelengths resonate within the spherical cavity due to total internal reflection of the light. These resonances can be seen on the measured spectrum of the Mie scattered light from the particle. By comparing the spectrum of the scattered light to that predicted by Mie Theory one can precisely determine the particle's diameter and/or its refractive index. Mie scattering theory and simulations will be briefly discussed to illustrate this.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Photonics / 134

Experimental Validation of Novel Point Spread Function Models

Author: Ratsimandresy Holinirina Dina Miora[1]

Co-authors: Gurthwin Bosman [2]; Erich Rohwer [2]; Rainer Heintzmann [3]

[1] *Stellenbosch University and Friedrich Schiller University Jena*

[2] *Department of Physics, Stellenbosch University*

[3] *Institute of Physical Chemistry and Abbe Center of Photonics, Friedrich Schiller University Jena; Leibniz Institute of Photonic Technology, Jena, Germany*

Corresponding Author: dina@aims.ac.za

Any image of a point source in a diffraction-limited system will result in a blurred pattern, the point spread function (PSF). In the case of fluorescence microscopy, incoherent imaging modality can be described by a convolution of the object with the PSF, a common approach to improve the image quality tries to undo this convolution. A successful deconvolution requires a good model of the PSF [1,2]. A practical way to obtain a PSF is by measuring it experimentally and averaging over images of multiple fluorescent beads with diameters far below the diffraction limit of the system, but the

photon noise and small depth of field in the region of interest can limit its use 3. Studies have been conducted for computing PSFs. Each technique has its own pros and cons. In this work, we present novel approaches for computing PSFs and we aim to validate the models experimentally.

Important parameters of the imaging system such as it satisfying the aplanatic condition and a possible refractive index mismatch are included in our theoretical PSF models. Aberrated PSFs with varying spherical aberration are measured by varying the refractive index of the embedding medium of the bead sample and/or the immersion medium. A high fidelity of a theoretical PSF model to represent the imaging system corresponds to the normalized cross-correlation (NCC) to the ground truth, which is the experimental PSF, being close to one. The accuracy of the PSF models are also tested by using them in image reconstruction. To this aim, we image a spherical sample object of diameter four times higher than the diffraction limit and retrieve the most accurate representation of the object by deconvolving the recorded image of the object with the theoretical aberrated PSFs and the experimental PSF. The accuracy of each PSF model is deduced from the NCC between the deconvolved image and the ground truth, which corresponds to our input sample object.

As a result, PSF models, which uses Fourier transform as a mathematical operator deviate significantly from the ground truth at higher depth if the window size of the image is too small. A combination of adjusted windows sizes and using the Chirp-Z transform prevents this large error but ads computational costs. This experimental validation and comparisons with respect to the precision and accuracy of each PSF technique under a given condition are discussed in depth in this presentation.

1 Griffa A, Garin N, Sage D. Comparison of deconvolution software in 3D microscopy: a user point of view—part 1. GIT Imaging & Microscopy. 2010;12(ARTICLE):43-5.
2 Griffa A, Garin N, Sage D. Comparison of deconvolution software: a user point of view—part 2. GIT Imaging & Microscopy. 2010;12(ARTICLE):41-3.
3 Diaz Zamboni JE, Casco VH. Estimation Methods of the Point Spread Function Axial Position: A Comparative Computational Study. Journal of Imaging. 2017 Mar;3(1):7.
[4] Ghosh S, Preza C. Fluorescence microscopy point spread function model accounting for aberrations due to refractive index variability within a specimen. Journal of biomedical optics. 2015 Jul;20(7):075003.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Astrophysics / **135**

Spatio-Kinematics of the Massive Star Forming Region NGC6334I during a Episodic Accretion Event

Author: Jakobus Vorster[1]

[1] *Centre for Space Research*

Corresponding Author: 28570057@nwu.ac.za

In 2015, the massive protostellar cluster NGC6334I-MM1 flared in various maser species detected by long term monitoring at HartRAO. Followup infrared, millimetre and centimetre observations confirmed that a massive protostar MM1B (M ˜ $6.7M_{\odot}$) inside the cluster underwent a period of high mass gain, an accretion burst. To probe the effects of such a transient event on the native protostellar environment, multi-wavelength, multi-epoch and multi-scale observations are required. We present high-resolution relative proper motion observations of highly variable water masers in NGC6334I during the onset of the accretion burst. High velocitiy ($\bar{v} = 85$ kms^{-1}) proper motions were detected in five regions, CM2-W2, MM1-W1, MM1-W3, UCHII-W1 and UCHII-W3. Using velocity variance

and covariance analysis, we calculated the position angle of the major axis of motions to be -79.4° centred on MM1B, showing the axis of the jet driving the CM2-W2 shock. The axis traced by water maser motion correspond to an outflow previously detected in CO emission. Complex motions in MM1-W1 indicate possible turbulent interactions between multiple outflows centred on MM1. Unpublished high resolution water maser maps of the period before, during and after the accretion burst will also be presented, showing the large effects of these bursts on protostellar environments.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Applied Physics / **136**

A review of solar food dryers with thermal energy storage.

Authors: Ashmore Mawire[None]; Maarten Vanierschot[None]; Molebogeng Mothupi[None]

Corresponding Author: mothupimolebogeng@gmail.com

Abstract
Food is the most essential need for both human and animal survival. During food production, and in high harvesting times, the food supply can be greater than food demand. This will result in more food wastage. The use of a solar dryer will reduce food wastage and preserve food for a longer time before consumption. Solar drying improves the quality of the dried products significantly, and also reduces crop losses when compared to the traditional method of open sun drying. A lot of recent work has been carried out on solar food drying for various agricultural products using different types of solar food dryers. The use of solar food drying can be disadvantageous since the sun is not available at night or during cloudy periods. Few studies have addressed this disadvantage by combining thermal energy storage (TES) with solar food dryers for superior thermal and economic performance leading to an increase in the drying capacity. Therefore, in this review paper, an attempt has been made to summarize the past and current research in the field of solar food drying combined with thermal energy storage. With the integration of the heat storage system, agricultural foods can be dried during late evenings or at night which cannot be done with a normal solar food dryer.
Keywords: Crops; Solar Food Dryer; Thermal Energy Storage (TES)

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

Msc

Astrophysics / **137**

Effects of emission by electron-positron pairs from gamma-ray absorption in the BLR of gamma-ray blazars on the broadband SED

Author: Mfuphi Ntshatsha[1]

Co-authors: Soebur Razzaque [1]; Richard Britto [2]

[1] *University of Johannesburg*

[2] *University of the Free State*

Corresponding Author: mfuphin95@gmail.com

Blazars are a class of active galactic nuclei. These objects are bright sources of radiation throughout the entire electromagnetic spectrum. The spectral energy distributions (SEDs) of some blazars have a distinct dip feature occurring in the gamma-ray energy band of 10 - 200 GeV. We have investigated this feature in the known bright blazar 3C 279 by analysing its spectrum in earlier work. Results from this analysis suggest that the optical-ultraviolet emission lines of the broad-line region (BLR) of 3C 279 contribute to the absorption of gamma rays in the observed dip energy range. We have also calculated the synchrotron self-Compton (SSC) emission from secondary electron-positron pairs from absorbed gamma rays. We find that if the magnetic field inside the jet is sufficiently high, SSC emission from the pairs has the effect of filling the SED dip. Subsequently, we derive an upper limit on the jet magnetic field.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Applied Physics / 138

A REVIEW ON MODELLING OF SOLAR FOOD DRYERS WITH THERMAL ENERGY STORAGE

Authors: Masodi Ramokali[1]; Ashmore Mawire[2]; Maarten Vanierschot[3]

[1] *Student*

[2] *Supervisor*

[3] *Co-supervisor*

Corresponding Author: masodiramokali@gmail.com

Food drying is an energy-intensive operation that results in the removal or reduction of the moisture content of different foods for storage, quality retention, and enhancement purposes. In developing countries, open solar drying is one of the major methods adopted for the preservation of agricultural products due to the availability of solar energy at little or no cost, especially in Africa. Open sun drying is not as effective as solar drying using a solar collector in terms of the quality of the product, and the reduced drying period, thus different types of solar dryers have been developed in recent years. The absence of solar energy at night and cloudy periods has led to the development of thermal energy storage (TES) for solar dryers. This stored solar thermal energy can be utilized for drying at night and cloudy periods. The aim of this article is to review various thermal energy storage systems used in solar dryers with a particular emphasis on numerical models aimed at enhancing the efficiency and cost of TES. Different types of models and numerical results of TES systems for solar dryers will be presented. These models include finite difference, computational fluid dynamics (CFD), and artificial neural network (ANN) models.

Keywords: Modelling, Thermal Energy Storage (TES), Solar Food Dryer

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Applied Physics / 139

Influence of coating techniques on the structural and optical properties of α-Fe2O3 nanostructures

Authors: Adiel Holtzhausen[1]; Mmantsae Diale[1]

[1] *Department of Physics, University of Pretoria, Private Bag X20, Hatfield 0028, South Africa*

Corresponding Author: adielholtzhausen@gmail.com

Adiel Holtzhausen, Mmantsae Diale
Department of Physics, University of Pretoria, Private Bag X20, Hatfield 0028, South Africa

Abstract
In this study, hematite (α-Fe2O3) thin films were synthesized, on fluorine-doped tin oxide (FTO) glass substrates, using dip coating and spray pyrolysis. This was done to study the morphological, optical and structural properties of the hematite. Six peaks were identified from X-ray diffraction (XRD) measurements: (012), (104), (110), (024), (122) and (124). The (104) and (110) phases describe the corundum structure of hematite, while other peaks represent high purity α-Fe2O3. Using Raman Spectroscopy, seven vibrational modes of hematite were observed within the first Brillouin zone: two A1g and five Eg modes, confirmed from group theory. Field emission scanning electron microscopy (FE-SEM) revealed amorphous mesoporous hematite nanospheres. The grain sizes were determined by average grain intercept (AGI) averaged at 45.82 and 50.00 nm respectively. Ultraviolet-visible spectroscopy (UV-Vis) results showed good absorbance at 596.75 and 608.57 nm, with the spray pyrolysis sample yielding slightly better results. From this work it was determined that coating techniques can contribute to grain sizes, consequently contributing to improved absorption of light for photoelectrochemical (PEC) device.

Keywords: hematite, dip coating, spray pyrolysis, structural properties, optical properties, nanostructures

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

140

Fine structure of the ISGMR in 90Zr, 120Sn and 208Pb

Authors: Armand Bahini[1]; Iyabo Usman[2]; Retief Neveling[3]; John Carter[4]

Co-authors: Philip Adsley [5]; Nolan Botha [4]; J Brummer [6]; Lindsay Donaldson [7]; Mouftahou Latif [8]; Kevin Li [9]; Chané Simone Moodley [4]; Sunday Olorunfunmi [10]; Paul Papka [11]; Luna Pellegri [12]; Bernadette Rebeiro [13]; ELIAS SIDERAS-HADDAD [4]; Frederick David Smit [3]; Smarajit Triambak [13]; J.J. van Zyl [14]

[1] *School of Physics, Wits*

[2] *University of the Witwatersrand, Johannesburg.*

[3] *iThemba LABS*

[4] *University of the Witwatersrand*

[5] *University of Stellenbosch/iThemba LABS*

[6] *University*

[7] *iThemba Laboratory for Accelerator Based Sciences*

[8] *University of the Witwatersrand, Johannesburg 2050*

[9] *Stellenbosch University, iThemba Labs*

[10] *University of Witwatersrand, Johannesburg*

[11] *Stellenbosch University*

[12] *University of Witwatersrand and iThemba LABs*

[13] *University of the Western Cape*

[14] *Stellenbosch University/iThemba LABS*

Corresponding Author: armand.bahini@wits.ac.za

Giant Resonances (GRs) are considered to be high frequency shape-vibrations of the nucleus. Since the new millennium it became apparent that the IsoScalar Giant Quadrupole Resonance (ISGQR) exhibits fine structure that is independent of probe, and soon after that it was shown that other GRs also exhibit such fine structure. As such, this fine structure as an additional GR observable has been shown to be a useful tool to determine the damping mechanism of different shape-vibrations using the Wavelet Analysis technique.

The ISGMR was excited in ^{90}Zr, ^{120}Sn and ^{208}Pb by using inelastic α-particle scattering measurements acquired with an $E_\alpha = 200$ MeV beam at $\theta_{\text{Lab}} = 0^0$ and 4^0. The high energy-resolution K600 magnetic spectrometer at iThemba LABS was used to detect the scattered alpha particles and an experimental energy-resolution of ~ 70 keV (FWHM) was achieved. This enabled the fine structure in the excitation energy region of the ISGMR to be investigated. Due to the limitations in angular acceptance and resolution, the $E0$ strength distributions in the present study was determined using the Difference-of-Spectra (DoS) method. Here, the $L = 0$ multipole excited (ISGMR $E0$ strength) has a maximum at $\theta_{\text{Lab}} = 0^0$ allowing the background from all other multipoles to be subtracted using an angle cut from the $\theta_{\text{Lab}} = 4^0$ measurements where the $L = 0$ has a deep minimum.

The aim of the work to be presented is to investigate the fine structure of the ISGMR in ^{90}Zr, ^{120}Sn and ^{208}Pb. The $E0$ strength distribution in ^{90}Zr, ^{120}Sn and ^{208}Pb will be discussed and compared to theoretical predictions from the Phonon-Phonon Coupling (PPC) model.

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Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics of Condensed Matter and Materials / **141**

L-SHELL X-RAY PRODUCTION CROSS SECTIONS IN A RARE EARTH ELEMENT INDUCED BY Cl AND C IONS.

Author: Ernest Ejeh[1]

Co-authors: Thulani Hlatshwayo [1]; Morgan Madhuku [2]; Matshisa Legodi [3]; Mandla Msimanga [4]

[1] *University of Pretoria*

[2] *iThemba LABS TAMS, National Research Foundation,Johannesburg, South Africa*

[3] *University of Pretoria, South Africa*

[4] *Tshwane University of Technology*

Corresponding Authors: ejehernest@gmail.com, thulani.hlatshwayo@up.ac.za

The utilization of different heavy ion beam analytical techniques such as heavy Particle Induced X-ray Emission, heavy ion Elastic Recoil Detection Analysis (ERDA), etc. is dependent on availability of accurate and reliable heavy ion-matter interaction database. Adding new experimental data of heavy ion induced X-ray production cross sections in elemental films to expand the existing global database of basic ion-atom interaction is of great importance.

In this work, L-shell X-ray production cross sections in bismuth induced by 7-35 MeV 35Clq+ and 4-12 MeV 12Cq+ ions have been measured. Multiple ionization effect on the ions is discussed. Experimental results are compared with ECPSSR, ECPSSR+EC and ECPSSR-UA theoretical predictions. There is fair agreement between the data, ECPSSR+EC and ECPSSR models for 12Cq+ ions while the ECPSSR+UA calculations overestimate experiment data. ECPSSR+EC calculations show good agreement with experiment for 35Clq+ ions while the ECPSSR prediction underestimates the experimental results.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Photonics / **142**

Interaction between the photo-induced electric fields of the front and rear Si/SiO2 interfaces of thin silicon membranes probed by Electric Field Induced Second Harmonic (EFISH) generation

Authors: Christine Steenkamp[1]; Pieter Neethling[1]; Wilfrid Innocent Ndebeka[1]; Herbert Stafast[2]; Erich Rohwer[1]

[1] *Laser Research Institute, University of Stellenbosch*

[2] *Leibniz Institute of Photonic Technology (IPHT)*

Corresponding Author: cmsteen@sun.ac.za

Electric Field Induced Second Harmonic (EFISH) generation is a technique to probe the structure of and charge transfer across buried interfaces. It is particularly suitable to study the Si/SiO2 interfaces that are crucial in electronics undergoing continuous miniaturization. This makes it important to investigate the interaction of the front and rear Si/SiO2 interfaces of thin silicon membranes. EFISH signals typically increase quadratically with both the pump beam intensity and the quasi-static electric field that builds up over the interface due to photo-induced charge transfer.
The EFISH signals from the front and rear Si/SiO2 interfaces of thin silicon membranes (10-30 micron thick, slightly p-doped) were generated by a laser beam (Ti:sapphire laser tuned to 800 nm, 90 fs pulse duration at 80 MHz repetition rate) transmitted through the membrane. Detailed measurements on samples with different thicknesses have confirmed counter-intuitive results that for thin samples the EFISH signal generated at the rear interface is stronger than that at the front interface in spite of attenuation of the incident beam. These results lead to a hypothesis that the quasi-static electric field at the rear interface consists of two counteracting components and the degree of interaction between the front and rear interfaces varies significantly with thickness over the 10-30 micron range. It is also shown that the effective third order susceptibility for the EFISH-active layers at the rear interface is larger than that at the front interface which paves the way for future theoretical modelling.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Photonics / **143**

Dr

Author: Darryl Naidoo[1]

[1] *Council for Scientific and Industrial Research*

Corresponding Author: dnaidoo3@csir.co.za

Photonics and Lasers have become the centre of several modern day technologies such as the internet, additive manufacturing, remote sensors and even entertainment. They have revolutionized how we view Physics opening the door to a plethora of applications and new Photonics phenomena. In this non-specialist lecture we will take you on a trip through the development of lasers and the concept of structured laser beams and its impressive advances in Photonics.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

No

Physics of Condensed Matter and Materials / **144**

Elastic recoiled detection analysis (ERDA) and Rutherford Backscattering Spectrometry (RBS) investigation of hydrogenated Pd/Ti/Pd multilayer system

Authors: Christopher Mtshali[1]; STEVEN MAGOGODI[2]; Sylvain Halindintwali[3]

[1] *iThemba LABS*

[2] *unversity of western cape*

[3] *University of the Western Cape*

Corresponding Author: mtshali@tlabs.ac.za

ERDA and RBS analysis of hydrogenated Pd-Ti-Pd multilayer stacked film prepared on CT-Ti and Ti6Al4V substrates using an electron beam evaporator were conducted in this investigation. The hydrogenation of the samples was achieved by flowing pure H2 (100%) and H2(15%)/Ar(85%) gas mixture while annealing samples at 550oC. The stability of the multilayer stack system at 550 ℃ was also investigated using RBS for the investigation of possible intermixing of layers and XRD for crystal structure and any possible new phase formation due to elevated temperatures. SEM was used for surface topography investigation. ERDA revealed an average H content of ˜ 3.5 at.% in CP-Ti and ˜6.2 at.% in Ti6Al4V for samples annealed under H2(15%)/Ar(85%) gas mixture. We recorded a hydrogen content of ˜19.5 at.% in CP-Ti annealed under pure H2 while ˜25.5 at.% was found in Ti6Al4V annealed under the same conditions. Rutherford backscattering spectrometry (RBS) revealed intermixing of layers as evidenced by the diffusion of Pd toward the bulk, while XRD indicated the formation of the PdTi2 phase in the samples annealed under vacuum and H/Ar gas mixture atmosphere. In-situ, real-time RBS showed that the annealing under pure H2 preserves the integrity of the Pd catalyst.

No indication of the PdTi2 formation in the pure H2 annealed samples was observed; instead only the TiH2 phase appeared, indicating the absorption of H into the system. These results indicated the sensitivity of such a system to the H2(15%)/Ar(85%) gas mixture.

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No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Photonics / **145**

Comparison of different techniques for resonance ionization spectroscopy and report on progress towards its application on tin isotopes

Author: Frederick Waso[1]

Co-authors: Christine Steenkamp [2]; Robert Bark [3]

[1] *Stellenbosch University*

[2] *University of Stellenbosch*

[3] *iThemba LABS*

Corresponding Author: fjw0628@gmail.com

Resonance Ionization Spectroscopy (RIS) is a spectroscopic technique that relies on the resonant excitation of an atom using lasers. The process involves series of atomic excitations, with at least one resonant transition, and ends when the atom is ionized. The RIS process can be applied in the production and study of rare and exotic nuclei via radioactive ion beams at accelerator facilities such as ISOLDE at CERN or LERIB at iThemba LABS. RIS can also be used to enhance the production and quality of isotopes used for medical applications.
The main aim of this project is to improve and optimize an existing RIS setup for the study of the various stable isotopes of tin. Tin is an important element in the study of nucleus structure as it has a high stability due to completely filled proton shells, and therefore a large number of isotopes. In this presentation, we report on the different methods applied at the RIS facility at CERN while highlighting key differences, advantages, and disadvantages of the methods used. We also report on the progress made at the RIS lab at Stellenbosch University and the future plans for applications.

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Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Applied Physics / **146**

Density modified tracer particles for Positron Emission Particle Tracking (PEPT)

Author: Michael Mike[1]

Co-authors: Andy Buffler [2]; Kathryn Cole [2]; Thomas Leadbeater [2]

[1] *UCT*

[2] *University of Cape Town*

Corresponding Author: michael.vanheerden@uct.ac.za

PEPT Cape Town has established the development of Gallium-68 based tracer particle analogues for use in positron emission particle tracking studies of granular and multiphase systems. The accuracy of the measured data relies strongly on how representative the tracer particle analogue is to the media of interest in these dynamic systems. The ability to control and manipulate the tracer particle properties expands the range of applications and systems suitable for investigation with PEPT. The density of the material represented by the analogue is often a critical parameter of the system under study. Tracer production methods developed at PEPT Cape Town rely on multiple layers of coatings on tracers created by radiolabelling ion exchange resin beads. The layers include the radioactive core, a density-controlled region and may include an additional coating used to control the surface chemistry of the particle. The current available densities range between 1.00 and 2.85 g cm-3 with final particle diameters as small as 450 microns. We report on our methods for creating density-modified tracer particles and illustrate their application in PEPT measurements from an industrial system designed to separate higher density minerals from lower density gangue.

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No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Applied Physics / 147

Seed-Mediated synthesis and application of Gold nanorods in Organic Solar Cells

Author: Siphesihle Mnguni[1]

Co-authors: Justine Nyarige [1]; Mmantsae Diale [1]

[1] *Department of Physics, University of Pretoria*

Corresponding Author: siphesihle.mnguni.963@gmail.com

The properties of noble metals are different when these materials are reduced to nano-scale dimensions (1 – 100 nm), dependent on shape and size of the particle. In this research gold nanorods were synthesized using the mediated-seed method. The absorption spectrum of these nanorods showed two bands; the transverse and longitudinal band. Transmission Electron Microscopy (TEM) images show nanorods with lengths that ranged from 10 to 12 nm, widths from 3.5 to 4.0 nm, and an aspect ratio of 2.9. X-ray diffractometer (XRD) confirmed the crystal nature of the nanorods with an fcc structure and average crystallite size of 1.32 nm. It was also noted that the predominant growth of the nanorods was in the direction of the (111) plane. The Raman peaks of the nanorods were more intense at the wavenumbers 452, 752, 937, 939, 1062, and 1128 cm-1. The ability to absorb light in two regions; absorption efficiency dominance over scattering efficiency, and near field enhancement from incident photon confinement makes gold nanorods attractive agents for applications in organic solar cells.
Keywords: Gold nanorods, plasmonic effect, surface plasmon

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Astrophysics / **148**

Optical spectropolarimetry monitoring of flaring blazars

Author: Joleen Barnard[1]

Co-authors: David Buckley [2]; Brian van Soelen [3]; Justin Cooper [1]; Richard Britto [3]; Johannes Petrus Marais [4]; Markus Bottcher [5]; Hester Schutte [6]

[1] *The University of the Free State*

[2] *Southern African Large Telescope*

[3] *University of the Free State*

[4] *UFS*

[5] *University of North West*

[6] *NWU Potchefstroom*

Corresponding Author: joleenels98@gmail.com

Blazars are a radio-loud subclass of active galactic nuclei (AGN), with relativistic jets closely aligned with the line of sight. These sources are highly variable across all timescales, often displaying flares that are observed across multiple wavelength bands. Blazars emit non-thermal emission across all wavelength regimes, which is characterised by a double-humped structure in its spectral energy distribution (SED). The lower-energy component (radio through UV or soft X ray) is powered by leptonic synchrotron emission, while the high-energy component (X ray through gamma) is powered by either leptonic inverse Compton scattering or hadronic processes. At optical wavelengths, there are also contributions from thermal emission components, namely, the accretion disk, broad line region (BLR) and dusty torus. The aim of this project is to disentangle these components using optical spectropolarimetry to separate the thermal (non-polarised) components from the non-thermal (polarised) component. This will be complemented by optical photometry observations to improve flux calibration. As part of a long-term project, we are using the Southern African Large Telescope (SALT) to undertake spectropolarimetry observations of flaring blazars. We present results on the degree of linear polarization evolution from flaring to non-flaring state for a sample of blazars.

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Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Astrophysics / **149**

Determining the orbital parameters of the gamma-ray binary HESS J0632 +057

Author: Natalie Matchett[1]

Co-authors: Brian van Soelen [1]; Richard Gray [2]

[1] *University of the Free State*

[2] *Appalachian State University*

Corresponding Author: natmatch98@gmail.com

Gamma-ray binaries are a small subclass of high mass binary systems that display multi-wavelength emission peaking in the gamma-ray regime (≥1 MeV). All known gamma-ray binaries consist of a massive O/B type star and a compact object, either a neutron star or a black hole. There are currently less than ten known systems. The compact object has been identified for only two systems, both as a young pulsar. In order to understand how the physical processes occurring within these systems result in the observed emission, it is necessary to know the geometry of the binary and its orientation with respect to the observer. Therefore the orbital parameters must be determined via radial velocity measurements of the optical companion. HESS J0632 +057 is a gamma-ray binary comprising of a Be type star and an unknown compact object with an orbital period of 316.8 days. Two previous studies by Cesares et al. 2012 and Moritani et al. 2018 have presented orbital solutions, which are very different and incompatible. This study aims to better constrain the orbital parameters. To do this, observations are currently being obtained with the High Resolution Spectrograph on the Southern African Large Telescope to establish the radial velocity and observe the long term behaviour of the Be star. Because of the long orbital period, observations are required over several years to obtain a sufficient coverage of radial velocity. We present the initial results from this project.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Astrophysics / **150**

A multi-band view on the evolution of group central galaxies

Author: Konstantinos Kolokythas[1]

Co-authors: Ilani Loubser [1]; Ewan O'Sullivan [2]; Sravani Vaddi [3]; Somak Raychaudhury [4]; Arif Babul [5]

[1] *North-West University*

[2] *Harvard-Smithsonian Center forAstrophysics*

[3] *Arecibo Observatory*

[4] *IUCAA*

[5] *University of Victoria*

Corresponding Author: k.kolok@nwu.ac.za

Much of the evolution of galaxies takes place in groups that occupy the interesting intermediate-mass range, where feedback has the greatest impact on galaxy formation and evolution. By using multi-band data (FUV, Mid-IR, Radio, CO, and X-rays), and an optically selected, statistically complete sample of 53 groups (< 80 Mpc; CLoGS sample) the galaxy evolution and star-formation activity of the central group dominant early-type galaxies is examined in relation to their gas content, AGN activity and local environment. The majority of the group dominant galaxies (87%; 41/47) are found to be passive systems without any significant star-forming activity, with the rest of the highest star-forming systems found to present significant cold gas detections, residing in X-ray faint groups (X-ray halo <65 kpc) and none hosting a powerful radio source (P1.4GHz>10ˆ23 W/Hz). As galaxy groups are a favorable environment for both cooling flows and gas-rich galaxy mergers and interactions, the significant role of both processes on the origin of cold gas and the fuelling of an AGN or star-formation will be discussed along with results on the properties of the highest star-forming systems and the implications on AGN feedback in galaxy groups.

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No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics for Development, Education and Outreach / **151**

10 years of Astronomy for Development

Authors: Kevindran Govender[1]; Vanessa McBride[2]

[1] *South African Astronomical Observatory*

[2] *University of Cape Town & SAAO*

Corresponding Author: kg@astro4dev.org

As a branch of Physics, Astronomy has put significant effort and resources into using all aspects of the field to stimulate global development. This talk will reflect on the first decade of the International Astronomical Union's Office of Astronomy for Development (OAD). Established in April 2011, the OAD is a partnership between the IAU and the South African National Research Foundation, mandated to use astronomy to stimulate development globally. Over the past decade the OAD has established 11 regional offices and language centres and funded over 200 projects targeting audiences in over 100 countries, which includes 43 COVID-related projects. We will discuss the OAD's activities, challenges and impact over the years, as well as plans for the future.

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No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Applied Physics / **152**

Effect of methoxy functionalized group on the photocatalytic properties of diphenylaniline organic Chromophores

Authors: ife Fortunate Elegbeleye[1]; Eric Eric Nnditshedzeni Maluta[2]; Regina Maphangarr[3]

[1] *Physics department, University of Venda*

[2] *National Institute of Theoretical Physics*

[3] *CSIR*

Corresponding Author: ifelove778@gmail.com

Diphenylaniline dyes are important sets of organic dyes that has stirred many research interest as photosensitizers in TiO2 semiconductor based dye sensitized solar cells (DSSCs). The advantages of organic dyes over metal based complexes are higher extinction coefficient, low cost, good environmental compatibility and electrochemical properties. The diphenylaniline organic dyes with basic configuration of donor-π-acceptor are relatively cheap, easy to synthesize and possess chemical structures that can easily be altered to optimize their photocatalytic properties. The enormous interest in dipheylaniline dyes as photosensitizers is due to their fascinating spectral properties which include visible light to near infra-red light absorption. In this work, density functional theory

approach via GPAW, Avogadro and ASE were employed to study the effect of the methoxy functionalized group on the spectral properties of diphenylaniline dyes to improve their photocatalytic properties to harness more near infrared photons. Our results shows that the two dyes with pure phenyl groups D5 and D7 shows maximum absorption peaks at 750 nm and 850 nm, while D9 and D11 with methoxy group shows maximum absorption peak at 800 nm and 900 nm respectively. The highest absorption wavelength is notable for D9 and D11 containing methoxy groups. Also D9 and D11 dyes with the methoxy group shows lower energy gap of 0.98 and 0.85 respectively than the corresponding D5 and D7 dyes with energy gap of 1.32 and 1.08. The analysis of their electron injection kinetics ΔGinject into the band gap of TiO2 shows that D9 and D11 with the methoxy group has higher electron injection kinetics of -2.070 and -2.030 than the corresponding pure phenyl dyes with ΔGinject values of -2.820 and -2.130 respectively. Our findings suggest that the photocatalytic properties of organic chromophores with donor-π-acceptor configuration can be enhanced by the addition of functionalized groups.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Applied Physics / 153

Structural and optical properties of shape-dependent gold nanoparticles

Author: Tlangelani Ngunyulu[1]

Co-authors: Justine Nyarige [1]; Mmantase Diale [1]

[1] *Department of Physics, University of Pretoria, Private Bag X20, Hatfield 0028, South Africa*

Corresponding Author: sharlot.ngunyulu@gmail.com

Abstract
At nanoscale, the electrical, optical, and catalytic properties of metal nanoparticles depend on shape and size. In this study, gold nanoparticles (AuNPs) were synthesized using the seed-mediated growth method. Au nanospheres, nanoprisms and nanorods with average sizes of 6 and 68 nm, (70 nm length, 40 nm width) and grain sizes of 14, 20 and 130 nm, respectively; obtained by SEM and TEM. The plasmon absorption bands of Au seeds, nanospheres, nanoprisms were observed to be 395, 511, 543 and 528-629 nm, respectively, using UV-Vis spectroscopy. As the AuNPs shape changed, size increased and the wavelength increased, hence a red-shift was observed. From Raman spectrum, strong and sharp Raman peaks for the three shapes were observed. The XRD patterns confirmed AuNPs with the face-centered cubic (fcc) of gold and crystalline. The crystallite sizes of Au nanorods and Au nanoprisms obtained from XRD studies were 14.65 and 11.44 nm, respectively. The lattice constants of Au nanorods and Au nano-prisms were 4.15 and 4.10 Å, respectively. The structural and optical properties of shape dependent AuNPs were studied. The obtained nanoparticles, Au nanoprisms, nanospheres and nanorods have good applications in organic solar cells, photothermal therapy, sensing and imaging. Therefore, the results indicate that the sizes and shapes of AuNPs can be controlled by using different reducing agents.
Keywords: Gold nanoparticles; Plasmonic effect; synthesis; Au nanorods; Au nanoprisms

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Photonics / 154

Comparison of spectral focusing approaches in single-beam CARS

Author: Ruan Viljoen[1]

Co-authors: Pieter Neethling [2]; Alexander Heidt [3]; Thomas Feurer [3]; Erich Rohwer [4]

[1] *Stellenbosch University*

[2] *Laser Research Institute, University of Stellenbosch*

[3] *Institute for Applied Physics, University ofBern*

[4] *University of Stellenbosch*

Corresponding Author: 16107500@sun.ac.za

Single-beam coherent anti-Stokes Raman scattering (SB-CARS) spectroscopy is a special implementation of CARS which utilises a single broadband light source, as opposed to the up to three lasers found in a traditional implementation. This CARS configuration, in combination with spectral focusing, has been shown to be able to target and isolate chosen Raman transitions from broad spectra in applications such as microscopy and stand-off detection. The experimental setup combines our unique white light source with our novel pulse characterization technique do develop new improved methods for SB-CARS.
In our implementation of SB-CARS we employ a fs-oscillator which pumps an all-normal dispersion photonic crystal fiber to produce a supercontinuum. The supercontinuum pulses arrive at the sample plane at a pulse repetition rate of 80 MHz, as inherited from the oscillator, and a pulse energy of 0.69 nJ. This configuration allows for fast acquisition of measurements with very low pulse energies. In order to utilise the temporally dispersed supercontinuum, with a bandwidth of about 100 nm, to its full extent, a ptychographic pulse reconstruction algorithm, i2PIE, is employed to ensure that pulses arrive at the sample plane compressed to near Fourier limit.
In this presentation we highlight two spectral focusing pulse shaping strategies implemented in the described setup. Spectral focusing allows for the targeting of chosen Raman transitions within the SB-CARS spectrum. These strategies use the introduction of known phase functions in the form of either quadratic phase functions or carefully tailored binary sequences. We show that the signal-to-background of spectra can be larger by a factor of three when using quadratic phase functions as compared to spectra obtained using binary sequences.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Applied Physics / 155

Optimization of processing parameters of dip coated CuO films for photoelectrochemical water-splitting

Author: Mano Mosalakgotla[None]

Co-authors: Pannan Kyesmen [1]; Mmantse Diale [1]

[1] *Department of Physics, University of Pretoria, Private Bag X20, Hatfield 0028, South Africa*

Corresponding Author: manomosalakgotla@gmail.com

Abstract.

In this work, thin films of dip coated CuO nanoparticles were prepared on fluorine-doped tin oxide (FTO) substrates and the film's processing parameters which includes the withdrawal rate, film thickness and annealing temperature were optimized for photoelectrochemical (PEC) water splitting. CuO films were prepared at withdrawal speeds ranging from 50-200 mm/min, with thicknesses of 158-627 nm and annealed at 400-650 ℃ for 1 hr. X-ray diffraction (XRD) and Raman spectroscopy studies confirmed the preparation of crystallized CuO films of high purity. The estimated crystal sizes for the films increases with withdrawal rate and annealing temperature, producing the highest value for films withdrawn and annealed at 150 mm/min and 600℃ respectively. The CuO films indicated strong optical absorptions in the visible region and their absorbance increases with increasing film thickness. The band gaps of all samples ranged from 1.69 to 2.08 eV. Linear Sweep Voltammetry (LSV) measurements yielded the highest photocurrent densities of 2, 2.6 and 2.9 mA/cm2 at 0.37 V vs RHE for films prepared at withdrawal speed of 150 mm/min, deposited with 7 layers and annealed at 600℃. The high photocurrent obtained for the films was due to the optimized film thickness, enhanced crystallization and the decrease in charge transfer resistance at solid/liquid interface achieved for the films. The least photocurrent was observed for films annealed at 400℃ due to poor crystallization and high charge transfer resistance obtained. This study emphasized the importance of optimizing processing parameters such as withdrawal speed, film thickness and annealing temperature in the preparation of CuO films for photocatalytic applications.

Keywords: CuO photocathodes, PEC water-splitting, withdrawal speed, film thickness, annealing temperature.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Applied Physics / 156

A new instrumental activation analysis facility at UCT

Authors: Sizwe Mhlongo[1]; Andy Buffler[1]; Tanya Hutton[1]; Ntombizikhona Beaulah Ndlovu[2]

[1] *University of Cape Town*

[2] *Stellenbosch University*

Corresponding Author: sizwesmhlongo@gmail.com

Instrumental neutron activation analysis (INAA) is a non-destructive technique used for qualitative and quantitative elemental analysis in a range of contexts, including the food, coal and minerals processing industries, and the detection of contraband. Broadly, INAA requires the irradiation of a sample in a neutron field, and the neutron interactions within the sample to produce radioactive isotopes with characteristic gamma ray emissions. These characteristic gamma ray emissions are then detected using a gamma ray spectrometer and further analysed to determine elemental composition.

In 2017, the UCT Department of Physics commissioned the n-lab, a fast neutron laboratory centred around a Thermo MP-320 deuterium-tritium sealed tube neutron generator (STNG) and a 220 GBq Americium-Beryllium (Am-Be) radioisotopic source. The aims of this project are to characterise the n-lab as an INAA facility, and to develop standardised analysis protocols for the elemental analysis of bulk materials. Fundamental to INAA is knowledge of the number and energy distribution of neutrons incident upon the sample of interest. The process of determining the neutron flux by the activation of foils is presented, in addition to the recent results from the activation of copper and aluminium samples by the STNG. The next stages of this project are discussed with respect to measurement and radiation transport simulations, with a particular focus on the use of pulsed 14.1 MeV neutron beams produced by the STNG.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Astrophysics / **157**

Interacting Viscous Dark fluid models

Author: BONANG GEORGE MBEWE[1]

Co-author: AMARE ABBEBE GIDELEW [1]

[1] *NORTH WEST UNIVERSITY*

Corresponding Author: bonang.mbewe@gmail.com

The observational data shows that the universe is dominated by the dark sector, which is comprising of dark matter ρ_{dust} and dark energy ρ_{Λ}. This is with budget allocation of 25% to dark matter while dark energy is about 70%. Now since most of the existing work in the literature is limited to the study of background cosmological dynamics, the project aims at deriving the equations that govern the evolution of a cosmological perturbations of a universe filled with interacting viscous dark fluids and analyzing their behaviour as compared to large scale structure. We will model and derive the background cosmological equations of interacting viscous fluid using the little rip model and pseudo rip model and analyze the results obtained.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Nuclear, Particle and Radiation Physics / **158**

A search for tWZ production in the trilepton channel using Run 2 data from the ATLAS experiment

Authors: Benjamin Warren[1]; James Michael Keaveney[2]; Sahal Yacoob[1]

[1] *University of Cape Town*

[2] *N/A*

Corresponding Author: wrrben001@myuct.ac.za

A search for tWZ production using events containing three leptons from Run 2 ATLAS proton-proton collision data with a centre of mass energy of 13 TeV will be presented. An event selection scheme was developed using simulation to select tWZ events and to broadly suppress background events. Events were then separated into mutually-exclusive regions of phase space to increase the amount of tWZ events compared to background events, and to calibrate the modelling of the background production processes. Background events were further suppressed through the use of Gradient Boosted Decision Tree (GBDT) machine learning algorithms. First, a GBDT was trained to

identify hadronically-decaying W bosons since these are a characteristic feature of tWZ events and help distinguish between tWZ and one of the major background processes, WZ. Then, this GBDT and other event information was used to train an event-level GBDT used to distinguish between tWZ and all backgrounds. Using the output of the event-level GBDT, a maximum likelihood fit was used to estimate the signal strength, μ, of tWZ production, where nuisance parameters were assigned to theoretical and experimental systematic uncertainties. A signal strength of $\mu = 1.80^{+1.88}_{-1.83}$ was determined with an expected significance of 0.55σ, and an expected upper limit on μ of $3.6^{+3.1}_{-1.7}$ was also determined. The preliminary blinded results show that the search has the potential to put the strongest ever constraint on tWZ production, but does not have the potential to observe tWZ production as predicted by the Standard Model. These constraints are limited by statistical uncertainties, therefore an outlook on future measurements of tWZ within ATLAS will be discussed.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Theoretical and Computational Physics / 159

Motor Protein Transport on Cytoskeleton Networks

Authors: Nadine Dempers[1]; Kristian Müller-Nedebock[1]

[1] *Department of Physics, Stellenbosch University and National Institute of Theoretical Physics*

Corresponding Author: nadinedempers@gmail.com

Molecular machines, known as motor proteins, walk along configurations of filamentous proteins which make up the cytoskeleton of a cell. These motor proteins, for example kinesins, are responsible for transporting a variety of cargoes within the cell. The arrival of the cargoes at specific locations within the cell are imperative for the successful execution of various cellular processes, including cell division. Although much detail is known about the different proteins that are able to transport certain cargoes, the exact processes that influence the distribution of these cargoes throughout the cell are still unclear. Whilst theoretical models may provide further insights into intracellular processes, there is an absence of such models describing the dynamics and diffusion of motor proteins throughout the interior of cells. In light of this, the aim of this talk is to explore possibilities for analytical modelling of the motion of motor proteins within the context of a cell. To begin this exploration, the Langevin dynamics of a single motor protein transporting a cargo as it progresses along different configurations of a single filament will be considered. The mathematical challenge posed by modelling this process in a similar manner for more intricate filament configurations will then be addressed through a combination of a dynamical field theoretical formalism with a networking theory employed in polymer physics (see e.g. 1). The talk will be concluded with a glimpse of how the formalism may allow for the extension of the model to describe transport over a density of filaments that one might expect to find within a cell.

1 S. F. Edwards, “A field theory formulation of polymer networks,” J. Phys. Fr., vol. 49, pp. 1673–1682, 1988.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / 160

Atomistic Simulation Study of Li-rich Li1.2Mn0.8O2 Cathode Materials

Authors: Nkgaphe Tsebesebe[1]; Phuti Ngoepe[1]; Raesibe Ledwaba[1]; Kenneth Kgatwane[1]

[1] *University of Limpopo*

Corresponding Author: nkgaphe.tsebesebe@ul.ac.za

The cathode materials that can exhibits a capacity of >270 mAh/g with little or no capacity fade are the most promising next-generation cathode active materials for Li-ion batteries. Hence, the layered oxides relative to the stoichiometry Li1+yMn1-yO2 can deliver discharge capacities of >250 mAh/g after they have been activated by charging first to a voltage of 4.6–4.9 V in a Li-cell. However, the structural inherent complexity of Li-rich oxides causes deficiencies, and the ways to illuminate them have not yet established. In the present work, we investigate the structures of the pure and Li-rich, LiMnO2 and Li1.2Mn0.8O2 at the nanoscale to shorten the path length of lithium-ion transportation, in an attempt to improve the rate performance of the systems. High-temperature molecular dynamics simulations running a DL_POLY code was utilized to carry out the amorphization and recrystallization technique under a microcanonical ensemble (NVE) and a canonical ensemble (NVT) respectively. The microstructure snapshots confirm the two defective phase composites of Li2MnO3/LiMnO2 with crystallographic defects within the nanostructures; dominated mainly by Li and Mn ions mixing layers and grain boundaries. Furthermore, the calculated XRD patterns confirm the single-phase formation of orthorhombic LiMnO2 in the pure structure and formation of the two-phase together with a spinel-type Li2Mn2O4 in the Li-rich nanoparticles. The findings of the current study will provide a better understanding of the Li-rich structures.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Theoretical and Computational Physics / 161

Ti CONTENT ON THE MAGNETIC AND MECHANICAL PROPERTIES OF B2 FeCo ALLOY: A COMPUTATIONAL STUDY

Authors: Hasani Chauke[1]; Phuti Ngoepe[1]; Ramogohlo Diale[1]; Tebogo Ledwaba[1]

[1] *University of Limpopo*

Corresponding Author: ledwaba.tebogo81@gmail.com

Abstract: Iron-cobalt alloys are considered a good candidate for high-temperature applications due to their high saturation magnetization and Curie temperature. These alloys are applicable in the automotive industry as actuators, however, they suffer brittleness at room temperature. In this study, ternary alloying was used to investigate the strength of the alloys. Titanium was chosen as the alloying element since it has the potential to enhance the ductility of the alloy system. A density functional theory applying the supercell approach was used to investigate B2 Fe50Co50-XTiX ($0 \leq X \leq 50$) structures. A full optimization was performed and provided equilibrium ground-state properties for both binary and ternary systems. It was found that the equilibrium lattice parameters are in good agreement with the experiment to within 2%. The stability of Fe50Co50-XTiX was evaluated from the formation energies, elastic properties, magnetic properties, and phonon dispersion curves. It was found that the thermodynamic stability increased with an increase in Ti content as observed from the heats of formation. Furthermore, the calculated Pugh's and Poisson's ratios showed that

alloying with Ti effectively enhances ductility. Moreover, Fe50Co50-XTiX systems showed positive shear modulus for the entire concentration range, a condition of stability. This observation accord well with the phonon dispersion curves analysis. Thus, the results suggest that the B2 FeCo-Ti alloy can be used for the development of magnetic components with good strength, that can be used for actuator applications.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / **162**

The study of amorphous GaAs following Ar+ and Si+ implantation

Author: Ongeziwe Mpatani[1]

Co-authors: Daniel Wamwangi [2]; Kudakwashe Jakata [3]; Hilary Masenda [3]

[1] *Wits School of Physics*

[2] *School of Physics, University of Witwatersrand, Johannesburg 2050, South Africa*

[3] *University of the Witwatersrand*

Corresponding Author: 1055218@students.wits.ac.za

Ion implantation is a technique of choice for inducing disorder in semiconducting materials such as crystalline GaAs. Interestingly, the properties of these amorphous materials such as the medium-range order (MRO) and small range order (SRO) depend heavily on the material of interest and its implantation conditions. Understanding the crystalline to amorphous phase transformations is vital for the continued use of GaAs in optoelectronic applications. In the present work, the configuration of the disordered layer in GaAs is generated using Ar^{+} and Si^{+} ions at different energies and different fluences, and the elastic properties are investigated. Raman spectroscopy was used to determine the structural configurations and phonon confinement of the damage layers after ion implantation. The crystal structure and the physical properties were determined using GIXRD and XRR for phonon dispersion simulations. The dynamics of acoustic propagation of the disordered layer are investigated using surface Brillouin scattering in the backscattering geometry. The derived phonon dispersion curves are fitted using surface elastodynamic Green's function to yield the elastic constants of the disordered layers on (001) GaAs substrate.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics for Development, Education and Outreach / **163**

Music, Context-Based Inquiry and Computer Simulation as Engagement Strategy

Author: Grace Djan[1]

Co-author: Miriam Lemmer [2]

[1] *SAIP, North West University, SAASTE, STERS*

[2] *North-West University (Potchefstroom)*

Corresponding Author: gdjan@hotmail.com

The standard of engagement in science classes is fundamental for effective learning. Creating an active learning environment is essential for engaging learners. However, implementing engagement is one of the most important problems facing teachers. Furthermore, there are different engagement strategies and teachers often do not know what strategy to use, or only use one of them. This paper attends to the factors that could influence the choice of an appropriate engagement strategy.

In a research study we set out to explore music, context-based inquiry, and computer simulation as engagement strategies as well as the impact of these strategies on the four components (behavioural, emotional, cognitive, and authentic) of engagement. The application of mixed methods comprised of a pre-test and post-test questionnaire (quantitative), video recording and semi-structural interviews (qualitative). The general results that follow from this research is that the choice of an appropriate engagement strategy does not only depend on the topic to be taught, but also on other factors namely teachers' acquaintance with the strategy, the learning environment, the background of the learners, the engagement components that need attention as well as the amount of time available. A combination of the three engagement strategies has proven to enhance engagement.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

165

Spectral analysis of S5 1803+784 in the recent flaring state

Authors: Joseph Omojola[1]; Andrew Chen[1]

[1] *University of the Witwatersrand*

Corresponding Author: 1926749@students.wits.ac.za

The temporal and spectral analysis of the flaring states of S5 1803+784 blazar as reported in Astronomy Telegram (ATel #13633) is presented using data from Fermi – LAT and the non-simultaneous data obtained from NED. The temporal analysis and the spectral energy distribution (SED) model of the flaring and the quiescent states are used to constraint the upper limit of the γ – ray emission region length scale, jet energetics and to infer the likely acceleration and emission processes of the blazar.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics of Condensed Matter and Materials / 166

STRUCTURAL AND OPTICAL CHARACTERIZATION OF BETA-GALLIUM OXIDE

Authors: Valentine Muramba[1]; Jacqueline M Nel[2]

[1] *University of Pretoria*

[2] *University of Prettoria*

Corresponding Author: valentinewabwire@gmail.com

Demands for higher performance of solar cells have led researchers to non-sophisticated, low temperature crystal-growth processes like spray pyrolysis and sol-gel spin coating as the future of efficient solar cells technology as stability remains challenge. This project seeks investigation of Beta-Gallium Trioxide (β-Ga2O3) for solar cells passivation to improve their stability and PCE, insulating barrier in light junctions, gas sensors, luminescent phosphors and dielectric coating for solar cells. In spray pyrolysis, precursor Tetrahydroxogallate (III) Ammonium from Gallium Nitrate with 32% concentrated ammonium hydroxide was deposited on 1cm2-Sapphire substrate at 3200C and 2.4kPa. In spin coating, precursor viscosity was improved by the addition of Monoethanolamine. Monocrystalline β-Ga2O3 was obtained by post annealing films at 7500C and investigated using XRD to determine crystallite size and orientation, Raman spectroscopy, EDX to determine percentage of elements composition and SEM to image film morphology. Film thicknesses were determined by profilometry, transmittance and absorbance were determined by UV-Vis spectroscopy and used to determine optical band gaps by Tauc technique. Spin coated films had orientation along (-201) with thickness range 165nm-354nm having 16.08nm grain size and optical band gap range 4.59eV-4.99eV. Films from spray pyrolysis had (-201) orientation with thickness range 158-255nm, grain size of 15.52nm and band gap 4.60eV-4.93eV that showed a broad emission in UV-blue region originating from oxygen and gallium vacancies in lattice; an essential component for good photodetectors and vital for solar cells passivation since dielectric coating with β-Ga2O3 will reduce refractive index between air and solar cells, hence improve solar energy absorption.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Nuclear, Particle and Radiation Physics / 167

Development of (p,p'γ) detection capabilities at iThemba LABS through the study of low-lying E1 strength in 58Ni

Authors: Refilwe Molaeng[1]; Lindsay Donaldson[2]; Iyabo Usman[3]; Luna Pellegri[1]

Co-authors: A. Bahini [4]; J.W. Brümmer [5]; H. Jivan [3]; P. Jones [2]; S. Jongile [5]; K.C.W. Li [5]; R. Neveling [2]; F.D. Smit [2]; G.F. Steyn [2]

[1] *School of Physics, University of the Witwatersrand, Johannesburg, 2050, South Africa., and Department of Subatomic Physics, iThemba LABS, P.O. Box 722, Somerset West 7129, South Africa.*

[2] *Department of Subatomic Physics, iThemba LABS, P.O. Box 722, Somerset West 7129, South Africa.*

[3] *School of Physics, University of the Witwatersrand, Johannesburg, 2050, South Africa.*

[4] *University of the Witwatersrand*

[5] *Physics Department, University of Stellenbosch, Matieland, 7602, South Africa.*

Corresponding Author: 1511527@students.wits.ac.za

This study aims to explore the (p,p'γ) detection capabilities of the K600 magnetic spectrometer coupled to the Ball of Germanium and Lanthanum bromide detectors (BaGeL) at zero degrees at iThemba LABS. This is being done through an investigation into the low-lying dipole strength of ^{58}Ni using the (p,p'γ) reaction at E_p = 80 MeV. The use of proton inelastic scattering at forward angles favours the electric dipole excitation and thus gives access to the full strength of the pygmy dipole resonance. These probes are, however, less selective with respect to the spin of the excitation, and the energy resolution obtainable with particle spectrometers is far poorer than that of the high-purity germanium detectors used in decay studies following electromagnetic excitation. Performing coincident measurements allows for the separation of nearby excitation, the assignment of multipolarities, the determination of branching ratios and the study of the isospin character of bound states. Results from both (p,p') and (p,p'γ) for the low-lying states of ^{58}Ni will be compared to elucidate the advantages of coincidence measurements at iThemba LABS. Important decay paths as well as transition levels will be presented.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Photonics / **168**

Setup of a 300-meter Optical Link through Atmospheric Turbulence

Author: Alice Vadimovna Drozdov[1]

Co-author: Mitchell A. Cox [1]

[1] *University of the Witwatersrand*

Corresponding Author: 1370992@students.wits.ac.za

One of the largest problems faced in free space optical communication is the influence of atmospheric turbulence on a beam's structure. Thus, investigating the effects of turbulence on beams has become a major research area in recent years. Experiments within this research area have mainly been performed by generating turbulence within a laboratory setting using, for example, phase screens on a spatial light modulator. Few experiments have made use of real atmospheric turbulence generated naturally outdoors. Therefore, in this work, a setup which has been used to investigate the effects of outdoor turbulence on a beam is described. This setup includes three main stages. The first stage is the beam generation stage which is used to produce modes within the Laguerre-Gaussian and Hermite-Gaussian mode sets. The second stage involves a 300-meter optical link through the atmosphere as well as the parts of the setup required to process the beam before and after sending it through the link. The third and final stage is the modal decomposition stage. This work describes the experimental setup and use of each of these stages as well as the challenges that arose during each stage due to the use of real atmospheric turbulence. Additionally, measurements taken using the setup are presented.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Nuclear, Particle and Radiation Physics / 169

The scissors resonance in 151Sm

Authors: SEBENZILE PRETTY ENGELINAH MAGAGULA[1]; Mathis Wiedeking[2]; K. L Malatji[3]; L Pellegri[4]

Co-authors: K. S Beckmann [5]; S Siem [5]; P. von Neumann-Cosel [6]; B. V. Kheswa [7]; K. O. Ay [5]; J.E Midtbø [5]; F. Zeiser [5]; T.W. Hagen [5]; V. W. Ingeberg [5]; M. Guttormsen [5]; A. Go¨rgen [5]; F. L. Bello Garrote [5]; A. C. Larsen [5]

[1] *IThemba Labs and University of the Witwatersrand*

[2] *Department of Subatomic Physics, iThemba LABS, P.O. Box 722, Somerset West 7129, South Africa. AND School of Physics, University of the Witwatersrand, Johannesburg 2050, South Africa*

[3] *Department of Subatomic Physics, iThemba LABS, P.O. Box 722, Somerset West 7129, South Africa.*

[4] *Department of Subatomic Physics, iThemba LABS, P.O. Box 722, Somerset West 7129, South Africa AND School of Physics, University of the Witwatersrand, Johannesburg 2050, South Africa*

[5] *Department of Physics, University of Oslo, N-0316 Oslo, Norway*

[6] *Institut für Kernphysik, Technische Universität Darmstadt, D-64289 Darmstadt, Germany*

[7] *Department of Applied Physics and Engineering Mathematics, University of Johannesburg, Doornfontein 2028, South Africa ANDDepartment of Subatomic Physics, iThemba LABS, P.O. Box 722, Somerset West 7129, South Afric*

Corresponding Author: 1113601@students.wits.ac.za

As the shape of the nucleus changes, statistical properties such as the nuclear level density (NLD) and γ-strength function (γSF) are expected to be affected. In particular, the evolution of the resonance modes such as the scissors resonance (SR) depends on the deformation of the isotopes. The SR resonance in the isotopic chain of samarium is being studied by comparing the scissors resonance strength of the ^{151}Sm isotope with that of neighboring samarium isotopes.
The experiment was performed at the Oslo Cyclotron laboratory where a ^{152}Sm self-supporting target was bombarded with a 13.5 MeV deuteron beam. The knock out reaction ^{152}Sm(d,tγ)^{151}Sm populated the nucleus of interest. An array of Sodium Iodine (NaI)Tl detectors, called CACTUS, detected γ-rays and the silicon particle telescope array, called SiRi, was used to detect charged particles in coincidence. The NLDs and γSFs are being extracted below the neutron separation energy, Sn, using the Oslo Method 1.
These results will be used investigate the SR in the ^{151}Sm and the extracted SR will be compared to those of previously measured (p,dγ)^{147,149,151,153}Sm 2and (d,pγ)^{153,155}Sm 3 isotopes. This will provide a near complete picture of the evolution of the SR in the samarium isotopic chain. I will present preliminary results of this investigation into the SR resonance in ^{151}Sm.

1A. Schiller et. al., Nucl. Instrum. Methods Phys. Res. A 447, 498 (2000)
2 A. Simon and F. Naqvi, Phys. Rev. C 101, 014619 (2020)
3K.L. Malatji et. al., Phys. Rev C 103, 014309 (2021)

Apply to be considered for a student ; award (Yes / No)?:

YES

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Nuclear, Particle and Radiation Physics / 170

Statistical correlations impacting a top quark mass measurement in 13 TeV proton-proton collision data from the ATLAS detector

Author: Kevin Nicholas Barends[1]

Co-authors: Sahal Yacoob [1]; James Michael Keaveney [2]

[1] *University of Cape Town*

[2] *N/A*

Corresponding Author: brnkev010@myuct.ac.za

The top quark is the heaviest particle in the standard model and reducing the uncertainty of the top quark mass directly speaks to/ affects precision tests of the consistency of the standard model, where breaks from this consistency would point to the existence of more massive particles. Since the top quark decays before hadronizing, either the kinematic properties of the decay products or measurements of the rate of the top quark production have been used to measure the mass of the top quark. The majority of measurements consider various decay modes of the W boson with no specification on the decay of the b-quark when utilizing the kinematic properties of the decay products. These measurements are predominantly limited by uncertainties related to the reconstruction of jets. However, there is a top quark decay mode which are largely independent of the aforementioned uncertainty but require large amounts of data due to their low production rate. This decay mode includes a J/ψ meson originating from a b-hadron and a semi-leptonic decay of the W boson. The invariant mass of the J/ψ meson and lepton is sensitive to the top quark mass. This paper describes a maximum likelihood approach to extract the top quark mass from a probability density function, pdf, while studying the impact of the correlations between each of the pdf parameters.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Theoretical and Computational Physics / 171

Studies on surface properties of SnO2 doped with Nitrogen, Antimony and Molybdenum

Authors: Nnditshedzeni Eric Maluta[1]; NEKHWEVHA Nditsheni [None]

[1] *University of Venda*

Corresponding Author: nekhwevhalulu@gmail.com

In this paper, GGA method and PBE pseudopotential method based on first principle density functional theory was used. The band structure and optical properties were calculated. It was noticed that doping SnO2 doped with N,Sb and Mo atoms reduces the bandgap of SnO2. The density of state was also calculated, and it was noticed that new states formed by new state of the dopants was introduced for the ejected electron to be trapped. Optical absorption was also seen in the visible region (350-600), which implies that the dopants selected can be suggested to be a good for semiconductors to be used in DSSC. Conductivity of the material increased due to the electron effective mass of the Nitrogen.

Apply to be considered for a student ; award (Yes / No)?:

yes

Level for award;(Hons, MSc, PhD, N/A)?:

Hons

Poster Session / 172

Investigation of limit of detection using standard radioactive sources with a LaBr3(Ce) detector

Authors: Ferdie van Niekerk[None]; Pete Jones[1]; Storm Johnson[2]

[1] *iThemba LABS*

[2] *University of Cape Town*

Corresponding Author: fvniekerk@tlabs.ac.za

Investigation of limit of detection using standard radioactive sources with a LaBr3(Ce) detector
F. van Niekerk (1,3), S.R. Johnson (2), P. Jones (3)
1 Department of Physics, University of Stellenbosch.
2 Department of Physics, University of Cape Town.
3 Department of Subatomic Physics, iThemba LABS.

Keywords: LaBr3(Ce) detector; Background radiation; Gamma radiation; Detection limits

Abstract

NaI(Tl) detectors has for long been used as the preferred scintillation detector for radioisotope identification. However, one of the most profound shortcomings of this detector, is poor spectral resolution. A suitable replacement for NaI(Tl) is the LaBr3(Ce) detector. This detector shows significantly improved sensitivity and spectral resolution. This will be especially evident through measurements employing both peak analysis and full spectrum analysis.

During this study, an energy calibration of a LaBr3(Ce) detector was performed using radionuclides 22Na, 60Co and 152Eu as radiation sources. Ambient background radiation was measured with the intention of correction purposes after actual source measurements. The mentioned sources have been measured at increasing distances from the detector. This study mainly focused on the determination of the detection limits of each radiation source considering the presence of background radiation. Therefore, the change in the intensity measured for each source as a function of increasing distance from the detector has been emphasised. This application is in relation to the solid angle between the points of the radiation source and the active detector volume.

Studies and the application of all data available will focus on the relevant factors to calculate the limit of detection for a specific activity for each radiation source. Results obtained during the investigation indicated a relation between detector counts, solid angle, and source activity. Further studies and application of all data available will focus on the relevant factors to calculate the limit of detection for a specific activity for each radiation source.

This study forms part of a broader research project that entails the design, building and commissioning of a prototype mobile gamma-ray detection system equipped with a LaBr3(Ce) detector. The successful development of such a detector system will enable in situ measurements of radiation in various robust terrestrial environments with improved sensitivity and spectral resolution.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Photonics / 173

On the interaction of structured light fields and the atmosphere

Authors: Asher Klug[1]; Isaac Nape[2]; Andrew Forbes[3]

[1] *University of the Witwatersrand*

[2] *Structured Light Lab, School of Physics, University of Witwatersrand*

[3] *U. Witwatersrand*

Corresponding Author: aklug11@gmail.com

It is well understood that structured light becomes distorted after propagating through the atmosphere. These distortions are the result of random refractive index fluctuations, themselves a product of atmospheric turbulence. In particular, these distortions have been realised as modal crosstalk in beams carrying orbital angular momentum. Such beams are ubiquitously used in free space optical communication applications. Commonly, the atmosphere is treated as a phase-only effect that induces this modal scattering. However, this approach offers little insight as it does not focus on the gain or loss of OAM that the beam experiences from interacting with the atmosphere. We ask the question: from where did the OAM come? We develop an alternate, novel model to provide generalised explanations to the sometimes-contested effects of atmospheric turbulence on light.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

Msc

Applied Physics / 174

Enhancing PEPT: high fidelity analysis with augmented detection

Author: Robert van der Merwe[1]

Co-author: Tom Leadbeater [1]

[1] *University of Cape Town*

Corresponding Author: robertvandermerwe@gmail.com

The Positron Emission Particle Tracking (PEPT) technique enables the tracking of a moving radioactive tracer particle at high spatial and temporal resolution, from which its trajectory can be accurately reconstructed. The uncertainty budget is complex and poorly understood, particularly for derived quantities such as momenta, energies, and forces, which are typically calculated using numerical differentiation techniques.

We report a filtering and data processing method based on a local polynomial least squares fitting approach known as the Savitzky-Golay filter. The method is adapted to incorporate the propagation of measurement uncertainties, maintaining them within useful bounds. The method is benchmarked against several systems of known particle motion, including constant velocity and constant acceleration, to place confidence limits on the results. Across all tested regimes the Savitzky-Golay filter resolves higher precision than existing methods, providing notable improvements to the uncertainty budget in PEPT analysis. We demonstrate tracking of a particle moving up to 3 m/s with location precision within its diameter, and a 60% and 40% average reduction in uncertainty bounds for velocity and acceleration respectively.

These results have motivated development of a high-resolution detector array for PEPT, enabling measurements on the micro-scale by making immediate use of the improvements in precision. Successful implementation will allow the meaningful application of PEPT to identified problems in diagnostic medicine and in the study of micro-fluidic devices.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / 175

Magnetic and physical properties of the Shastry-Sutherland compound Pr2Pd2In

Authors: Redrisse Djoumessi Fobasso[1]; Baidyanath Sahu[1]; Andre M. Strydom[1]

[1] *Highly Correlated Matter Research Group, Physics Department, University of Johannesburg*

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

The class of R2T2X intermetallics (R = rare earth, T = transition metal, X = main group) have a geometrically frustrated R-lattice which forms layers arranged in a Shastry-Sutherland lattice. In addition, due to the basic triangular motif in the frustrated structure, stabilization of different nearest-neighbor J values leads to complex low-temperature magnetic behavior. In this work, we have synthesized the Pr2Pd2In compound by arc-melting technique. The powder X-ray diffraction spectrum with a full-profile refinement confirms that Pr2Pd2In crystallizes in the layered Mo2B2Fe-type tetragonal structure, where planes of R = Pr ions lie on a triangular network. Dc-magnetic susceptibility shows that the Pr ions are in the magnetic trivalent state. Field-dependent magnetization shows metamagnetic behavior in the compound with the critical field of 1.5 T at 2 K. The antiferromagnetic order is unstable in applied magnetic fields, becoming ferromagnetic beyond a field value of 1.5 T. The magnetic entropy from our heat capacity studies revealed that the magnetic ground state is a well-isolated doublet. The electronic heat capacity coefficient value estimated from C4f data indicated that the compound belongs to the heavy-fermion family. The variety of magnetic properties such as para- ferro- and antiferromagnetic behavior including metamagnetic transition is observed due to the magnetic frustration from distorted triangles of Pr-atoms in Pr2Pd2In. This study may contribute towards a better understanding of the physics in Shastry-Sutherland structure compounds since in a frustrated lattice system such as this there are strict constraints imposed upon the magnetic order parameter.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics of Condensed Matter and Materials / 176

Multiband superconductivity in the doped Skutterudite compound Pr0.5La0.5Pt4Ge12.

Author: Masego Katametsi[1]

Co-author: Andre Strydom [1]

[1] *University of Johannesburg*

Corresponding Author: masegokatametsi@gmail.com

A suite of electronic and magnetic property studies were conducted on a Pr0.5La0.5Pt4Ge12 (Skutterudite) polycrystalline sample with an objective of investigating its superconducting state. The two parent compounds PrPt4Ge12 (Tc= 8K) and LaPt4Ge12 (Tc= 7.8K) both form in the filled-cage cubic Skutterudite structure and both have a superconducting ground state. However, their superconducting order parameters differ: PrPt4Ge12 has been characterized in the literature as an unconventional, multi-band superconductor and furthermore with evidence for time reversal symmetry breaking in its superconducting state. The isostructural compound LaPt4Ge12 on the other hand is a conventional superconductor. In this work we report the results of magnetization, magnetic susceptibility and heat capacity as functions of temperature and applied magnetic field in order to study the entanglement of the two types of superconductivity, and in an attempt to search for evidence of time-reversal symmetry breaking that may result from an internal magnetic field generated in the superconducting state.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Poster Session / **177**

Towards hydrodynamic initial conditions in the fragmentation region

Author: Mawande Lushozi[1]

Co-authors: Isobel Kolbe [2]; Larry McLerran [3]; Gongming Yu [4]

[1] *University of Washington*

[2] *University of Cape Town*

[3] *Institute for Nuclear Theory*

[4] *Harbin Engineering University*

Corresponding Author: mawande.lushozi@gmail.com

The fragmentation region of a heavy ion collision is a hot and dense place, which makes it ideal for studying the phase diagram of Quantum Chromodynamics (QCD). I will discuss recent work that aims to build an initial state model for the fragmentation region that incorporates the phenomenon of gluon saturation. We find some interesting results on baryon stopping and compression in terms of the saturation momentum scale.
The ultimate goal is to calculate baryon and energy densities in the fragmentation region to be fed into relativistic hydrodynamics equations.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Theoretical and Computational Physics / **178**

Bianchi Type V Model In Rˆn Gravity: A Dynamical System Approach

Author: Thato Tsabone[1]

[1] *North-West University*

Corresponding Author: tsabonethato@gmail.com

The accelerated expansion of the universe and the rotational dynamics of galaxies have become part of the mysteries of the physical world and have had theorists working tirelessy for the past years. There is no consensus on what is causing these observable effects: whether it is the the unknown dark energy and dark matter or it is the breaking down of our currently accepted theory of gravity, General Relativity, at larger scales. In this work we study the dynamics of a cosmological model described by the Bianchi Type V spacetime in f(R) gravity using the dynamical system analysis. We derive the field equations for a general Bianchi model in the context of f(R) gravity using the tetrad formalism and then specialize in the Type V model. Qualitative description and exact solutions are given for f(R) = R (General Relativity) and for f(R) = Rˆn. We find no accelerating solutions in the case of General Relativity with an exception when darkn energy is considered where we find one accelerating solution. In the case of Rn-gravity we find 2 possible accelerating solutions depending on the value of n.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Applied Physics / 179

In situ test results for a cavity solar receiver

Author: phil ferrer[1]

[1] *wits*

Corresponding Author: philippe.ferrer@wits.ac.za

A novel cavity type solar receiver for solar trough thermal plants was developed. Previously, the theory for such a receiver was developed, and a simulation written based on it. Some results from the simulation were compared to an indoors experiment to encouraging agreement. In this talk, I present a version that was developed for a ˜20kW solar plant and is tested in the open using an in-house designed solar setup. Engineering and economic aspects of the solar plant will be discussed as well as some results related to the thermal properties.

Apply to be considered for a student ; award (Yes / No)?:

no

Level for award;(Hons, MSc, PhD, N/A)?:

NA

Physics of Condensed Matter and Materials / 180

MACHINE LEARNING MODEL FOR PREDICTING FORMATION ENERGIES FOR LITHIUM-ION BATTERY MATERIALS

Author: Keletso Mabel Monareng [1]

Co-authors: Petros Senauoa Ntoahae [2]; Rapela Regina Maphanga [3]

[1] *UL Student*

[2] *UL*

[3] *CSIR*

Corresponding Author: mabelkmonareng@gmail.com

KM Monareng1, RR Maphanga2,3 and SP Ntoahae1
1Department of Physics, University of Limpopo, Private bag x 1106, Sovenga, 0727
2Next Generation Enterprises and Institutions, Council for Scientific and Industrial Research, P.O. Box 395, Pretoria, 0001
3National Institute of Theoretical Physics, NITheP, Gauteng

Abstract

Machine learning methods have recently found applications in many areas of physics, chemistry, biology and materials science, where large datasets are available. In this paper, machine learning methods are used to predict the formation energies of lithium-ion battery (LIB) materials. Thus, using LIB materials' properties calculated from density functional theory as an input dataset, as well as feature vectors from properties of chemical compounds and elemental properties of their constituents, different machine learning algorithms are explored in order to predict the formation energies for the battery materials. Models based on different algorithms, i.e., extremely randomized trees, gradient boosting, light gradient boosting machine, catboost and random forest were developed and evaluated. The catboost regressor model was found to be the best model in predicting the formation energies, with accuracy of 0.95 and 0.06 for coefficient of determination and mean square error, respectively. Thus, the features used to predict the formation energies have predictive capability with a high accuracy.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

Hons

Physics of Condensed Matter and Materials / 181

Spin-imbalances in atomistic systems: Using non-equilibrium Green's function density functional theory to model spin-selective phenomena mediated by spin-orbit coupling in non-magnetic materials.

Author: Wynand Dednam[1]

Co-authors: Linda Zotti [2]; Sahar Pakdel [3]; Enrico Lombardi [4]; Juan Jose Palacios [2]

[1] *University of South Africa*

[2] *Universidad Autonoma de Madrid*

[3] *Technical University of Denmark*

[4] *UNISA*

Corresponding Author: dednaw@unisa.ac.za

Heavy transition metals are frequently used as electrodes and substrates in scanning tunneling microscopy experiments. In the constricted low dimensional systems that occur in such experiments, typically under conditions of non-zero bias voltage, spin-imbalance may develop even in non-magnetic atomic- and nano-systems. This phenomenon arises as a result of spin selective effects mediated by spin-orbit coupling. It is important to not only understand the emergence of the spin imbalance, but also to model associated properties such as spin-polarized electron transport in these systems. Conventional theoretical approaches cannot model these effects because they usually neglect spin-orbit coupling. Therefore, to model spin-imbalance in the electronic transport of constricted nano-systems, such as in atomically sharp transition metal electrode tips or surfaces, as well as in organic molecules bridging the electrode tips, we have implemented spin-orbit coupling as a post-self-consistent correction in atomic orbital basis density functional theory within the non-equilibrium Green's function formalism. Our method takes advantage of optimized Gaussian orbital basis sets and effective core potentials and one-shot transport calculations with steady convergence and charge transfer properties compared to other similar approaches. We apply this method to a selected number of sample constricted low dimensional systems where spin-imbalance is important by performing density functional transport calculations. This permits us to demonstrate that incorporation of spin-orbit coupling is essential to understanding emergent spin-imbalance in molecular electronics, while in certain instances, the consideration of the applied bias is also important to the manifestation of spin imbalance phenomena in heavy transition metal electrodes and substrates.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics for Development, Education and Outreach / **182**

Unlocking Education lockdown with the iNethi platform

Authors: David Johnson[1]; Melissa Densmore[1]; Andre van Zyl[1]

[1] *University of Cape Town*

Corresponding Author: djohnson@cs.uct.ac.za

In South Africa, only 22% of households have a computer, and 10% have an internet connection at home. This disparity has exacerbated education inequalities during the COVID-19 pandemic; school closures and limited online schooling saw learners struggling to catch up – especially in crucial subjects like Science and Mathematics. The iNethi project seeks to solve the lack of access or affordable access to the Internet and locally relevant content in low-income communities. The iNethi platform allows communities to quickly bootstrap a community owned network to provide affordable Internet access and host a local cloud server that allows communities to interact with fast free local content easily. The local cloud service currently provide free access to a local file storage platform, a local chat server, and a video streaming platform and education-focused resources such as Physics Education Technology (PhET) simulations, Wikipedia, Khan Academy and TED talks. iNethi also provides a mechanism to automatically synchronise content uploaded to a global server from anywhere in the world to a server running in a local community. iNethi has been deployed in Ocean View, Cape Town and during COVID-19 it allowed teachers to stay in contact with high school learners. The learners downloaded free teaching videos from nine hot spots around Ocean View; these videos were recorded by the high-school teachers, uploaded to the global platform and then synchronised to the server in Ocean View. The "Essential Skills" Physics Videos and resources created by the UniZulu Science Centre have also recently been uploaded to the platform to enrich the learning experience of matric students. These videos will also be available for free from any iNethi hotspots in Ocean View. In this work, we will describe the architecture of iNethi, its current impact

and the potential of iNethi to provide public access to high-value digital resources in low-income communities throughout South Africa.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Space Science / **183**

Equatorward large-scale travelling ionospheric disturbances of high latitude origin during quiet conditions

Authors: Thaganyana Golekamang[1]; John Bosco Habarulema[1]

[1] *South African National Space Agency*

Corresponding Author: cthaganyana@sansa.org.za

The observations of large-scale travelling ionospheric disturbances (TIDs) originating from high latitude, and crossing the equator into the other hemisphere in the African-European sector, during geomagnetically quiet conditions within the period of 2010-2018. For each month, the four international geomagnetically quiet days were selected. The Global Navigation Satellite Systems (GNSS) total electron content (TEC) data were used to obtain the two dimensional (2-D) TEC residuals. We have identified 7 interhemispheric equatorward TIDs out of 384 days that were analysed with most of them originating from the southern hemisphere. TIDs propagation velocities and periods are in the range of 270-322 m/s and 48-100 minutes. Observations of the 4.3 μm brightness temperature (BT) from the Atmospheric Infrared Sounder (AIRS) instrument on board the NASA Aqua satellite point to the likely sources of these TIDs as AGWs of troposphere-stratosphere origin.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics of Condensed Matter and Materials / **184**

IMPROVEMENT OF GAS SENSING SELECTIVITY OF VANADIUM PENTOXIDE NANO-STRUCTURES TOWARDS SULPHUR DIOXIDE BY GOLD DOPING

Authors: Mick Molukie Mokwena[1]; Olatunbosun Nubi[2]; Amos Adeleke Akande[3]

[1] *University of limpopo*

[2] *University of Limpopo*

[3] *Co-supervisor*

Corresponding Author: 201506225@keyaka.ul.ac.za

Vanadium pentoxide (V2O5) is a semiconductor metal oxide material with properties that makes it suitable for gas sensing applications. These properties are strong catalytic activity, high conductivity and structural ability. Despite this, literature showed that low selectivity and high operating temperatures still limit its functionality in practice. Sulphur dioxide (SO2) is a highly toxic greenhouse gas with an unpleasant odour that is emitted primarily by the combustion of fossil fuels and volcanic eruptions. Even at concentrations as low as 5ppm, SO2 can cause serious health issues to human lives. Fabrication of highly selective and low operating temperature SO2 gas sensors are of utmost importance. The current work presents low temperature and SO2 selective gas sensor developed by doping V2O5 nanoparticles with Au using the hydrothermal synthesis method. Possible gas sensing mechanisms of the combined materials in the presence of SO2 gas are also presented.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Nuclear, Particle and Radiation Physics / **186**

Simplified Template Cross Section measurements of the V(H->bb) process with the ATLAS detector at sqrt(s)=13 TeV

Author: Ryan Atkin[1]

Co-authors: Sahal Yacoob [1]; James Michael Keaveney [2]

[1] *University of Cape Town*

[2] *N/A*

Corresponding Author: atkrya002@myuct.ac.za

Presented are the studies of the production of the Standard Model Higgs boson in association with a W or Z boson, where the Higgs decays to $b\bar{b}$ and the W/Z bosons decay leptonically. The $H \to b\bar{b}$ decay has a branching fraction of $\sim 58\%$, so this study allows the probing of the dominant Higgs decay mode, as well as providing the best sensitivity to the WH and ZH production modes and allowing the study of the Higgs at high transverse momentum. These points are important for the interpretation of the Higgs measurements in Effective Field Theories (EFTs). Since b-hadrons are the only down-type hadrons that can be effectively tagged, this decay mode also allows the study of the Yukawa coupling of the Higgs boson to the down-type quarks.\\
The full Run-2 dataset, corresponding to 139 fb^{-1} of instantaneous luminosity, was collected in proton-proton collisions with the ATLAS detector at a centre of mass energy of $\sqrt{s} = 13$ TeV. The cross-sections of this process were measured using the Simplified Template Cross Section (STXS) method. Here, the cross sections are measured as a function of the W/Z boson transverse momentum in different fiducial volumes based on kinematic cuts. Results of both the resolved (where each b-jet is reconstructed as a separate jet) and the boosted (where the two b-jets are reconstructed as one fat jet) analyses are shown, as well as the future prospects of the combination of these two different methods.

Apply to be considered for a student ; award (Yes / No)?:

yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Nuclear, Particle and Radiation Physics / 187

Simulation of the strip sub-detector system in the new Inner Tracker of the ATLAS detector

Author: Ryan Atkin[1]

Co-authors: James Michael Keaveney [2]; Sahal Yacoob [1]

[1] *University of Cape Town*

[2] *N/A*

Corresponding Author: atkrya002@myuct.ac.za

In the beginning of 2025, the Large Hadron Collider (LHC) will be shutdown in order for the final upgrades to the High Luminosity LHC (HL-LHC) to commence. This will almost quadruple the amount of collisions in the LHC, increasing the amount of data the detectors will have to deal with. Since the detectors were not designed to operate at these levels, they will also need an upgrade to deal with the increased radiation, data rates and amount of particles travelling through the detectors. One of the most extensive upgrades to the ATLAS detector will be the replacement of the current Inner Detector (ID) with an all silicon semiconductor based Inner Tracker (ITk). However, not only will the actual detector be upgraded, but the simulation of the detector will also need to be updated to match this new version. An accurate simulation of the detector is important since this is what is used to convert the outputs of the theoretical calculations (be it Standard Model (SM) or Beyond the Standard Model (BSM)) into a format that can be directly compared with the data coming from the experiment. Presented is some of the work behind updating the simulation of the strip detector in the ITk, from the sensors to the support structures and shielding components.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Applied Physics / 188

Plasma Diagnostics of Miniaturised DC Glow Discharge Thruster Concept

Author: Maheen Parbhoo[1]

Co-author: Philippe Ferrer [2]

[1] *University of the Witwatersrand*

[2] *University of Witwatersrand*

Corresponding Authors: 1074016@students.wits.ac.za, phillipe.ferrer@wits.ac.za

The DC discharge microthruster concept is a simple, energy efficient plasma micropropulsion system that operates using an ionisation-acceleration coupling mechanism. This system was developed in the hopes of addressing some of the shortcomings of many state-of-the art electric micropropulsion systems. Preliminary studies have been conducted on the thruster from which the stable operating parameters were deduced. Plasma plume diagnostic measurements, including the ion current density and ion energy distribution and the influence of changes in the operating parameters (applied voltage, discharge current etc.) on these measured quantities will be presented. The estimated thrust-to power-ratio of the system and its overall feasibility as a micropropulsion mechanism will also be discussed.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Nuclear, Particle and Radiation Physics / **189**

Search for a heavy di-photon resonance in association with b-jets with the ATLAS detector at the LHC

Authors: Esra Shrif[1]; Xifeng Ruan[2]; Bruce Mellado[2]; Salah Dahbi[2]

[1] *University of the Witwatersrand*

[2] *Wits university*

Corresponding Author: shrif.esra@gmail.com

We search for a heavy resonance decaying into diphoton in association with at least one b jet. The search uses Run II proton-proton collision data with an integrated luminosity of 139˜fb^{−1} recorded by the ATLAS experiment at a centre-of-mass energy of \sqrt{s} = 13˜TeV during 2015 to 2018 at the Large Hadron Collider. Three models are tested in this final state. A Higgs boson like heavy scalar X produced with top quarks, b quarks or Z boson decaying into b\bar{b} are examined. In this Analysis, we setup limits on production cross-section times branching ratio on these models for the resonance mass ranging from 180˜GeV−1.5˜TeV.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Photonics / **190**

Generation of a Hybrid Mode Vector Beam

Author: Alice Vadimovna Drozdov[1]

Co-authors: Mitchell A. Cox [1]; Keshaan Singh [1]; Andrew Forbes [1]

[1] *University of the Witwatersrand*

Corresponding Author: 1370992@students.wits.ac.za

Vector beams have inhomogeneous polarisation distributions that introduce a new degree of freedom that can be used to structure light. Pure vector beams have spatial and polarisation components that are non-separable affording them various interesting properties. Common examples include cylindrical vector vortex modes, Poincaré beams and vector beams on the Higher Order Poincaré Sphere. These beams are created using orthogonal modes from the same mode set, on two orthogonal polarisation bases. Vector modes have been studied in atmospheric turbulence and have displayed no specific advantage over scalar modes. Interestingly, it has recently been shown that different modal bases experience turbulence differently- can we use this to improve the robustness of a vector mode

in turbulence by creating a “hybrid mode vector beam” that makes use of orthogonal component modes from the Hermite-Gaussian and Laguerre-Gaussian bases? Here we present an analysis of experimentally generated hybrid mode vector beams by determining the state of polarisation through Stokes’ polarimetry and by calculating the vector quality factor.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics for Development, Education and Outreach / **191**

GA2024: an opportunity for physics in Africa

Authors: Vanessa McBride[1]; Kevindran Govender[2]

[1] *University of Cape Town & SAAO*

[2] *South African Astronomical Observatory*

Corresponding Author: vanessa@ast.uct.ac.za

In 2024, for the first time in the 100 year history of the International Astronomical Union (IAU), the General Assembly will take place on the African continent! The capacity to host a General Assembly is a result of exciting infrastructure and human capital development projects on the continent, and also shows that Africa is no longer just peripheral to the global scientific endeavour. In this presentation, we share the vision for the 2024 General Assembly of the IAU through the lenses of research, people, infrastructure and legacy. We hope to stimulate collaborations that can shape the future of astronomy and physics both on the African continent, and globally.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics of Condensed Matter and Materials / **192**

The effects of implantation temperature and annealing on glassy carbon implanted with Se ions

Author: Samuel Adeojo[1]

Co-authors: Johan Malherbe [2]; A.Yu Azarov [3]; Opeyemi Odutemowo [2]; Eric Njoroge [1]; Hesham Abdelbagi [1]; Thulani Hlatshwayo [2]

[1] *University of Pretoria South Africa*

[2] *University of Pretoria*

[3] *University of Oslo*

Corresponding Author: u19288124@tuks.co.za

Using Raman spectroscopy and Secondary ion mass spectrometry (SIMS), the effects of implantation temperature and annealing have been investigated for glassy carbon (GC) samples implanted with Se ions. 150 keV Se ions were implanted into GC separately at RT, 100 ℃, 150 ℃, and 200 ℃ to a fluence of 1.0 × 10ˆ(16) ions/cmˆ(2). The as-implanted samples were subjected to annealing from 1000 ℃ up to 1300 ºC for 5h in steps of 100 ℃. Implantation resulted in the accumulation of defects with more defects observed in the RT implanted samples. Annealing caused progressive healing of defects in all implanted samples. However, the original structure of pristine GC was not achieved after annealing at 1300 ℃. No migration of Se was observed in the samples implanted at different temperatures. Annealing at 1000 ℃ already caused the migration of Se towards the surface and deeper into the bulk of all the GC substrates. This migration of implanted Se towards the surface and the bulk accompanied by the loss from the surface progressed with annealing in all samples

Apply to be considered for a student ; award (Yes / No)?:

YES

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Applied Physics / 193

Effects of partial soiling on Thermal Infrared imaging of crystalline PV modules

Author: Monphias Vumbugwa[1]

Co-authors: Jacqueline. L. Crozier McCleland [1]; Frederik. J. Vorster [1]; Ernest. E. van Dyk [1]

[1] *Nelson Mandela University*

Corresponding Author: s218207115@mandela.ac.za

Thermal Infrared (TIR) imaging identifies abnormal thermal signatures in photovoltaic (PV) modules as cell areas operating at elevated temperature. Contaminants on a PV module glass can cause mismatch in operation of PV cells connected in series and can result in hotspots. The hotspots can occur due to different thermal emissivity of the module glass and contaminants and current mismatch created when the contaminants partially shade cells. TIR imaging is generally misinterpreted due to the dynamic nature of abnormal thermal signatures caused by mismatched cells when the modules operate under real field conditions. This paper analyses the behaviour of thermal signatures observed by TIR imaging of crystalline silicon PV modules operating under changing soiling conditions. PV modules in the field are prone to soiling just like any outdoor surface. Wind-blown dust, which is unavoidable, can settle on bottom rows of PV modules and unevenly shade the cells. When cells are partially soiled, defective and of poor quality, they can operate at elevated temperature which results in non-uniform temperature distribution in the affected modules and can be detected on TIR images. Uniform soiling on PV modules limits the irradiance incident onto the shaded modules and impact on power generation. Abnormally hot cells were identified on TIR images of an unsoiled module. The hot cells operated and appeared as good cells on TIR images that were captured when three good cells in different substrings were each partially soiled (≤10%). Partial soiling forced cracked cells, which were identified through electroluminescence (EL), to behave as good cells and not revealing their abnormal thermal signature on TIR images due to minimal current mismatch. The dynamics of thermal signatures were also observed on a large scale when an array of nine monocrystalline PV modules was operating with one module partially soiled. This scenario can mislead decisions during maintenance of PV plants to only cleaning the soiled modules yet other anomalies are hidden. Incorporating EL imaging and I-V measurements can give a better insight into the state and performance of PV cells. Abnormal thermal signatures can only emerge under certain operational conditions which create significant cell mismatch else, all cells (bad and good) will appear normal

on TIR images. This results in dynamics of thermal signatures since the operational conditions of PV modules in the field always change.

Keywords: Shading, current mismatch, defective cells, thermal signature

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Theoretical and Computational Physics / 194

First principle study of Hematite (α-Fe2O3) surface structures doped with Copper (Cu) Titanium (Ti) and Nickel (Ni).

Authors: Nnditshedzeni Eric Maluta[1]; CLARENCE VUSI MABASO[2]

[1] *University of Venda*

[2] *STUDENT*

Corresponding Author: vusie2055@gmail.com

Hematite has attracted research interest for many years due to its application in water splitting. Despite their desirable optical band gap and other attractive features, there are great challenges for the implementation of hematite-based photoelectrochemical cells for water splitting. Doping with transition metals have shown to be a practical solution to overcome some of the limitations faced with hematite to improve its photoelectrochemical (PEC) activity. This study explored two different surfaces of hematite doped with Ti, Cu and Nickel, the surfaces were orientated in the directions (001) and (101). First principle study using the density functional theory (DFT) was adopted for calculations. The results show that the band gap of a bulk structure of hematite is 2.29 eV, doping Ti on surface (101) indicate an improved electric conductivity in the visible light region while, Cu dopant reduces the bang gap by upshifting the valence band maximum to a higher energy level. Previous reports stated that a narrow band is confirmed to result in a low rate of charge recombination by showing a high absorptive coefficient in the visible light region. Nickel on the other hand exhibits an absorptive and conducting surface, with an absorption coefficient of approximately 8.5 x104 cm-1 better than the other doped surfaces. The overall analysis of the result shows an opportunity to a successful photoelectrochemical water splitting.

Apply to be considered for a student ; award (Yes / No)?:

YES

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Nuclear, Particle and Radiation Physics / 195

Measurement of the leptonic charge asymmetry in the tri-lepton final state of ttW in proton-proton collisions at a centre-of-mass energy of 13 TeV using the ATLAS detector

Author: Cameron Garvey[None]

Corresponding Author: cameron.michael.garvey@cern.ch

Studies towards a measurement of the leptonic charge asymmetry in top quark pair production in association with a W boson($t\bar{t}W^{\pm}$) at 13 TeV with the ATLAS experiment are presented. Previous measurements of the $t\bar{t}W^{\pm}$ cross-section have been shown to be higher than that predicted by the standard model indicating a potential discrepancy in the modeling of the $t\bar{t}W^{\pm}$ process. This analysis aimed to study the leptonic charge asymmetry of $t\bar{t}W^{\pm}$ as it provides an independent method of verifying the modeling of the process and has never been measured before in $t\bar{t}W^{\pm}$. The full run II data(139 fb^{-1}) was utilized in these studies. An event selection scheme was put in place to optimally select for $t\bar{t}W^{\pm}$ events in the three-lepton final state while suppressing background events. The leptonic charge asymmetry is calculated using the η of the top and anti-top leptons. As such a machine learning algorithm was implemented to optimally select the pair of leptons decaying from the top quarks from the total three leptons in the event. Finally, the extraction of the leptonic charge asymmetry was implemented using a method known as template morphing. This analysis has remained blinded as it forms the basis of an official ATLAS analysis. Several sources of error have been considered namely: cross-sections, lepton trigger efficiencies, and b-tagging efficiencies. The main source of uncertainty in these studies is the limited statistics. With this in place a leptonic charge asymmetry of $A_C^{\ell} = -0.08^{+0.29}_{-0.31}$ was extracted using Asimov data. This analysis does not have sufficient statistics to observe the leptonic charge asymmetry at the level predicted by the standard model. However, novel constraints on effective field theories may be possible and are being investigated.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Nuclear, Particle and Radiation Physics / **196**

Transfer reactions to populate the PDR in 96Mo

Authors: Luna Pellegri[1]; Mathis Wiedeking [1]; Thuthukile Khumalo[2]

Co-authors: Alessandro Spatafora [3]; Diana Carbone [4]; Francesco Cappuzzello [3]; Manuela Cavallaro [4]

[1] *iThemba LABS/Wits*

[2] *Wits/iThemba LABS*

[3] *INFN Laboratori Nazionali del Sud, Catania, Italy/Universita di Catania, Catania, Italy*

[4] *INFN Laboratori Nazionali del Sud, Catania, Italy*

Corresponding Author: charmanekhumalo75@gmail.com

The pygmy dipole resonance (PDR) is a cluster of 1- states around and below the neutron separation energy and has gained traction in nuclear structure studies. The microscopic nature of the PDR is still an open question in particular, whether these 1- states are of single-particle or collective nature. The study here presented is a first attempt to investigate the single-particle or the collective nature of these 1- states by exploiting the sensitivity of one-particle transfer reactions to excite single-particle states. The measurements on transfer reactions (p,d) and (d,p) were performed on two different targets to populate the 96Mo residual nucleus. The ejectiles were detected, identified and momentum-analyzed by the MAGNEX spectrometer and its focal-plane detector which is installed at the Laboratori Nazionali del Sud of Instituto di Fisica Nucleare in Catania. In this talk, the data reduction process of the (p,d) reaction will be presented together with some preliminary results.

This work is based on the research supported in part by the National Research Foundation (NRF) of South Africa grant number 118846.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Space Science / **197**

Numerical Simulation of Sunspot Rotation

Author: Daniel Johnson[1]

Co-authors: Daniel Brown [1]; Gert Botha [2]

[1] *The University of Central Lancashire*

[2] *Northumbria University*

Corresponding Author: djohnson18@uclan.ac.uk

The study of sunspot rotation is a mature subject that has been investigated both theoretically and observationally. Sunspot rotation is recognised as an important mechanism for depositing energy into the Sun's atmosphere. An understanding of the characteristics of this energy input is important, because this energy may be transported and stored in the solar atmosphere, effectively enhancing the free magnetic energy above sunspots and in the larger systems in which they reside. This additional source of free energy may provide, or contribute to, the energy budget for space weather phenomena like solar flares, coronal mass ejections and solar energetic particles. We present a parametric investigation that deconvolves the complex real-world phenomenon of sunspot rotation into its components. This project uses the Lare3D numerical code to model an idealised rotating sunspot; the influence this rotating sunspot has on itself and its environment is investigated. Key physical parameters of the sunspot and its environment are varied to determine the mechanisms responsible for energy production, transport and release. A unique feature of this work is that the penumbra forms an important component of our idealised sunspot. Preliminary results find that the penumbra makes a significant contribution to the storage and transport of energy injected by sunspot rotation.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics of Condensed Matter and Materials / **198**

EXPERIMETAL AND DENSITY FUNCTIONAL THEORY COMPARISON STUDY OF XANTHATE, DITHIOCARBAMATE AND DITHIOPHOSPHATE ADSORPTION ON SPERRYLITE SURFACE

Authors: Bradley Nemutudi[1]; Sophia Pikinini[2]; Peace Mkhonto[1]; Belinda McFadzean[2]; Xingrong Zhang[3]; Phuti Ngoepe[1]

[1] *University of Limpopo*

[2] *University of Cape Town*

[3] *BGRIMM*

Corresponding Author: bradley.nemutudi@ul.ac.za

The comparison study on adsorption of normal butyl xanthate (PNBX), mono butyl dithiocarbamate (BDTC) and dibutyl dithiophosphate (DBDTP) on sperrylite mineral forms a basis in understanding the floatability improvement and paves a way for design of collectors that may impact a wide range of arsenide minerals. This study used a computational density functional theory (DFT) and experimental microcalorimetry approach to determine the adsorption energies of NBX, BDTC and BDTP collectors onto sperrylite mineral surface. For computational aspect, we considered the most stable surface plane of (100) surface, which had been found to give the lowest surface energy as compared to the other surface planes. We observed that the NBX, BDTC and BDTP preferred to bridge on the As and Pt atoms through the S atoms. These finding showed that the collector adsorb on the surface through both Pt and As atoms and indicated that the As atoms were significantly active in the adsorptions. The computational calculated adsorption energies were in the order: BDTC (–376.93 kJ/mol) > NBX (–369.47 kJ/mol) > BDTP (–350.97 kJ/mol), indicating that the dithiocarbamate had strong exothermic adsorption. From the microcalorimetry test we also found that the BDTC was more exothermic than the BDTP and the PNBX and the adsorption energies were in the order: BDTC (–473.50 kJ/mol) > BDTP (–392.56 kJ/mol) > NBX (–331.13 kJ/mol). These results showed that nitrogen atom in the BDTC collector had a great influence in the adsorption strength of the collector on the mineral surface. These results paved a way for design of novel collector for sperrylite and other chalcogenide minerals and suggested that nitrogen in a collector may significantly improve the affinity of the collector for better recovery.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics of Condensed Matter and Materials / 199

Characterization of P3HT-CNT thin films for photovoltaic solar cell application

Authors: Angelina Seithati Qotso[1]; Pontsho Mbule[1]; Bakang Mothudi[1]

[1] *University of South Africa*

Corresponding Author: qotsoas@gmail.com

The global share of photovoltaic (PV) technologies in the electricity and energy production still remain marginal today and is likely to remain this way for a long period of time especially in the poor developing countries 1. The evidence of the limited global impact of PV is marked by the increasing market share of fossil fuels in the generation of electricity 2. Carbon nanotubes (CNT) have emerged as one of the leading additives for improving the thermoelectric properties of organic materials due to their unique structure and excellent electronic transport properties 3. CNT are the most commonly used and effective material among numerous fillers. They can provide conductive paths when embedded in polymer matrix because CNT possess excellent electrical conductivity and high charge mobilities 3. In this study poly(3 – hexylthiophene) P3HT-CNT at different ratios is investigated for the purpose of improving P3HT absorption and conductivity for applications in organic solar cells. The X-ray diffraction (XRD) results revealed that P3HT-CNT (1:1) is more crystalline and also have the highest intensity in both ultra violet to visible (UV-Vis) spectrophotometer and photoluminescence (PL) spectroscopy. The disordered structured of CNT was observed from the field emission scanning electron microscopy (FESEM). Energy-dispersive spectroscopy (EDS) confirmed the incorporation of P3HT in CNT. Fourier Transform Infrared Spectroscopy (FTIR) confirmed the P3HT and CNT vibration modes and current-voltage (I-V) characterization showed an improvement in conductivity.
Keywords: Carbon nanotube, Ratio, Photoluminescence, Conductivity

Reference
1 E.R. Rwenyagila, Int. J. Photoenergy, (2017) 1–12.
2 N. Grossiord, M.J. Kroon, R. Andriessen, P.W.N. Blom, 13 (2012) 432–456.
3 S. Qu, M. Wang, Y. Chen, Q. Yao, L. Chen, RSC.Adv. 8 (2018) 33855–33863.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Astrophysics / **200**

Phase-resolved polarimetric constraints on the white dwarf pulsar in AR Sco

Author: Louis Du Plessis[1]

Co-authors: Christo Venter [1]; Alice Harding [2]; Zorawar Wadiasingh [3]

[1] *NWU, Potchefstroom, Department of Physics*

[2] *Theoretical Division, Los Alamos National Laboratory*

[3] *Astrophysics Science Division, NASA Goddard Space Flight Center*

Corresponding Author: louisdp95@gmail.com

Marsh et al.˜(2016) detected radio/optical/UV pulsations from the binary system AR Scorpii (AR Sco) mainly at the beat period of 118˜s. This system, with an orbital period of 3.55h, is composed of a cool, low-mass star and a white dwarf with a spin period of 117˜s. More recent observations also showed X-ray pulsations from this source (Takata et al. 2018). Buckley et al.˜(2017) found that the polarimetric emission from the white dwarf is strongly linearly polarised (up to $\sim 40\%$) with periodically changing intensities. This emission is thought to be powered by the highly magnetised (5×10^{8}˜G) white dwarf that is spinning down. We fitted a standard rotating vector model to these polarisation position angle data, and found a magnetic inclination angle $\alpha \sim 90^{\circ}$ and an observer angle $\zeta \sim 60^{\circ}$, similar to independent constraints found by others. Previously we determined that synchrotron radiation dominates other radiation mechanisms for producing the optical emission as long as the pitch angles of the particles can be maintained; otherwise curvature radiation would dominate. We applied our model to the orbitally phase-resolved polarisation position angle data from Potter and Buckley (2018b) and present these results on the evolution of α and ζ vs. orbital phase. Additionally, we investigate the evolution of the linear-flux light curves binned independently at the spin and beat frequency independently vs. orbital phase. Finally we include a Lomb−Scargle periodogram for the different regions of the orbital phase thereby constraining any potential signature of precession in the system.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Applied Physics / **201**

Spatial resolution in positron emission particle tracking (PEPT)

Authors: Thomas Leadbeater[1]; Andy Buffler[1]; Ameerah Camroodien[1]; Nicholas Hyslop[1]; Stephen Peterson[1]; Robert van der Merwe[1]; Michael van Heerden[1]

[1] *University of Cape Town*

Corresponding Author: tleadbeatr@gmail.com

Time coincidence detection of annihilation photon pairs is used to determine the instantaneous position of point-like particles used as flow following tracers in dynamic systems. Locations are calculated by a minimisation approach applied to a small number of reconstructed pairs assuming a fixed signal to noise ratio. Consecutive locations define the particle trajectory, and hence the dynamic parameters of particle motion, from which the global system behaviour is inferred. The measurement precision depends upon the positron range and annihilation physics, the spatial resolution and geometry of the detector array, and the amount of photon scattering and absorbing material within the field of view. Statistical processes further limit the precision, with high activity tracers (100s MBq) and high event rates (MHz) preferred. However, deadtime, pulse pileup, and the increased contribution of random coincidences reduce the signal to noise ratio in these conditions.

At PEPT Cape Town large arrays of position sensitive detectors are used to track particles with diameters down to 50 um to within 1 mm in 3D. Typically particles moving at speeds up to 10 m/s can be reliably tracked, by measuring locations many thousands of times per second. In an effort to observe flow phenomena on the micro-scale we have investigated the use of small scale pixelated semiconductor detectors with superior energy resolution. An analysis of the factors contributing to spatial resolution in PEPT measurements in both scenarios is presented.

Apply to be considered for a student ; award (Yes / No)?:

no

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Space Science / 202

Energy deposition through Landau damping

Author: Gert Botha[1]

Co-authors: Bo Li [2]; E.A. Evangelidis ; Matthew Bones [1]

[1] *Northumbria University*

[2] *Shandong University*

Corresponding Author: gert.botha@northumbria.ac.uk

Charged particles and plasma waves occur throughout the solar system. These particles can move slowly relative to the plasma or be accelerated to relativistic speeds by reconnection events such as solar flares. The types of waves depend on whether one considers the plasma in the solar chromosphere, solar corona, solar wind or the planetary magnetospheres. In this study we investigate the amount of energy that becomes available when the charged particles interact with the plasma waves through the mechanism of Landau damping. The linearised Vlasov equation is solved, from which we obtain an expression for the total amount of energy available for transfer through the Landau mechanism. The interactions with Alfven, slow and fast magnetosonic, as well as ion-cyclotron waves are obtained. In each case the energy deposited into the plasma is calculated, which is then available to do work in the form of heating or acceleration of the local plasma. The final expressions are presented in terms of Stokes parameters.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Nuclear, Particle and Radiation Physics / **203**

Search for the non-resonant Higgs-pair production in $\ell^+\ell^-\ell^+\ell^-$ final state at $\sqrt{s} = 13$ TeV in the ATLAS detector

Author: Abdualazem Fadol[1]

Co-authors: Bruce Mellado [2]; Xifeng Ruan [3]; Yaquan Fang [4]

[1] *University of Witwatersrand*

[2] *University of the Witwatersrand*

[3] *University of the Witwatersrand*

[4] *Institute of High Energy Physics, Chinese Academy of Sciences*

Corresponding Author: amohammed@aims.ac.tz

A search for the non-resonant production of a pair of the Standard Model Higgs boson h via gluon-fusion, $gg \rightarrow hh$, is performed. Each Higgs boson decays to either $W^+W^-W^+W^-$, $ZZZZ$ or ZZW^+W^- leading to $4\ell + X$ in the final state. The ℓ could be an electron or a muon, and X is missing transverse energy or jets. The b-tagged as jets is vetoed in this analysis. The search uses the data at a centre-of-mass energy of 13 TeV collected by the ATLAS detector between 2015-2018 at the Large Hadron Collider. Cut-based and multivariate analyses are used to exploit the signal.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics of Condensed Matter and Materials / **204**

Investigating the effect of heat transfer on immersion behavior of plasma sprayed HAp coatings deposited on Ti-6Al-4V alloy substrates

Authors: Unaisa Dockrat[1]; Thabsile Thabethe[1]; Tshepo Ntsoane[2]

[1] *University of Pretoria*

[2] *Necsa*

Corresponding Author: unaisadockrat@gmail.com

In this investigation, air plasma spraying was used to coat two sets of geometrically different Ti-6Al-4V alloy substrates with hydroxyapatite (HAp). The two sets of samples were then immersed

in simulated body fluid (SBF), a fluid whose ionic composition resembles that of the human fluid, to determine the biofunctional performance of the coatings. Immersion was done for varying time periods (0, 7, 28 and 56 days) under physiological conditions. Samples where then analyzed using X-ray diffraction (XRD) and scanning electron microscopy (SEM) in order to compare coatings deposited on the two geometrically different substrates before and after immersion. XRD technique was used to investigate the effect of the simulated body fluid on the thermal products formed, the degree of crystallinity and the residual stresses of the coating for both substrate geometries. SEM was used to study the surface morphology and microstructure of both samples after coating and immersion. Previous investigations conducted on these coatings indicated that immersion in SBF has an effect on the morphology and chemical composition of the samples.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Applied Physics / **205**

Injection dependent dark IR imaging of PV modules as an alternative to EL imaging for individual cell characterisation

Author: Ross Dix-Peek[1]

Co-authors: Ernest van Dyk [2]; Frederik. J. Vorster [1]

[1] *Nelson Mandela University*

[2] *Mandela University*

Corresponding Author: ross.dix-peek@mandela.ac.za

The determination of the dark electrical characteristics of each cell within a PV module enables the simulation of the complete PV modules electrical performance when in operation. It is, therefore, possible to estimate the power output of a PV module in operation. In a previous study, a method was developed that used injection dependent Electroluminescence (EL) images to characterise individual cells within a module. However, this method has specific weaknesses. The first major weakness is that when the cells are not luminescing, the cell voltages cannot be determined. The second weakness is that if the module has parallel string, the assumption that all cell currents are equal, is not valid. The method developed in the current work proposes that individual cell voltages can be determined using dark IR imaging only. When combined with the previous method, the proposed method allows for the individual cell characterisation in modules with parallel strings. This paper discusses the method employed and presents results for various modules, including modules with parallel strings.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Space Science / **206**

Aviation dosimetry science in South Africa

Authors: Godfrey Mosotho[1]; Du Toit Strauss[2]; Corrie Diedericks[2]

[1] *NORTH - WEST UNIVERSITY*

[2] *North-West University*

Corresponding Author: 23853786@nwu.ac.za

Radiation exposure during commercial flights remains one of the dominating and inevitable factors relevant to flight personnel and passengers' health and safety. At aviation altitudes, the radiation environment that the flight personnel are exposed to, during their day-to-day occupational activities, differs significantly from terrestrial radiation received by the general population on the ground. Currently, there are no dosimetric services in South Africa that collects data of the flight personnel's exposure during their occupational activities. The North-West University, in conjunction with scientists from the *Christian-Albrechts-Universität zu Kiel*, have assembled an active (battery powered) dosimeter (known as the RPiRENA) to measure the flight personnel and passengers' exposure during commercial flight cruises. Here we introduce this device, discuss its calibration, and show initial results during long-haul flights.

keyword(s): Radiation dosimetry, Active dosimeters, Cosmic-rays

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics of Condensed Matter and Materials / 207

Investigation of a novel iron-based cubic compound RhFe3C

Authors: Nyawasedza Magoda[None]; Chandan Mazumdar[1]; Sudip Chakraborty[2]; Shuvankar Gupta[2]; Shovan Dan[2]; Adam Shnier[3]; Dave Billing[3]; Daniel Wamwangi[3]; Abhishek Pandey[3]; Deena Naidoo[4]

[1] *Saha Institute of Nuclear Physics*

[2] *Saha Institute of Nuclear Physics*

[3] *University of the Witwatersrand*

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

Corresponding Author: 1361911@students.wits.ac.za

A polycrystalline sample with the nominal composition RhFe3C was synthesized and its properties were investigated using powder x-ray diffraction (XRD), transmission Mössbauer spectroscopy and heat capacity Cp(T) measurements. The XRD data shows that RhFe3C has a cubic structure with a lattice parameter of 5.8907(3) Å. The room temperature Mössbauer spectrum of RhFe3C exhibits magnetic structure with three spectral components assigned to three different iron sites. The site assignments will be discussed in detail. The Cp(T) data show a distinct behavior and can be fitted with the Debye model with an additional Einstein term. The extracted fitted value of the Debye temperature was determined as 371(1) K. The results obtained from the different experiments will be discussed and compared with literature.

Apply to be considered for a student ; award (Yes / No)?:

yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Nuclear, Particle and Radiation Physics / 208

Search for a heavier Higgs like boson and a dark force boson using ATLAS experiment results

Author: Xola Mapekula[1]

[1] *University of Johannesburg*

Corresponding Author: xola.mapekula@cern.ch

This paper presents the search for the Higgs boson, with mass 125GeV, decaying to two new intermediate states and then into four lepton final states, H ⟶ ZdZd ⟶ 4l together with the search for a double Zd1 and Zd2 hypothesis. The analysis is conducted using the Run II data set from pp collisions collected with the ATLAS detector corresponding to a total integrated luminosity of 140fb−1 at a centre of mass energy of √s = 13TeV. A study on modifying the signal region has also been conducted, assuming a broader width on the Zd. Based on the signal and background models, the total number of expected events is 14, while 19 events were observed in the modified signal region. The results are compatible with Standard Model predictions. The search for the double hypothesized Zd1 and Zd2 is performed in the medium signal region. For this study, clustering algorithms and azimuthal integration are used to find the hypothesized Zd1 and Zd2 vector boson masses. Particular emphasis is also given to the limit setting procedure used in this analysis. In addition, the procedure used to port the limit setting code from CPU to GPU is reviewed together with the performance of the modified machinery.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Space Science / 209

Simulations of coronal loops undergoing transverse decay-less oscillations

Author: Konstantinos Karampelas[1]

[1] *Northumbria University*

Corresponding Author: konstantinos.karampelas@northumbria.ac.uk

Observations of solar coronal loops with the Atmospheric Imaging Assembly (AIA) instrument of SDO have revealed the existence of a low amplitude decay-less regime of transverse oscillations. These appear to be like the well understood large amplitude and rapidly decaying fast kink-mode oscillations observed in loops, but their means of excitation and exact nature are still debated. Addressing these two questions is essential for using the former as diagnostic tools in coronal seismology, as well as determining their potential role in wave heating of the solar corona. In this talk, results from a number of 3D numerical magnetohydrodynamic studies will be presented, in which we have studied loops undergoing decay-less oscillations. The different proposed interpretations and excitation mechanisms of these waves will be presented, alongside our results on the spatial evolution of these oscillating loops. Wave energy dissipation in the case of decay-less oscillations will also be

discussed, alongside some of our recent findings supporting the idea that the dissipated energy can potentially overcome of the radiative losses for the Quiet Sun.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Space Science / **210**

Remote sensing of atmospheric Aerosol Optical Depth

Authors: Zimbini Faniso[1]; Tsholofelo Malatji[1]

[1] *CSIR*

Corresponding Author: zfaniso@csir.co.za

The paper presents the data analysis of Aerosol Optical Depth (AOD) measured from a CIMEL Sunphotometer at CSIR-Defence and Security in Pretoria, South Africa. This Aeronet instrument has been recording data since 2011 till 2018 for use in the calibration and validation process of space sensors such as earth observation satellites in space. These sensors encounter challenges while capturing information about the earth surface since the presence of aerosols in the atmosphere inhibit the target image and degrade information about the area. The purpose of ground truth instruments such as the CIMEL Sunphotometer is to generate aerosol measurements specifically the AOD, and requires analysis of the data to ensure stability and quality before any calibration or validation of the Satellite sensor. The study will provide an overview of the AOD behaviour during warm and dry seasons of the 2017 data.

Apply to be considered for a student ; award (Yes / No)?:

NO

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics for Development, Education and Outreach / **211**

Science teachers' beliefs about the impact of 4IR on their classroom practices

Author: Lydia Mavuru[1]

[1] *University of Johannesburg*

Corresponding Author: lydiam@uj.ac.za

Embracing 4IR in the education system has become mandatory more than before considering the current global pandemic. Teacher beliefs influence their practices. It has also been found that sometimes there is a mismatch between teachers' beliefs about the affordances of technology and the actual practices in the classrooms due to contextual factors. Many countries have embraced 4IR in

their education system and South Africa is part of the change. Because this is a 'revolution' many science teachers have been caught off guard and they harbour mixed feelings regarding their roles and what the future has in store for them. The current study sought to establish newly qualified science teachers' perspectives on their roles due to the call to embrace 4IR tools in their classrooms. The qualitative study was guided by the research question: What are teachers' beliefs about their roles in science classrooms where 4IR is embraced? The participants were ideal considering their relative young age which is coined as 'the digital age'. An online questionnaire was administered to 60 teachers who had just qualified to teach science. The questionnaire specifically sought science teachers' levels of preparedness in terms of competencies, resource availability and management, and future professional prospects. Data was subjected to content analysis and three themes emerged. 1. Teachers believed that the government and the Department of Basic Education's stance to embrace 4IR is a vehicle that promotes unequal education opportunities for science learners. The teachers' argument was that whilst it is a welcome development, there has not been parity in resource distribution in schools because learners come from diverse socioeconomic backgrounds. Those from disadvantaged backgrounds even struggled with acquisition of simple calculators in which case the acquisition of electronic gadgets could even be out of reach for many. 2. Most of the science teachers showed lack of confidence as they believed they were not technologically prepared to embrace 4IR tools such as AI, coding and robotics. As such, they expressed fears and insecurities when it comes to their competencies to deliver technology led classroom teaching and learning of science. 3. The science teachers believed that too much utilisation of technology in a science classroom will demean the actual teaching and learning of scientific concepts. In this case the teachers questioned the effectiveness of technology in providing meaningful learning of science. The findings of this study contribute towards the need to change the status quo on the disparities between urban, rural as well as township and suburban schools in terms of resource distribution; and teacher professional development on the need for continued technological knowledge and skills development.
Key words: Classroom practices, science teacher beliefs, 4IR.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Nuclear, Particle and Radiation Physics / **212**

Anomaly detection with Data Quality Early Warning Systems in ATLAS using machine learning

Author: Senzo Msutwana[None]

Co-authors: Sahal Yacoob [1]; James Michael Keaveney [1]

[1] *University of Cape Town*

Corresponding Author: senzomsutwana@gmail.com

In this project, ideas for the implementation of a data-quality early warning system (DQEWS) are explored. The DQEWS project aims to use supervised machine learning (ML) methods to evaluate data-quality from the ATLAS detector for each sequential luminosity-block over the course of a run. The idea is to then
make use of feature extraction from the results of the classification procedure in order to determine which of these features in the data-sets can reliably indicate problems in the detector, while accounting for expected differences in distributions as the beam intensity reduces over the course of a run. In principle, it is these features which may point experts to issues further down in the DAQ process which may be resulting in this drift during a run of the detector. This is, in essence, an exploration of an idea for a data-quality monitoring
system for the ATLAS detector. Within the scope of this project thus far, the following have been shown. Firstly, the use of gradient boosted decision trees (GBDTs) are preferable to deep neural

networks (DNNs). This is due to DNNs requiring more computational power than GBDTs to back-propagate through the trained
models' internal weights in order to rank the features used in classification. Secondly, differences in datasets have been shown with the training of the GBDTs, and are shown to increase with comparisons of LB data further apart from the initiation of a run of the detector.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Theoretical and Computational Physics / **213**

Density Functional Study on the adsorption of O2 and H2O on PtSb2 (100) surface.

Authors: Samuel Seshupo Mangwejane[1]; Peace Mkhonto[1]; Phuti Ngoepe[1]

[1] *University of Limpopo*

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

The interactions of O2 and H2O with mineral surfaces are the major factors that determine the oxidation and wettability behaviour of minerals. This study employed the first-principles density functional theory to explore the bonding behaviour, adsorption energies and electronic properties directly related to the reactivity of O2 and H2O with geversite (100) mineral surface. The oxidation of the surface resulted in formation of superoxide, peroxide and bridging adsorption, where the peroxide adsorption on Pt atom was more exothermic (-64.29 kJ/mol). The hydration showed that both Pt and Sb atoms interact with water through oxygen atom. However, under multi water adsorption (-38.19 kJ/mol), the water molecule flipped hydrogen down and consequently interacts with the surface through hydrogen atoms. In comparison of adsorption energies of the O2 and H2O, we found that oxidation was more exothermic than the hydration, which suggest a preferential oxidation of the geversite mineral. This study provides insights on the hydration and oxidation of geversite that may be applicable in the recovery processes.

Apply to be considered for a student ; award (Yes / No)?:

no

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Applied Physics / **214**

Performance analysis of thin-film Photovoltaic (PV) technologies in an embedded generation network

Author: Roelof Roodt[1]

Co-authors: Jacqueline Crozier McCleland [2]; Ernest van Dyk [2]; Frederik Vorster [3]

[1] *Nelson Mandela University*

[2] *Supervisor*

[3] *Supervisor*

Corresponding Author: s217357709@mandela.ac.za

Thin-film photovoltaic (PV) technology has been around for quite some time with varying performance for the different technologies. A major shortcoming of thin-film PV modules compared to crystalline PV technology is their shorter guaranteed operational lifespan as they degrade faster. In this study, the performance of thin-film technology operating in an outdoor environment is monitored and analysed.
An embedded generation network has been established by the PV Research group at Nelson Mandela University. The network is currently based at the PV Outdoor Research Facility (ORF) on the Nelson Mandela University, South Campus in Port Elizabeth. This embedded generation network contains three kW-scale grid-connected PV arrays comprising of various thin-film technologies. These technologies are Cadmium Telluride (CdTe), Copper Indium diselenide (CIS) and amorphous Silicon (a-Si). Custom designed and built data loggers were used to acquire AC and DC data for the various PV systems, as well as relevant meteorological data. a LabVIEW program was developed and used to process the respective datasets and for analysis. This paper presents and discusses the performance data of these three arrays over an extended period of time. A thorough comparison of the energy production is given, together with preliminary performance loss and degradation. From the data acquired, it is observed that the CIS and CdTe systems have higher performance ratios of the order of 85 %, while the performance ratio of the a-Si system consistently below 80 %.

Key words: PV systems, Thin-film technology, embedded generation, performance monitoring, PV modules

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / 215

Computational Studies of Pentlandite Mineral: Structural and Dynamical Properties Probed by Molecular Dynamics

Author: Mofuti Mehlape[1]

Co-authors: Sentserere Kgalema ; Phuti Ngoepe [2]

[1] *University Of Limpopo*

[2] *University of Limpopo*

Corresponding Authors: phuti.ngoepe@ul.ac.za, mofuti.mehlape@ul.ac.za

Pentlandite is a major precious metals-bearing mineral and plays a very important role in mining. Precious metal ores co-exists with base metals either as solid-solution and intergrowths, hence rendering its detailed understanding important for efficient extraction of these precious metals. In order to extract the precious metals from the ores effectively it is necessary to study and understand structural and physical properties, of pentlanidte mineral in detail. This work relates to problems in applied areas such as mineralogy, geophysics and geochemistry, whereby phase transition is modified by impurities, so there is the additional concern of the effect of temperature. Computational modelling technique, molecular dynamics (MD) is applied to investigate structural and physical properties of nickel rich pentlandite (Fe4Ni5S8). Radial distribution functions (RDFs) and mean square displacement (MSD) are used to establish the effect of temperature on the pentlandite mineral. The MD results are found to compare well with the experimental results.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Theoretical and Computational Physics / 216

A QUANTUM LOOK AT DIFFERENCE-FREQUENCY GENERATION

Authors: Tanita Permaul[1]; Thomas Konrad[1]

[1] *UKZN*

Corresponding Author: 216044254@stu.ukzn.ac.za

In today's growing field of quantum communication, a major quest is trying to increase the bandwidth of information that can be sent. An interesting avenue is looking at nonlinear optical processes which also allows one to incorporate the spatial degrees of freedom of light. A widely used nonlinear process is spontaneous parametric down conversion (SPDC), which is a source for entangled photons. As it is considered a quantum effect, the process is well defined in the quantum regime. A less explored topic is the stimulated version of down conversion, which is also called difference-frequency generation (DFG) in classical nonlinear optics. Although it is considered a classical effect, it can have interesting applications in quantum theory, e.g. the process is currently used to achieve optimal quantum cloning. It is therefore important to be able to formulate this process using standard quantum optics notation, so it can be integrated in quantum schemes. In this talk, I will give a brief description of difference-frequency generation, before deriving a quantum optical description for the process, based off the standard description for SPDC. Using this new approach, I introduce prospective applications for DFG, specifically where it is used for measurement-free error correction, a new type of teleportation scheme and potentially as an anti-linear quantum channel.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / 217

Computational modelling studies of Pentlandite (Fe, Ni)9S8 surface: Oxidation and hydration

Author: Thapelo Ntobeng[None]

Co-authors: Mofuti Mehlape [1]; peace prince mkhonto [2]; Phuti Ngoepe [2]

[1] *University Of Limpopo*

[2] *University of Limpopo*

Corresponding Author: thapelosegoarihle@gmail.com

Minerals are exposed to oxidation due to weathering and aging which have significant effect on their floatation. Furthermore, the hydrophobicity and hydrophilicity of minerals are crucial in determining their wettability that can be useful in the floatation process design. In this study we investigate the structural, surface and electronic properties of the nickel-rich pentlandite (Fe4Ni5S8) and the bonding and electronic structure of (111) surface oxidation and hydration. We employed computational modelling technique; the density functional theory (DFT). CASTEP code was used to investigate the oxidation and hydration reaction on nickel-rich pentlandite (111) surface. The oxidation resulted in metal preferential bonding and formation of Ni-Peroxide (-262.41 kJ/mol), which resulted from the bridging (Fe-O2-Ni) was observed to be more exothermic. For the hydration we noted strong exothermic interaction of H2O with Fe (-52.9233 kJ/mol) than Ni (-21.4832 kJ/mol) on pentlandite (111) surface and it indicated that water adsorb on the pentlandite surface through the Fe atoms. The computed density of states (DOS) for the most stable exothermic adsorption sites displayed a transition of the EF to the pseudo gap for Fe atoms, suggesting stability. We further observed that the oxygen molecule accept electrons from both Fe and Ni atoms. The hydration also displayed the oxygen and hydrogen peak to move to the valance band indicating electron acceptor from the Fe atom. This study predict the oxidation and hydration of pentlandite mineral that may be applicable in their recovery.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

Hons

Astrophysics / **218**

Modelling the Spectral Energy Distributions and Multi-Wavelength Polarisation of Blazars

Author: Hester Schutte[1]

Co-authors: Markus Bottcher [2]; Richard Britto [3]; Brian van Soelen [4]; Johannes Petrus Marais [5]; Amanpreet Kaur [6]; Abe Falcone [6]; David Buckley [7]; Haocheng Zhang [8]; Andry Fitiavana Rajoelimanana [9]; Justin Cooper [10]

[1] *NWU Potchefstroom*

[2] *University of North West*

[3] *on behalf of the Fermi-LAT Collaboration*

[4] *University of the Free State*

[5] *UFS*

[6] *Penn State University*

[7] *Southern African Large Telescope*

[8] *Purdue University*

[9] *South African Astronomical Observatory / University of Cape Town (SAAO/UCT)*

[10] *The University of the Free State*

Corresponding Author: schuttehester1@gmail.com

The radio through optical/UV/X-ray emission from blazars is dominated by highly polarised synchrotron emission from relativistic electrons in their jets. The total degree of polarisation is a composition of the polarised non-thermal synchrotron emission and thermal unpolarised emission components from the dusty torus, host galaxy, emission lines from the broad line region (BLR) and accretion disk. For some blazars the accretion disk is not directly observed as it is outshone by synchrotron emission. However, it reveals its presence through a decrease of the optical polarisation degree towards higher frequencies in spectropolarimetry observations, where the disk is diluting the synchrotron polarisation. Considering a leptonic model, the high-energy X-ray and gamma-ray emission can be modelled as polarised synchrotron self-Compton radiation which is diluted by

Compton up-scattering of unpolarised external radiation fields of the BLR and accretion disk. A model is constructed that simultaneously fits spectral energy distributions and multi-wavelength polarisation of blazars. A target-of-opportunity, Large Science program "Observing the Transient Universe" from the *Southern African Large Telescope*, provides spectropolarimetry data for flaring blazars in the optical-UV regime. This program includes co-ordinated multi-wavelength observations from the *Las Cumbres Observatory*, the *Swift*-XRT and the *Fermi*-LAT. We present results for the flat spectrum radio quasar 4C+01.02 ($z = 2.1$), for which we constrained its black hole mass as $4 \times 10^8\ M_\odot$ and obtained a scaling factor that is indicative of the degree of order of the magnetic field (and dependent on line-of-sight) in the emission region.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics of Condensed Matter and Materials / **219**

High-resolution deep level transient spectroscopy (DLTS) study of vacancy defects donor pairs in P-, AS- and Sb-doped n-type Silicon

Authors: Asil Alnaim[1]; Fatemeh Taghizadeh[2]; Helga Danga[3]; Mohammed Ahmed[2]; Francois Danie Auret[4]; Walter Meyer [3]

[1] *university of Pretoria*

[2] *university of pretoria*

[3] *University of Pretoria*

[4] *University of pretria*

Corresponding Author: aseelmohamed@hotmail.com

We have used conventional deep-level transient spectroscopy (DLTS) and high resolution Laplace deep level transient spectroscopy (L-DLTS) to investigate electron-irradiation induced defects in phosphorous doped (n-type) silicon implanted additionally with arsenic, antimony and both arsenic and antimony. All samples exhibited similar DLTS spectra, with peaks at 219 K, 166 K, 128 K, and 92 K. These defects were attributed to the E-center, divacancy, hydrogen-oxygen vacancy and Oxygen-vacancy, observed at rate window of 80 s-1. The E-center appears in all the spectra. The activation energies of the defects were extracted from Arrhenius plot measurements. The calculated activation energies were found to be 0.444, 0.432, 0.389 eV for P-As, P-Sb, P-Sb-As, respectively.

Apply to be considered for a student ; award (Yes / No)?:

yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Applied Physics / **220**

Computational study of electronic and optical properties of graphene/brooki (210) composite

Author: Lutendo Phuthu[1]

[1] *University of Venda*

Corresponding Author: phutulutendo@gmail.com

Recently, carbonaceous nanomaterials such as carbon nanotubes and two-dimensional graphene have attracted the attention of the scientific community in probe to improve energy conversion and storage technologies. The graphene sheet is more preferred due to its large specific area, flexible structure, high transparency, excellent mobility of charge carriers and is expected to be able to slow the charge recombination. Graphene/Transition metal oxides nanocomposite study has become much of a wide interest recently with metal oxides like TiO2 and ZnO. These metal oxides are used as thin films in photovoltaic technology to harness energy. The final composite embodies both the transport properties of the former and the semiconducting properties of the latter species. This work describes an analysis of the electronic and optical properties of graphene/TiO2 studied using the Density Functional Theory (DFT) in application to dye-sensitized solar cells (DSSCs).

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Nuclear, Particle and Radiation Physics / **221**

Investigation of the Rare Earth Elements Pattern for uranium attribution in nuclear forensics environment

Author: Tebogo Kupi[1]

Co-author: Manny Mathuthu [1]

[1] *North-West University*

Corresponding Author: tebogo.kupi@nwu.ac.za

Illicit trafficking of radioactive material and especially nuclear material (thorium, uranium, and plutonium) has been an issue of concern since the beginning of the 1990s, when the first seizures of nuclear material were reported to the International Atomic Energy Agency. In this work, twenty samples selected for investigation originate from South Africa and Namibia uranium mines. The aim of this study was to determine whether the lanthanides patterns measured in a particular sample can be used to attribute the uranium sample to the production or reprocessing plant. Measurements were carried out using an inductively coupled plasma mass spectrometer (ICP-MS) NexION 2000. The results for the Namibian mine show the REEs exhibit light REE-enriched patterns with pronounced positive Ce anomaly when normalized to chondrite which indicates that the REEs are taken up in proportion to their relative concentration in the source rocks. While for the South African mine, the REEs exhibit heavy REE-enriched patterns with pronounced positive Tb anomaly when normalized to chondrite. These results confirm that, REE patterns used for origin location do reflect significant variation within mine and thus provide valuable information about the geochemical formation and origin.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics of Condensed Matter and Materials / 222

Impact of helium (He) in the migration of strontium implanted 6H-SiC

Author: Thapelo Freddy Mokgadi[1]

Co-authors: Mandla Msimanga [2]; V.A Skuratov [3]; Thulani Hlatshwayo [1]

[1] *University of Pretoria*

[2] *Tshwane University of Technology*

[3] *Joint Institute for Nuclear Research*

Corresponding Author: u10307908@tuks.co.za

Impact of Helium (He) in the migration of strontium implanted 6H-SiC

T.F. Mokgadi[1], T.T. Hlatshwayo[1], M. Msimanga[2], V.A. Skuratov[3]

[1] *Physics Department, University of Pretoria, Pretoria, South Africa.*
2 *Physics Department, Tshwane University of Technology, P Bag X680, Pretoria 0001, South Africa*
[3] *Joint Institute for Nuclear Research, Dubna, Russia*

Silicon carbide (SiC) is regarded as the main candidate material for nuclear energy application, such as a structural material in future fusion reactors and as fuel cladding in future generation fission reactors, based on its low neutron capture cross-section, outstanding chemical and thermal stability. In fission reactors such as the PBMR, the fuel particle (TRISO particle) where SiC is the main diffusion barrier of fission products (FPs), is able to retain most of the radiologically important FPs with the exception of strontium (^{90}Sr), Europium (Eu) and silver (Ag). ^{90}Sr is an isotope of naturally occurring nontoxic and nonradioactive strontium, it is also a by-product of fission reactions in nuclear reactors with yields of about 5.7% and 6.6% from U-235 and U-233, respectively. It has a half-life of about 29 years and undergoes a beta decay into yttrium-90 (^{90}Y) accompanied by a decay energy of about 0.55 MeV. This, is the more reason why it is important to investigate the retention of Sr in the TRISO particle, specifically SiC. Simultaneous to the release of FPs in fission reactions is the release of alpha-particles. Alpha-particles/helium ions (He^{+}) are a product of nuclear reactions with generation rates of about 2.5 appm He/dpa and have been reported to form bubbles in SiC which in the long run compromises its structural integrity. Therefore, in the nuclear reactor environment SiC will be exposed to high dose, temperature irradiation, and He^{+} generation. We will be presenting the results of a study that looks into the dual implantation of Sr and He at room temperature and the impact of He bubbles in the Sr migration in SiC at high temperatures.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Astrophysics / 223

Potential of the MeerKAT telescope to detect the stimulated decay of axion-like particles

Authors: Ahmed Ayad[1]; Geoff Beck[2]

[1] *University of the Witwatersrand*

[2] *University of Witwatersrand*

Corresponding Author: ahmed@aims.edu.gh

The nature of the cold dark matter (CDM) can be understood by looking for light scalar candidates such as axion-like particles (ALPs). The coupling between ALPs and photons allows for the spontaneous decay of ALPs into pairs of photons. However, the rate of this process is believed to be small enough to be ignored on cosmological timescales. Furthermore, it has been claimed in several recent works that ALPs can gravitationally thermalize and form macroscopic condensates. The stimulated decay of the ALP condensates is also possible with a significantly high rate. Consequently, the photon occupation number can receive Bose enhancement and grows exponentially. This can lead to radio emissions produced from this process and could be observed by the forthcoming radio telescopes. In this work, we investigate the detectability of such a radio signature from some astrophysical targets using the MeerKAT radio telescopes. This might provide indirect evidence for the existence of the CDM ALPs.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

224

Effects of deposition cycle and heating rate on the structural, optical and photocatalytic properties of electrodeposited hematite films

Author: William Pooe[1]

Co-authors: Mmantsae Diale [1]; Pannan Kyesmen [1]; Nolwazi Nombona [2]

[1] *Department of Physics, University of Pretoria*

[2] *Department of Chemistry, Unirversity of Pretoria*

Corresponding Author: wpooe3@gmail.com

Hematite (⍺-Fe2O3) nanostructures were prepared on fluorine-doped tin oxide (FTO) substrates using the electrodeposition method at different voltametric cycles ranging from 15-80 revolutions. The films were first heated to 550℃ at 10℃/min and annealed at that temperature for 1 hour (hr). In addition, the films consisting 60 cycles were annealed at 550℃ at different heating rates of 2, 10 and 35℃/min, and under rapid thermal calcination. X-ray diffraction results of all the films revealed prominent peaks at (104) and (110) lattice planes, confirming the rhombohedral crystal structure of hematite. Raman spectroscopy results showed the 2 A1g and 5 Eg vibrational phonon modes, further confirming the formation of hematite. The surface morphology of the films showed porous and spherical nanoparticles with estimated average grain size as high as 710 nm, indicating agglomeration. The films deposited at 60 cycles and prepared at 10℃/min heating rate recorded the highest photocurrent density of 20.7 μA/cm2 at 1.23 V vs reversible hydrogen electrode (RHE) while films produced at 2℃/min yielded the least photoactivity. The high photocurrent can be associated with the crystallinity and the suppressed electron-hole pair recombination rate due to the annealing rate. This study shows that the photocurrent of nanostructured hematite thin films can be improved by varying both the voltametric cycle and heating rate.
Keywords: Hematite nanostructures, Electrodeposition, annealing rate, Photoelectrochemical performance

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / 225

Effects of helium (He) in the migration behavior of silver (Ag) implanted into polycrystalline SiC

Author: Sive Mtsi[1]

Co-authors: T.T Hlatshwayo [1]; M Msimanga [2]; V.A. Skuratov [3]

[1] *University of Pretoria*

[2] *Tshwane University of Technology*

[3] *Joint Institute for Nuclear Research*

Corresponding Author: cve.mtsi@gmail.com

Effects of helium (He) in the migration behaviour of silver (Ag) implanted into polycrystalline silicon carbide (SiC) were investigated. Sliver ions at 360 keV were implanted into SiC to a fluence of 2 × 1016 cm-2 at 350 oC. Some of the as-implanted samples were then implanted with helium (He) ions of 17 keV to a fluence of 1 × 1017 cm-2 at 350 oC. The Ag implanted and He & Ag co-implanted samples were annealed at 1000°C and 1100°C for 5 hours. The structural and morphological evolutions in the as-implanted and annealed samples were characterized by Raman spectroscopy and scanning electron microscopy (SEM) while the migration of implanted species was monitored by elastic recoil detection analysis (ERDA). Implantation and co-implantation resulted in the formation of defects with no amorphization. Annealing at 1000oC resulted in some healing of defects. This annealing of defects progressed with annealing temperature. SEM micrographs of the co-implanted samples had cavities due to burst of He bubbles while no significant changes were observed in the Ag only implanted SiC. The number of cavities increased with annealing temperatures. Migration of silver was observed in the co-implanted samples annealed at 1100 oC and no migration of Ag was observed in the Ag implanted samples. Hence He bubbles assisted the migration of Ag.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Photonics / 226

Light Sheet Microscope Development

Author: Imraan Badrodien[1]

Co-authors: G.W Bosman [1]; P.H Neethling [1]

[1] *Stellenbosch University*

Corresponding Author: 17694698@sun.ac.za

Light sheet fluorescence microscopy is a powerful tool within the field of microscopy. The inherent advantages over other fluorescence microscopy techniques inclue high sectioning capabilities, reduced photo-damage in the sample and short data acquisition times.

In this presentation, the development of a light sheet microscope is described. The system relies on the use of a thin sheet of light to illuminate a fluorescent sample. The light sheet can be generated using a cylindrical lens or by rapidly scanning a circular beam using a galvonometer. Two dimensional images are acquired perpendicular the the illumination path. The sample can be translated through the light sheet, acquiring images at different depths in the sample. The images are then used to reconstruct a three dimentional fluorescence image of the sample.

The light sheet microscope system is developed to allow for the incorporation of various light sheet generation techniques, allowing for the parameters of the light sheet to be tailored for various applications. The implementation of the scanned beams to generate light sheets allow for the use of non-diffracting beams. A comparison of the results for various light sheet generation techniques are presented. Using the microscope, images are acquired and analysed to demonstrate the systems capabilities and limitations. Image restoration is implemented by the deconvolution of the point spread function and the images. Using the deconvolved images, three dimensional fluorescence images of the sample are obtained. The result is a multi-purpose light sheet microscope for use in biological imaging.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / **227**

Ab-initio study of ethylene carbonate adsorption on the major α-Al2O3 (0001) surface

Author: Brian Ramogayana[1]

Co-authors: David Santos-Carballal [2]; khomotso Maenetja [3]; Nora. H de Leeuw [2]; Phuti Ngoepe [4]

[1] *UL*

[2] *Leeds University*

[3] *University Of Limpopo*

[4] *University of Limpopo*

Corresponding Author: brian.ramogayana@ul.ac.za

Aluminium oxide (α-Al₂O₃) emerged as a potential surface coating material for Li-ion batteries because it has proved to improve the electrochemical performance and capacity upon cycling. It was also considered due to its high thermal conductivity, resistance against extreme temperatures and excellent electric insulation. Despite the intense studies on the surface coating with α-Al₂O₃, there remains a lack of deep understanding of its reactivity towards the electrolyte content. Herein, we report the adsorption of organic solvent, ethylene carbonate (EC) on the major α-Al₂O₃ (0001) surface using density functional theory calculations. During the single EC adsorption, it was found that the molecule prefers to binds with the surface when placed parallel interacting through the carbonyl oxygen. The adsorption energy per EC molecule (*E*_{ads}/EC) was found to increases for parallel interactions and decrease for perpendicular. Upon increasing the surface coverage, we have noted a decrease in surface free energy, thus a decrease in surface stability. Furthermore, it has been observed a decrease in electronic charge transfer as we increase the EC coverage.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Photonics / **228**

Toolbox for the Development of a MIR NOPA for Time-Domain Ptychography and Initial Results

Author: Anthonie de Beer[1]

Co-authors: Gurthwin Bosman [2]; Pieter Neethling [3]

[1] *Stellenbosch University Physics Department*

[2] *Stellenbosch University*

[3] *Laser Research Institute, University of Stellenbosch*

Corresponding Author: 18978762@sun.ac.za

This presentation discusses a noncollinear optical parametric amplifier as a source of ultrafast mid-infrared light for spectroscopic experiments and aims to provide a consistent method for the generation thereof. The proposed laser source at the Laser Research Institute is intended for the investigation of molecular vibrations of organic molecules on a femtosecond timescale. The underlining theory and fundamental principles of this device is outlined, as well as various experimental considerations considering key concepts such as difference frequency generation, phase matching and group velocity matching.
A design for an experimental setup to generate suitable ultrafast mid-infrared light is proposed and preliminary optical devices are implemented. This design features multiple optical amplification and generation stages to enhance both the intensity of the output pulses and the degree of spectral tuneability. Output pulse are expected to be centred between 3-8 μm. Initial experiments indicate that simple approaches to mid-infrared pulse generation fall short. Given the limited pulse energies, generation of a 160 nm bandwidth, near-infrared supercontinuum centred at 1067 nm is shown to be inadequate for the generation of mid-infrared pulses. Parasitic second harmonic-, sum frequency and difference frequency generation processes are also shown to impede mid-infrared generation. These restricting experimental phenomena are highlighted and methods to bypass these limits are given.
Finally, as a demonstration of the usefulness of such a source of infrared pulses, the novel time-domain ptychographic measurement, HIPPY, of a material's response to mid-infrared light is simulated. This spectroscopic method is shown to be efficient and computationally undemanding. Its introduction into an ultrafast spectroscopy lab expected to be relatively simple.
By covering the various aspects concerning the generation of mid-infrared pulses and some limiting phenomena, long with a proposed optical design and spectroscopic application, a comprehensive yet concise picture of mid-infrared pulse generation and application is shaped.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Poster Session / **229**

Multi-photon decay mode spectroscopy of positronium

Author: Storm Johnson[1,21]

Co-authors: Pete Jones[2 2]; Tom Leadbeater[1 1]

[1] *University of Cape Town*

[2] *iThemba LABS*

Corresponding Author: sjohnson@tlabs.ac.za

[1]Department of Physics, University of Cape Town, Private Bag X3, Rondebosch, 7701, South Africa
[2]Department of Subatomic Physics, iThemba LABS, PO Box 722, Somerset West, 7129, South Africa

Positronium (Ps) is a system consisting of an electron and its anti-particle, a positron, bound together into an exotic atom, specifically an onium. The system is unstable: the two particles annihilate each other to predominantly produce two or three gamma rays, depending on the relative spin states. Energy and momentum conservation forbid annihilation to a single photon, with no constraints on higher order multiplicities at greatly decreased probability. The branching ratio for decays producing four or more photons is on the order $<10^{-6}$.

Experiments using ^{22}Na as a source of positrons of various intensities have been measured with an array of eight $LaBr_3$:Ce scintillation detectors. These detectors combine good energy resolution (˜40 keV FWHM at 511 keV) with excellent timing resolution (˜300 ps) which allow for high quality photon time-of-flight measurements. From these measurements, the branching ratio for the next-to-leading order decay (four photon decay) of parapositronium (p-Ps) is determined, and compared to its theoretically calculated value $\mathrm{BR}(\text{p-Ps} \to 4\gamma) \approx 1.49 \times 10^{-6}$ 1.

1 Andrzej Czarnecki and Savely G. Karshenboim. Decays of positronium, November 1999.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Photonics / **230**

ACCELERATING POLARIZATION STATES AND STRUCTURES

Authors: Wagner Tavares Buono[1]; Keshaan Singh[1]; Angela Dudley[2]; Andrew Forbes[3]

[1] *University of the Witwatersrand*

[2] *CSIR National Laser Centre*

[3] *U. Witwatersrand*

Corresponding Author: wagner.tavaresbuono@wits.ac.za

Optical fields can often show unexpected effects when interference effects are used. Examples of these are angularly accelerating beams. In this work we present a novel structure of light that exhibits State-of-Polarization (SoP) structures that rotate with acceleration and deceleration when propagating in free space. We achieve this by creating a superposition of beams with accelerated transport of intensity in different polarization components, in such a way that the intensity profile remains constant, but each polarization projection changes differently. The Stokes vector for each point of the transverse profile exhibits a circular trajectory in the Poincaré sphere, showing an accelerated rotation around the axis of the generating polarization basis. We hope that this vector field with non-trivial structures can be used to study the interaction of vector light with matter.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics of Condensed Matter and Materials / 231

Elastic and Magnetic properties of Tb-MnO based Thin Films

Author: Geoffrey Mwendwa[1]

Co-authors: Mathe Bhekumusa [2]; Dave Billing [3]; Rudolph Erasmus [2]; Morgan Madhuku [4]; Adam Shnier [3]; Daniel Wamwangi [2]

[1] *School of Physics, Material Physics Research Institute, University of the Witwatersrand, Private Bag 3, 2050, South Africa*

[2] *School of Physics, Material Physics Research Institute, University of the Witwatersrand*

[3] *School of Chemistry, Molecular Sciences Institute, University of the Witwatersrand*

[4] *iThemba LABS (Gauteng), Private Bag 11, Johannesburg, WITS 2050, South Africa*

Corresponding Author: geofmutua@gmail.com

Multiferroic rare-earth composites in thin-film format have shown promising results towards the attainment of strong coupling of ferroic orders (ferroelasticity, ferromagnetism, ferroelectricity, and ferrotoroidicity) at room temperature, which is a key parameter to the realization of low-energy dissipating devices such as solid-state refrigerators, spintronic memory storage, etc. In this work, we have synthesized Tb-MnO based thin films on (001) Si at ambient temperature using radio frequency magnetron (RF) sputtering at 50 W and investigated their elastic and magnetic properties. The elastic properties of the films have been measured by surface Brillouin scattering (SBS) at ambient temperature, optimized, and fitted with data simulated using surface Elastodynamic Green's function for discrete phonon dispersion in the k//d range of 0–5. By least-squares fitting approach, the measurement uncertainties have been obtained from the Taylor series expansion of the phonon phase velocity dependence on the primary elastic constants (C11 and C44), yielding the optimum values as; C11 = 180 +/- 4.90 GPa and C44 = 43 +/- 0.89 GPa. On the other hand, the magnetic properties of the films have been studied by vibrating sample magnetometry (VSM). The films have been noted to attain ferromagnetic ordering at T<150 K. Spin-glass-like behaviour associated with competing ferromagnetic and antiferromagnetic magnetic ordering has also been observed at T˜50 K.

Keywords: Multiferroics, thin-film, elastic constants, ferromagnetism, spin-glass

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Photonics / 232

Fluorescence spectroscopy of quantum dots in an optical tweezer

Author: Ané Kritzinger[1]

Co-authors: Valeria Rodríguez-Fajardo [2]; Sifiso A Nsibande [1]; Andrew Forbes [2]; Patricia B. C. Forbes [1]

[1] *Chemistry Department, University of Pretoria, Pretoria, South Africa*

[2] *School of Physics, University of the Witwatersrand, Johannesburg, South Africa*

Corresponding Author: anek1205@gmail.com

Optical tweezers have found countless applications in the fields of physics and biology ever since its advent in 1986 by Arthur Ashkin. Using only focused light, optical tweezers are able to trap and manipulate microscopic particles. In this work, we investigate the possibility of combining the optical tweezer with fluorescence spectroscopy to develop an ultra-sensitive analytical instrument. We specifically focus on the feasibility of quantum dot nanoparticles used in conjunction with optical tweezers. In this work, we report on the synthesis of L-cysteine capped CdSe/ZnS quantum dots (QDs) and the coupling thereof to commercial carboxyl-modified beads. The QD-tagged beads which are two μm in diameter can be trapped with the optical tweezers and will be used as the fluorescence probe. A setup of an optical tweezer with a 532 nm laser was employed with which trapping of particles was demonstrated. The detection of fluorescence emission from the QDs that are covalently bonded to the beads was also demonstrated with the optical tweezer. This research, therefore, serves as a proof of concept for a sensitive analytical method that makes use of an optical tweezer in combination with fluorescent QDs.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Applied Physics / 233

Modulating properties of solid carbon nanospheres via ion implantation with heteroatoms.

Authors: Boitumelo Matsoso[1]; Daniel Wamwangi[2]; Rudolf Erasmus[3]; Neil J Coville[4]; Trevor Derry[5]

[1] *DSI-NRF Centre of Excellence in Strong Materials and Molecular Sciences Institute, University of the Witwatersrand*

[2] *School of Physics, University of Witwatersrand, Johannesburg 2050, South Africa*

[3] *DSI-NRF Centre of Excellence in Strong Materials and Materials Physics Research Institute, School of Physics, University of the Witwatersrand*

[4] *DSI-NRF Centre of Excellence in Strong Materials and Molecular Sciences Institute, School of Chemistry, University of the Witwatersrand*

[5] *Centre of Excellence in Strong Materials and School of Physics, University of the Witwatersrand*

Corresponding Author: trevor.derry@wits.ac.za

Solid carbon nanospheres of about 4 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 B+, N+ and Ne+ ions into the carbon shell over 7h and 14h implantation periods at room temperature. SEM analysis revealed significant surface deformation in the form of cracks for the N+ implanted samples, whilst little structural deformation was observed with Ne+ and B+ implanted samples. On the other hand, TEM micrographs showed formation of varying thicknesses of the amorphous carbon depending on the implantation period. In particular, both N+ and Ne+ implanted samples exhibited thicker amorphous layers of ˜21 ± 2 nm and ˜12 ± 3 nm, respectively, whilst a reduction to ˜12 ± 2 nm was observed after the 14h implantation

period with B+ ions. Raman spectroscopy indicated significant structural changes upon implantation, as evident by large values for the defect density ratios. Moreover, compromised BET surface area was observed for B+ and N+ implanted samples, whereas an improved thermal stability was recorded for both Ne+ and B+ implanted samples. Finally, electrical measurements were carried out. 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 to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics of Condensed Matter and Materials / 234

Nanostructured meta-surfaces for arbitrarily structured twisted light

Author: Bereneice Sephton[1]

Co-authors: Yao-Wei Huang [2]; Antonio Ambrosio [3]; Cheng-Wei Qiu [4]; Adam Valles [5]; Takashige Omatsu [5]; Fredrico Capasso [2]; Andrew Forbes [1]

[1] *University of the Witwatersrand*

[2] *Harvard University*

[3] *Istituto Italiano di Tecnologia*

[4] *National University of Singapore*

[5] *Chiba University*

Corresponding Author: bereneice21@gmail.com

Structuring materials to exhibit phenomena such as negative refractive indices and near-zero indices has given rise to an exciting class of materials, known as metamaterials and their 2D counterparts, metasurfaces. Due to these unique properties and the ability to control the size, shape, density and orientations of these materials, one is able to have unprecedented control of their impact on light striking these structures. Controlling light with subwavelength-designed metasurfaces (MSs) has thus allowed for the arbitrary creation of structured light by precisely engineering both the material and composite structures formed from them. With structured light modes such as those carrying orbital angular momentum (OAM) taking hold in many fields from communications, cryptography and optical trapping to metrology, it follows that arbitrary generational control and easily employed devices such as these can form an important part in helping develop these fields.

As such, we characterize both the purity and conversion efficiency of such MSs, designed to generate hybrid twisted light modes, which exemplify the versatility of the imparted properties that are possible. Here we used a recently reported method to design and fabricate meta-surfaces that exploit generalized spin-orbit coupling and propagation phase to produce vector OAM or twisted states with asymmetric superpositions; this allowing for one to break the symmetrical restrictions imposed by previous classes of such devices. Here, the symmetrical restrictions are broken both in the input spin states required for the modal patterning as well as the OAM values paired in each device. For example, asymmetrical charges of 1 and 5 are coupled to linear and circular polarization states in addition to fractional vector OAM states with charges of 3.5 and 6.5 being generated on the same device. The common symmetrical conjugate spin and OAM of 1 is also demonstrated as reported in previously restricted spin-orbit coupling devices. The generated structures of the resulting beams are quantitatively studied here, by exploiting the reciprocal nature of light. We thus establish both the purity and conversion efficiency with conversion efficiencies exceeding 75% and purities in excess of 95%, yielding good modal quality.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Photonics / **235**

Changing colour for detecting spatial structures of light

Author: Bereneice Sephton[1]

Co-authors: Adam Valles [2]; Fabian Steinlechner [3]; Thomas Konrad [4]; Filippus Roux [5]; Andrew Forbes [1]

[1] *University of the Witwatersrand*

[2] *Chiba University*

[3] *Fraunhofer Institute for Applied Optics and Precision Engineering*

[4] *UKZN*

[5] *NMISA*

Corresponding Author: bereneice21@gmail.com

Light affords a convenient avenue for transmitting, encoding, computing and filtering information where structuring the spatial degree of freedom allows us to perform operations at the speed of light and transfer a large range of information simultaneously in both the classical and quantum realms of physics. For example, exploiting the spatial structure of light provides a notable increase in the rate of transmission in both free-space and optical fiber transmissions. Applying this to photons also extends quantum protocols, entangling experiments into multidimensionality.

Accordingly, these schemes rely on the ability to detect and distinguish the structures holding the information encoded. Hermite-Gaussian (HG) or Laguerre-Gaussian (LG) modes are two examples of spatial modes that form an orthogonal basis and thus allows one to identify, extract and thus retrieve the entirety of the states being carried by the beam by projecting onto the individual states.

Traditionally, this is done by unitary transformations whereby the light is passed through linear elements such as a spatial light modulator. Here we demonstrate that this idea is not confined to this, but can also be extended into the non-linear regime by utilizing sum-frequency generation (SFG). By co-linearly directing the beam one would like to analyze into a χ^2 crystal with another beam carrying the basis mode one would like to project onto, one can detect the associated information in the resulting color-converted or SFG beam due to the conservation of momentum. Not only is non-linear optics shown to be a viable method for detecting spatial structures, changing the color of the light being detected offers additional flexibility in the detection hardware required as well as encryption schemes, such as high dimensional teleportation.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics of Condensed Matter and Materials / **236**

ELECTRONIC PROPERTIES OF OXYGEN ADSORBED Li/MO2 (M= Ti, V, Mn) SURFACES IN Li-AIR BATTERY

Authors: PERCY NGOBENI[1]; Phuti Ngoepe[2]; khomotso Maenetja[3]

[1] *UL*

[2] *University of Limpopo*

[3] *University Of Limpopo*

Corresponding Author: khehlapercy0@gmail.com

Lithium-air batteries, based on their high theoretical specific energy, are a particularly attractive technology for electrical energy storage that promises a long-range electric vehicle extensively affordable. However, they suffer from the production of unstable discharge products which leads to capacity fading of the battery. Several catalysts have been used to improve Oxygen Reduction Reaction (ORR) and Oxygen Evolution Reaction (OER) which will yield stable discharge product. In this study, Density functional theory (DFT) is employed to investigate the relative stability of electronic properties of oxygen adsorption on Li/MO2 (110) surfaces. Electronic properties such as band structures and density of states (DOS) are investigated on different configurations (dissociated, peroxo on Li, peroxo on Li-M, and peroxo on M) as oxygen is adsorbed on Li/MO2. The electronic band structures were calculated to check the conductivity of the systems. The DOS was calculated to check the stability of the system by comparing how each system behaves towards the Fermi level. These findings are important in improving the cycling performance of Li-air batteries and give insight into the reactivity of Li/MO2 (110) surfaces.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / 237

Fabrication of MIT layers in diamond via boron ion implantation processes.

Author: Nyiku Mahonisi[1]

[1] *University of Witwatersrand*

Corresponding Author: ncmahonisi@gmail.com

The physio-chemical properties of semiconducting diamond materials under extremely low temperatures have fundamental implications in Condensed Matter Physics. Highly doped boron diamonds have been shown to reach a superconductive state at critical temperatures (T_c) ranging from $4-10$K, albeit, such properties are “at the moment” only attributed to heavily boron-doped synthesized samples via HPHT and CVD growth methods. Theoretical predictions have shown that by exceeding the current solubility limit of boron in diamond, an increase in T_c beyond the $4-10$K is possible, even close to room temperatures. However, in order to gain such a feat, an increase in active boron concentration beyond the metal-to-insulator transition (MIT) is an absolute necessity, and hence, non-equilibrium doping fabrication processes such as CVD growth and ion implantation are required. In this study, we explore carefully the properties of degenerate diamond layers with p-type impurity bands via low energy and low fluence ion implantation.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Astrophysics / **238**

Multi-messenger observations of ultra-faint dwarf galaxies as probes of dark matter

Author: Raees Noorbhai[1]

[1] *Wits School of Physics*

Corresponding Author: rnoorbhai@gmail.com

Multi-messenger observations using next generation telescopes have great potential in understanding the nature of Dark Matter. DM indirect detection through observations with CTA and LHAASO (in the gamma ray domain) and KM3NeT (in the neutrino domain) can shed light upon the non-Gravitational properties of DM. The DM models under consideration in this work were proposed to explain the DAMPE excess flux detected by Wukong in late 2017 and all involve Weakly Interacting Massive Particles, with a mass on the TeV scale, coupled exclusively to Standard Model Leptons via a heavy mediator. We make use of simulations of the expected indirect emissions from the Annihilation and Decay of the WIMPs, in both gamma and neutrinos. We consider observations, in both domains, of two Dwarf Spheroidal galaxies in the Local Group. The target galaxies are chosen as Segue I and Tucana II – with four observations in total being proposed for the three telescopes under consideration. All target Dwarf Spheroidal galaxies are Ultra-faints with particularly high astrophysical J and D factors. Using conservative estimates of telescope sensitivities, we forecast non-detection upper bounds upon the free parameters - the WIMP Annihilation Cross Section and the Decay Rate respectively.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / **239**

First principles calculations study of O3 and P2 NaMn1/2Fe1/2O2 as potential cathode for Sodium ion battery application

Authors: Ratshilumela Steve Dima[1]; Rapela Maphanga[2]; Nnditshedzeni Eric Maluta[3]; Prettier Morongoa Maleka[4]

[1] *University of venda*

[2] *CSIR*

[3] *University of Venda*

[4] *Yes*

Corresponding Author: dimaratshilumelasteve@gmail.com

Sodium oxides with mixed transition metals have received significant attention as positive electrode candidates for sodium-ion batteries, due to their high reversible capacity. To understand the relation between layered structures and electrochemical properties, it is necessary to understand layered compound phase transformations during electrochemical responses. Using first-principles calculations, we successfully investigate the electrochemical performance of the O3 and P2 NaMn1/2Fe1/2O2 for the sodium-ion batteries. We calculated the structural, electronic, and mechanical properties and both O3 and P2 NaMn1/2Fe1/2O2. The computational results are found to be well consistent with the experimental investigations. The electronic properties show that the metallicity of NaMn1/2Fe1/2O2 steadily increases during Na extraction, whereas the elastic properties show that adding 50% Mn NaFeO2 does not compromise the structure's stability.

Apply to be considered for a student ; award (Yes / No)?:

YES

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Nuclear, Particle and Radiation Physics / **240**

Upgrade of the iThemba LABS Fast Neutron Beam Facility towards ISO/IEC 17025 Accreditation

Authors: Zina Ndabeni[1]; Albert Boso[2]; Andy Buffler[3]; Mirco Dietz[4]; Quentin Ducasse[4]; Dieter Geduld[3]; Tanya Hutton[3]; Veronique Lacoste[5]; Tom Leadbeater[3]; Wynand Louw[6]; Peane Maleka[7]; Ralf Nolte[4]; Marcel Reginatto[4]; Ricky Smit[7]

[1] *University of Cape Town/iThemba LABS*

[2] *National Physical Laboratory*

[3] *University of Cape Town*

[4] *Physikalisch-Technische Bundesanstalt*

[5] *Institut de Radioprotection et de Sûreté Nucléaire*

[6] *NMISA*

[7] *iThemba LABS*

Corresponding Authors: ralf.nolte@ptb.de, zina.ndabeni@uct.ac.za, veronique.lacoste@irsn.fr, andy.buffler@uct.ac.za, pmaleka@tlabs.ac.za

The iThemba LABS fast neutron beam facility (D-line vault) is an international niche facility that can provide ns-pulsed quasi-monoenergetic neutron beams in the energy range of 30 to 200 MeV. Available neutron beam facilities with energy range similar to this facility are described in details by the EURADOS (European Radiation Dosimetry) Report 1. The facility has remained practically unchanged since it was first built more than 30 years ago and over the years, a number of problems associated with low energy neutron backgrounds in the vault and the stability of the proton beam on target were identified 2.

As a plan going forward and motivation for the vault development, the National Metrology Institute of South Africa (NMISA) designated iThemba LABS facility as an entity responsible for providing traceability for the medium and high-energy neutron measurements in South Africa. This resulted in a formal collaboration between iThemba LABS, University of Cape Town, together with international partners Institute de Radioprotection et Sûreté Nucléaire (IRSN in France), National Physical Laboratory (NPL in UK) and Physikalisch-Technische Bundesanstalt (PTB in Germany) to upgrade the facility in order to achieve ISO/IEC 17025 accreditation status for the medium and high-energy neutron region. We present the status on the progress of the D-line vault upgrade, including results from previous measurements of the neutron background from the original configuration of the vault. Results from these measurements, together with results from Monte-Carlo simulations, were used to reconfigure the physical infrastructure of the D-line vault.

References
1 Pomp S. et al., “High-energy quasi-monoenergetic neutron fields: existing facilities and future needs”, EURADOS, Braunschweig, Germany, EURADOS Rep. 2013-02 (May 2013).
2 Mosconi M. et al., “Characterisation of the High-energy Neutron Beam at iThemba LABS”, Radiation Measurements 45, 1342-1345 (2010).

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Astrophysics / **241**

Scaling Relations of the galaxies Interstellar Medium in Cosmological Simulations

Authors: Mpendulo Sibiya[None]; Lerothodi Leeuw [1]; Erwin de Blok [2]; Maarten Baes [3]

[1] *UWC (supervisor)*

[2] *Ugent/UCT (co-supervisor)*

[3] *Ugent (co-supervisor)*

This project is within a bigger project on Atomic Hydrogen in Simulated Galaxies. It is aim is to critically investigate and compare the interstellar medium scaling relations in SIMBA cosmological hydrodynamical simulations, with the interstellar medium scaling relations in the MeerKAT MHONGOOSE observed data. After post-processing, the SIMBA snapshots outputs with SKIRT parameters to produce spectral energy distributions (SEDs) for the investigation.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Astrophysics / **242**

Bow shocks formed by massive runaway stars in 3D

Author: Katlego Ramalatswa[1]

Co-author: Shazrene Mohamed [2]

[1] *University of Cape Town*

[2] *SAAO*

Corresponding Author: katlego@saao.ac.za

Hyper-runaways are stars moving at supersonic speeds through the interstellar medium; they can be thought of as a subset of runaway stars but moving with velocities that are comparable to the

Galactic escape velocity ($\sim 500\,\mathrm{km/s}$). Because of the strong stellar winds and high space velocities, we expect massive (hyper)runaway stars to produce bow shocks. We use PLUTO, a magneto-hydrodynamics grid code, to simulate these bow shocks, performing axi-symmetric hydrodynamic simulations in 3-dimensions while including thermal conduction and detailed radiative cooling processes. In this talk we will present our results for a range of stellar velocities ($100 \leq v_{\mathrm{star}} \leq 500\,\mathrm{km/s}$) and discuss the implications for potentially observing hyper-runaways.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Theoretical and Computational Physics / **243**

Robust control of quantum systems by quantum systems

Authors: Thomas Konrad[1]; Amy Rouillard[2]

[1] *UKZN*

[2] *University of KwaZulu-Natal*

Corresponding Author: rouillardamy@gmail.com

We present a quantum control scheme which allows for the control of a quantum system by other quantum systems, also called coherent feedback.1 An assembly of control quantum controllers are coupled sequentially to the to-be-controlled quantum system, driving the system into a target state. We determine a broad class of coherent feedback control channels by identifying the necessary and sufficient conditions which guarantee convergence to the target state, independent of the initial state of the system. We are especially interested in the possibility of autonomous control, meaning that once the system-controller interaction is set up the system converges to any target state encoded in the controllers without intervention by the experimenter. An explicit example of a unitary interaction between system and controllers which implements such a channel is given and we show that even weak system-controller coupling is sufficient to successfully stabilize the system in a target state as well as protect it against noise. The possibility to implement control dynamics is also explored.

Reference
1 Thomas Konrad, Amy Rouillard, Michael Kastner, and Hermann Uys “Robust control of quantum systems by quantum systems.” In preparation.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Photonics / **244**

Spatial profile shaping for use in optical fibres.

Author: Ashley Phala[None]

Co-authors: Andrew Forbes ; Angela Dudley

Corresponding Authors: angela.dudley@wits.ac.za, andrew.forbes@wits.ac.za, 2529303@students.wits.ac.za

Controlling the spatial profile of light through optical fibres is extremely useful in being able to deliver tailored high-power beams directly to the point of contact, as well as in optical communication systems. In this presentation, we compare various types of optical fibres, ranging from single mode, multi-mode step index and graded core fibres, as well as photonic crystal fibres. We first demonstrate spatial control by dynamically modifying the beam size of the fundamental mode coupled to an optical fibre with the use of a Digital Micro-mirror Device (DMD), which is verified against the expected coupling efficiency. Two methods are presented for generating and tailoring a Flattop profile with the use of a DMD. Ultimately, we plan to propagate the generated Flattop profile through a multimode fibre, of which we will outline the planned process.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc.

Applied Physics / **245**

Birefringence from digital phase-shifting measurements

Authors: Keshaan Singh[1]; Wagner Tavares Buono[1]; Manuel Fernandes[1]; Angela Dudley[None]; Andrew Forbes[2]

[1] *University of the Witwatersrand*

[2] *U. Witwatersrand*

Corresponding Author: keshaansingh@gmail.com

Measuring phase differences between orthogonal polarisations has become a common industry practice. In food and drug production the circular birefringence exhibited by chiral molecules has been used to identify and measure the concentrations of enantiomers, while linear birefringence has been used in stress and biological imaging. Conventional techniques regularly rely on stressing photoelastic materials to produce birefringence in order to measure the same phenomenon. We demonstrate how holographic phase shifting induced by a digital micro-mirror device (DMD) can be used to acquire spatially resolved arbitrary birefringence measurements. Linear and circular birefringence in both static and dynamic liquid crystal optics, metasurfaces as well as chiral sugar solutions were measured through maximum-likelihood estimation fitting. The acquired images have resolutions dependent purely on the camera used and the entire measurement process involves no moving parts. The polarisation and wavelength independence of DMDs as well as high refresh rates and relative low cost makes the technique a promising digital candidate for applications in industry.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Photonics / **246**

Diffraction from polarisation filtering axicons

Authors: Keshaan Singh[1]; Sabino Chavez-Cerda[2]; Wagner Tavares Buono[1]; Andrew Forbes[3]

[1] *University of the Witwatersrand*

[2] *Instituto Nacional de Astrofísica, Óptica y Electrónica*

[3] *U. Witwatersrand*

Corresponding Author: keshaansingh@gmail.com

Non-diffracting optical fields have exhibited numerous interesting properties, including self healing and radial acceleration, in addition to their propagation invariant intensities. Naturally, these properties have proven desirable in applications such as optical trapping, communication and metrology. One class of these fields is the set of Bessel-Gaussian modes which can be generated through the interference of conical waves from an axicon lens. Vectorial realisations of such fields have led to the observation of further interesting properties such as periodic acceleration and deceleration of local Stokes vectors. We investigate how the diffraction of orthogonal polarisation components across cylindrically asymmetric axicons recovers conical interference behaviour along the line of asymmetry. Total intensity sections as well as orthogonal polarization projections along lines of interest present proportionality to squared Bessel functions while orthogonal lines reveal no such structures. Total intensities maintain qualitative resemblance to parabolic non-diffracting beams, while the introduction of azimuthally varying phases associated with orbital angular momentum perturb the distributions. The results provide new insights into the nature of propagation invariant optical fields.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Applied Physics / **247**

Corrosion behaviour of spark plasma sintered Ti-Al alloys

Author: Mukonazwothe Sinthumule[1]

Co-author: Thato Tshephe [2]

[1] *University of Johannesburg*

[2] *Supervisor*

Corresponding Author: sinthumulemukzz@gmail.com

CORROSION BEHAVIOUR OF SPARK PLASMA SINTERED TI-AL ALLOYS
M. T. Sinthumule, T. Tshephe

Faculty of Engineering and Built Environment, University of Johannesburg, P.O. box 524, Auckland Park 2006, Johannesburg, South Africa

Tel.: +27 (65) 864 5787 E-mail: sinthumulemukzz@gmail.com
Abstract
The research study focusses on the corrosion characteristic of titanium-aluminum (Ti-Al) sintered alloys in various electrochemical solutions, such as sodium sulphate (Na2SO4) and potassium sulphate (K2SO4), respectively. Strong corrosion resistant material offers a long lifespan during service, to avoid maintenance or replacement costs, thus material should be treated before material application. This is important excess corrosion affects the mechanical properties of the material, thus material

not reaching its expected lifespan. Furthermore, the main aspect of the research study will be analyzing whether spark plasma sintering, which is a fast and efficient material fabrication method, will produce quality corrosion material when sintering the Ti-AL alloy as compared to conventional sintering and casting. Essentially, the rate of corrosion and the corrosion severity will be investigated through multiple quantitative experiments.
Key Words:
Ti-Al alloy, corrosion, spark plasma sintering, electrochemical

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

Undergraduate

Applied Physics / 248

Characterising laser beams through tubulence using vector beams and a simple quantum trick

Author: Isaac Nape[1]

Co-authors: Nikiwe Mashaba [2]; Nokwazi Mphuthi [3]; Sruthy Jayakumar [4]; Shanti Bhattacharya [4]; Andrew Forbes [5]

[1] *Structured Light Lab, School of Physics, University of Witwatersrand*

[2] *Optronic Sensor Systems, Defence and Security, Council for Scientific and Industrial Research (CSIR)*

[3] *School of Physics, University of the Witwatersrand, Private Bag 3, Johannesburg 2050, South Africa*

[4] *Department of Electrical Engineering, Indian Institute of Technology Madras*

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

Corresponding Author: isaacnape@gmail.com

Structure light beams that are tailored in the polarisation and transverse spatial degrees of freedom are ubiquitous to numerous applications and emerging technologies ranging from laser cutting, particle tracking, to high dimensional classical and quantum secure communication. Imperfections in optical elements or perturbations in a propagation medium can degrade the quality of spatial modes therefore limiting the performance of structure light beams in practical applications. For vector beams, where the spatial and polarisation components are coupled in a nonseparable way, spatially dependent perturbations can also indirectly distort the polarisation vector fields. Remarkably, vector beams possess intriguing features such as the ability to behave like quantum entangled particles, where the nonseparable correlations exist between the internal degrees of freedom (polarisation and spatial). Here we show that vector beams can be used to characterise the nonseparability, or equivalently entanglement, between the spatial and polarisation components of modes within the same subspace. By exploiting the parallelism between nonseparability in vector beams and quantum entanglement, we invoke a unique feature inherent to entangled states, namely channel state duality, to map the nonseparability of any spatial mode using a single vector beam. We demonstrate this principle through turbulence and apply it to different mode sets. This method advances the use of nonseparable states of light for the analysis of spatial mode decay through an optical medium.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Theoretical and Computational Physics / 249

Three-party reference frame independent quantum key distribution with an imperfect source

Authors: Comfort Sekga[1]; Mhlambululi Mafu[2]

[1] *Department of Physics and Astronomy, Botswana International University fo Science and Technology, Private Bag 16 Palapye, Botswana*

[2] *Botswana International University of Science and Technology*

Corresponding Author: comfort.sekga@studentmail.biust.ac.bw

Traditionally, quantum key distribution (QKD) is used for sharing secret key between two distant authorized participants with unconditional security. Here, we extend the reach of QKD by proposing a reference frame independent quantum key distribution (RFI-QKD) which allows three legitimate parties to share the common secret keys without any alignment of reference frames in their quantum channels. Furthermore, we relax the assumption of perfect state preparation by employing loss tolerant technique proposed by Tamaki et al. [Phys. Rev. A 90, 052314 (2014)] in our security proof, which makes the proposed protocol suitable for practical applications. In addition, we derive bounds of the proposed RFI-QKD protocol by considering finite-size key security analysis against general attacks in the presence of statistical fluctuations. The simulation results show that the performance of RFI-QKD with an imperfect source is comparable to that of RFI-QKD with a perfect source. Also, we investigated the impact of reference frame misalignment on the stability of our protocol for drifting of reference frames by angles = /4, /6 and = /8. Remarkably, our results demonstrate that our proposed protocol is not heavily affected by an increase in misalignment of reference frames as the achievable transmission distances are still comparable to the case where there is no misalignment in reference frames (when = 0). The proposed protocol has immediate application in quantum network scenarios such as web conferences and online courses, where there are more than two users who need to share keys.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Photonics / 250

Simulating a deformable mirror with a digital micro-mirror device

Authors: Lehloa Mohapi[1]; Angela Dudley[1]; Andrew Forbes[1]

[1] *University of the Witwatersrand*

Corresponding Author: lehloapeter@gmail.com

Lehloa Mohapi1, Andrew Forbes1 and Angela Dudley1

1. School of Physics, University of the Witwatersrand, Private Bag 3, Johannesburg 2050, South Africa

The generation of unique spatial profiles for high-power applications is becoming more topical, ranging from high-power, high bandwidth optical communication to spatial profile control in additive manufacturing and other laser-material interactions. In this presentation, we make use of a Digital Micro-mirror Device (DMD) in order to execute real-time, dynamic beam-shaping, which is capable of handling optical powers on the order of Watts. Here we outline and discuss the working principle of the DMD and compare it to other beam-shaping technologies. Ultimately, we plan to generate various spatial profiles with the use of a deformable mirror (capable of handling powers on the order of kilowatts). Here, we mimic the mechanical design of a bimorph deformable mirror on a DMD (as a proof of concept) and investigate the quality of the resulting spatial profiles.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Photonics / **251**

Quantitative measurements of the purity and dimensionality of high dimensional entagled states

Author: Isaac Nape[1]

Co-authors: Valeria Rodr´ıguez-Fajardo [2]; Feng Zhu [3]; Hsiao-Chih Huang [4]; Jonathan Leach [3]; Andrew Forbes [5]

[1] *Structured Light Lab, School of Physics, University of Witwatersrand*

[2] *School of Physics*

[3] *School of Engineering and Physical Sciences, Heriot-Watt University*

[4] *Department of Physics, National Taiwan University*

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

Corresponding Author: isaacnape@gmail.com

Quantum information processing beyond the traditional 2-dimensional qubit states has recently become topical, benefiting numerous applications such as quantum computing, quantum ghost imaging, quantum cryptography and quantum teleportation with high information capacities. The need to accurately characterize key performance parameters, such as the dimensionality of the encoding basis or the purity of an entangled state, is an essential step towards deploying any quantum protocol that uses high dimensional entanglement as a resource. Quantum state tomography takes far too long as the measurements scale to the fourth power with increasing dimensions while a simple spectral decomposition is not sufficient to confirm entanglement. Here, we present a simple to implement approach that scales linearly with dimensions and returns the purity and dimensionality of a quantum state accurately. In our approach a set of conditional measurements return visibilities that can be used in a simple fitting procedure to infer the purity and dimensions of the system. Our technique advances the toolbox for accurate characterisation of entangled quantum states. We demonstrate the technique in the orbital angular momentum and pixel (coordinate) basis using photons generated from spontaneous parametric down conversion.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Astrophysics / 252

The Diffuse Extragalactic Radio Background and the implications for gamma-ray astrophysics

Author: Nomthendeleko Motha[None]

Co-author: Soebur Razzaque [1]

[1] *University of Johannesburg*

Corresponding Author: 201400537@student.uj.ac.za

Radio emission from normal galaxies and radio galaxies is due to synchrotron radiation by relativistic electrons accelerating helically in the presence of a magnetic field. At low frequencies (in the kHz to GHz frequency band), the radio emissions accumulate over cosmological time to form a diffuse background that is similar to the cosmic microwave background (CMB). This background is known as the diffuse Extragalactic Radio Background (ERB). In this work, we produce an updated Protheroe and Biermann (1996) ERB model and test it against radio survey data at different redshifts using the evolution of galaxies with cosmic time. We conclude by presenting the implications for gamma-ray astrophysics, and therefore use our resulting ERB model to calculate the opacity of ultrahigh-energy gamma-rays in the universe.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Applied Physics / 253

Improvement of Abrasive Wear Resistance and Toughness on Hammer Mill Beaters by Additions of Molybdenum and Vanadium-Ferroalloys in White Cast Iron

Author: Fumani Nyambi[None]

Co-authors: Mbulelo Ngqase ; Willie Nheta

Corresponding Author: mngqase@uj.ac.za

Improvement of Abrasive Wear Resistance and Toughness on Hammer Mill Beaters by Additions of Molybdenum and Vanadium-Ferroalloys in White Cast Iron

F. Nyambi, M. Ngqase, W. Nheta

Faculty of Engineering and Built Environment, University of Johannesburg, P.O. box 524, Auckland Park 2006, Johannesburg, South Africa

Tel.: +27 (0) 76 875 5938 E-mail: fumaninyambi@gmail.com

Abstract

White cast iron (WCI) hammer mill beaters (HMB) are used as a secondary crushing equipment for comminution processing in the gold ore processing. The WCIHMBs are normally lasting for 336hrs in service and research study is proposed to improve the wear resistance without compromising the toughness of the iron. WCI normally consist of matrix consisting of pearlite and solid phase, i.e. cementite (Fe3C), which is precipitated within the pearlitic matrix. The additions of carbide formers, such as molybdenum (Mo) and vanadium (V), respectively is proposed for the improvement of wear

resistance and toughness of the iron, thus improving the material lifespan from 336hrs. Vanadium alloying element will be added in different quantities, such as 05, 1.0 1.5 wt. %V, respectively, thus forming vanadium carbides (VC), which will precipitate within the matrix. While, Mo additions will be kept constant, thus forming its own molybdenum carbides (Mo2C) and some will be absorbed by the matrix. In addition, V will be limited absorbed by the Fe3C, thus improving the Fe3C mechanical properties. The additions of both Mo and V alloying elements is expected to improve the iron hardness and toughness, respectively, thus improving the WCIHMB wear life expectancy. The proposed research study is an ASTM A532, class I, Type A and material designation NiCrHC and proposed mechanical tests will be material and wear Characterisation, such as hardness, micrography and wear, respectively. The improvement of wear resistance will be due the strong synergical effect of both Mo and V added together. The improvement in toughness will assist an WCIHMBs to absorb more energy during service, since the hardness will be higher normal WCI.

Key Words:
White cast iron, carbide formers, cementite (Fe3C), wear resistance and pearlitic matrix.

Apply to be considered for a student ; award (Yes / No)?:

yes

Level for award;(Hons, MSc, PhD, N/A)?:

undergraduate

Physics of Condensed Matter and Materials / 255

Effect of Eu3+ concentration on the BaAl2O4/CaAl4O7:x% Eu3+ (0 ≤ x ≤ 5.5) mixed phases nanophosphors synthesized using citrate sol-gel method.

Authors: Bamba Mahman[1]; Mpho Enoch Sithole[1]

[1] *SMU*

Corresponding Author: mahmanbamba@gmail.com

A series of undoped mixed phase BaAl2O4/CaAl4O7 (hereafter called BC) and doped BC:x% Eu3+ (0 < x ≤ 5.5) mixed phases nanophosphors were successfully prepared by the citrate sol-gel technique. The structure, morphology and optical properties of the nanophosphors were studied in details by the X-ray diffraction (XRD), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM) and Photoluminescence (PL) spectroscopy. XRD and SEM showed that all the BC:x% Eu3+ samples consists of the crystalline structure of the mixed phases of both the BaAl2O4 and CaAl4O7 materials. The structure resembles more of the BaAl2O4 than the CaAl4O7 phase. The TEM results suggest that crystallite sizes are in the nanometer scale with rods-like particles. PL results showed multiple emission peaks located at 436, 590, 616, 656 and 703 nm, which were assigned to the intrinsic defects within the BC matrix, 5D0 ⟶ 7F1, 5D0 ⟶ 7F2, 5D0 ⟶ 7F3 and 5D0 ⟶ 7F4 transitions of Eu3+, respectively. The decay curves evidently showed that the nanophosphors have persistent luminescence. The Commission International de l'Eclairage (CIE) analysis revealed that BC emits a blue colour while the Eu3+-doped BC phosphors emit in the orange-red region. The results indicate that the Eu3+-doped samples can potentially be used in the orange/red-emitting phosphors.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics of Condensed Matter and Materials / 256

White-light emitting BaAl2O4/CaAl4O7:x% Dy3+ (0 ≤ x ≤ 3) mixed phase nanophosphors synthesized using citrate sol-gel method.

Authors: Bamba Mahman[1]; Mpho Enoch Sithole[1]

[1] *SMU*

Corresponding Author: mahmanbamba@gmail.com

Light emitting un-doped mixed phase BaAl2O4/CaAl4O7 (here after named BC) and BC: x% Dy3+ (0 < x ≤ 3) nanophosphors were prepared using citrate sol-gel method. Their morphology and photoluminescence (PL) properties were studied by X-ray Diffraction (XRD), Scanning electron microscope (SEM), Transmission electron microscope (TEM) and Commission international de l'éclairage (CIE). XRD and SEM analysis revealed that the BC nanophosphors had both monoclinic and hexagonal structures. SEM unveiled nanostructures consisting of nanorods, which have been grown during the preparation. TEM confirmed the SEM results and further showed that crystallite sizes were in the nanoscale order. The PL increased when x% Dy3+ (0 < x ≤ 0.6) was increased. The optimum concentration was found to be 0.6% Dy3+, after which, the PL decreased due to concentration quenching. The emission peaks are located at 436, 477 and 571 nm corresponding to the defects within the intrinsic bandgap, 4F9/2 ⟶ 6H15/2 and 4F9/2 ⟶ 6H13/2 transitions of Dy3+, respectively. The CIE coordinates revealed that BC emits in the blue region while the Dy3+-doped BC nanophosphors emit in the white region. The results showed that a white-light LED can be produced with the nanophosphors.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Applied Physics / 257

Improvement of Abrasive Wear Resistance and Toughness on Hammer Mill Beaters by Additions of Molybdenum and Titanium-Ferroalloys in White Cast Iron

Authors: Bakang Johannes Motepe[None]; Ngqase Mbulelo[None]; Willie Nheta[None]

Corresponding Author: johannes.baki@gmail.com

Abstract
The research study will be focusing on the improvement of white cast iron hammer mill beaters that will be manufactured by casting and additions of alloying elements, such as carbide formers, i.e. molybdenum (Mo) and titanium (Ti) into the liquid melt. White cast iron, ASTM A532, Class I, Type A, material designation, NiCrHC alloy. A supplied hammer mill beater (HMB) of white cast iron (WCI) is widely used as crushing component during comminution processing in the gold ore processing. The supplied HMB are approximately lasting less than 336hrs in service. The proposed study will be casting, material characterization and wear testing, respectively. WCI are normally established with cementite (Fe3C), which normally gives wear resistance, while the matrix is responsible for toughness. While, an improvement of wear resistance can be achieved through additions of carbide formers, that will reduce the grain size, establish new carbides, such as molybdenum carbides (Mo2C) and titanium carbides (TiC), plus alloyed Fe3C and alloyed matrix with Mo content of approximately 50% of the melt content. Thus, the aim of the research study is to improve the WCI, HMB wear resistant lifespan by investigating using Brinell hardness tester, emission spectrometer,

Vickers's hardness tester, DWART, etc.
Key Words:
White cast iron, hammer mill beaters, titanium and molybdenum, wear resistance

Apply to be considered for a student ; award (Yes / No)?:

yes

Level for award;(Hons, MSc, PhD, N/A)?:

BEng Tech in Physical Metallurgy

Photonics / **258**

Beam shaping applied to Spontaneous Parametric Down-Conversion (SPDC)

Authors: Michael Lovemore[1]; Nicholas Bornman[2]; Wagner Tavares Buono[2]; Andrew Forbes[3]

[1] *Univeristy of the Witwatersrand*

[2] *University of the Witwatersrand*

[3] *U. Witwatersrand*

Corresponding Author: michael.lovemore98@gmail.com

The study of the spatial properties of light has been rapidly evolving in the past decades. One of many applications of studying spatial light can be found in the field of quantum optics and quantum information. In these fields of study, it has become increasingly important to shape beams in experiments. This is done in order to achieve a desired output, such as increasing the entanglement amongst photons for example. This can be achieved in theory by investigating the degree of entanglement of two correlated photons created by the process of spontaneous parametric down-conversion of an input photon whose transverse probability distribution is given by the field known as a pump field. Manipulation of the pump beam in order to attain a specified correlation between the two output beams is what is known as pump shaping. Here we aim for an arbitrary decomposition of the output beams in two bases (Hermite-Gaussian or Laguerre-Gaussian transverse modes), depending on the desired properties that wish to be explored. One noteworthy result is the generation of high dimensional maximally entangled states with no post-selection.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Astrophysics / **259**

Capturing Transients – From Biostatistics to Astronomy

Author: Anke van Dyk[1]

Co-authors: Vanessa McBride [2]; Paul Groot [3]

[1] *University of Cape Town/SAAO*

[2] *University of Cape Town & SAAO*

[3] *Radboud University & SAAO & UCT*

Corresponding Author: anke@saao.ac.za

Capture-recapture has been identified as a possible use case for estimating the underlying size of astrophysical transient and variable populations. We present a series of exploratory analyses using capture-recapture methods from biostatistics. Several estimators were tested for their applicability. We implemented two different capture-recapture approaches: a statistically closed population and a robust design, a mixture of closed and open population modelling.

In the first approach, we used simulations of the X-ray lightcurves of high mass X-ray binaries (HMXBs) to probe the convergence to the input population for several estimators as a function of the number of observations. The cadence played a crucial role in the rate of convergence to the underlying population with respect to the number of observations relative to the underlying period distribution of the recurrent source outbursts. The cadence and threshold discrimination of sources between outburst and quiescent states affect the capture probability of sources. Capture probability was demonstrated to be a key factor for population estimation, categorised into 'behavioural', 'temporal', and 'heterogeneous' effects. The simulations were extended to a real data application for HMXBs in the Small Magellanic Cloud using the OGLE-IV XROM survey. The observations were grouped into a fixed number of samples, and the optical characteristics included large variation in quiescent flux that creates heterogeneous population capture probability. The estimation was notably limited by the observational flux threshold in this instance.

The robust design investigated a population of Dwarf Nova identified from the OGLE-II, -III, and -IV phases. New individuals were added to the monitoring sample between phases, which the robust design accounts for in its modelling, and abundances were estimated within phases and for the entire study.

These investigations have opened a course for population estimation of transients and variable stars alongside population synthesis simulations. The generation of capture histories remain non-trivial through the choice of observation grouping, brightness scale, and imposed flux threshold. Recommendations are made for further exploration of the topic.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Poster Session / 260

Optic Fibre Sensors for Temperature Sensing in Pressurized Water Reactors

Authors: Bongani Maqabuka[1]; Simon Connell[1]; Eric Chinaka[2]; Graham Daniel[2]; Francois Pieterse[1]; Johan Slabber[3]

[1] *University of Johannesburg*

[2] *Necsa*

[3] *University of Pretoria*

Corresponding Author: bmaqabuka77@gmail.com

Fibre Optic Sensors (FOS) are fibres with optionally a specific preparation or functional coating, which endows the sensitivity to various environmental parameters. The sensor is designed for extreme environments. Specifically, the environment of a nuclear reactor core, where the dose may be 2 GGy in two weeks of operation. The technologies are based on Fibre Bragg Gratings (FBGs),

and also Long Period Gratings (LPGs). Using sense-region-gratings written into the fibre, one can measure length changes at the sensor with 1 pico-meter precision.

There is growing interest in optical fibre based sensors for application in nuclear reactors because of their intrinsic attributes, such as package compactness, high bandwidth, multiplexing, able to measure remotely in real time, and immunity to most electromagnetic perturbations. In-core, real-time, on-line and multi-parameter information gathering sensors throughout the nuclear power system could have the potential to improve efficiency and subsequently the overall cost of the nuclear power systems. In addition, the safety case would be greatly enhanced. FOS are presented as a remarkable new opportunity for sensing, especially in all kinds of extreme environments, and they represent a niche opportunity in the context of nuclear energy generally (PWR, BWR). In-core-sensor, on-line technology for sensing temperature, as well as other parameters can enable instantaneous Reactor State knowledge enabling novel reactor operations and management. We discuss the current state of our experimental and theoretical programme.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Theoretical and Computational Physics / **261**

Comment on the Quantum Supremacy Claim by Google

Author: Anirudh Reddy Segireddy[1]

Co-authors: Adenilton Silva ; Benjamin Perez-Garcia [2]; Thomas Konrad [3]

[1] *University of KwaZulu-natal*

[2] *Photonics and Mathematical Optics Group, Tecnológico de Monterrey*

[3] *UKZN*

Corresponding Author: anirudh.segireddy@gmail.com

The recent paper by google 1 claiming to achieve quantum supremacy in quantum computing has risen a lot of interest. While there seems to be lot of questions regarding the validity of their claims of achieving quantum supremacy and comparison with the classical time frames in calculating the same quantity, it seems that there is little doubt they indeed perform computation using quantum operations. But the question still remains "after operating the random quantum gates on the input state and making measurement, with just the output data available, how do we classify the data as quantum or classical?" I.e, The inputs sate has indeed has gone through a series of quantum operations (that operate on more than 2 qubits at a time) to produce the available data. This due to the fact that the data supporting supremacy is not verified. To address this question we propose a modified verification scheme to test the output data which can tell us whether data available is generated from a quantum computer or not along with the fidelity and number of qubits in the quantum computer.

References:

1 Frank Arute etal. Quantum supremacy using a programmable superconducting processor, Nature, Vol574, 24 October 2019, 505.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics for Development, Education and Outreach / **262**

Quantum technology: A potential tool for development in Africa

Authors: Makhamisa Senekane[1]; Mhlambululi Mafu[2]

[1] *Institute for Intelligent Systems, University of Johannesburg, South Africa*

[2] *Botswana International University of Science and Technology*

Corresponding Author: makhamisa12@gmail.com

The first quantum revolution started in the early 1900s and was characterized by the exploration of physics at the sub-atomic level. This was followed by a second revolution around the 1970s, which witnessed the application of quantum physics to develop quantum technologies. Currently, quantum technology is gaining traction in most parts of the world. However, besides having a history of innovation in quantum physics, Africa has fallen behind in each quantum revolution. Therefore, this paper addresses challenges relating to quantum technologies and points to the opportunities that quantum technologies present to close the gap and drive economic growth and development in Africa. The latter can be achieved through capacitation and the democratization of quantum technology knowledge. This initiative will, in turn, ensure that Africa is adequately represented in the second quantum revolution. Finally, in this paper, we introduce a new development framework, namely quantum technology for development (QT4D), and explore how Africa could deploy this framework to advance the adoption and use of quantum technology and become part of mainstream computing landscape. This will allow Africa to apply these technologies in space communications, finance, drug
development, and material science, thus solving some everyday challenges and opening new opportunities for industries leading to economic growth and development.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Applied Physics / **263**

Forecasting photovoltaic power generation using the temperature-based model – A case study at Vuwani Science Resource Centre

Author: Livhuwani Masevhe[None]

Co-author: Eric Nnditshedzeni Maluta [1]

[1] *SAIP*

Corresponding Author: livhuw1m@gmail.com

The maximum photovoltaic (PV) power output is not always achieved in real time measurement due to the unsteady weather conditions. Local solar irradiance plays a critical role in the performance of

solar panels. Therefore, the site assessment of weather conditions is necessary for a better forecasting of potential PV power output and recommendation of the suitable solar panel. Due to limited weather stations, solar irradiance data is not always available to be used as input in the models to predict power output in different locations. This paper presents two steps approach to be used in the location with insufficient weather parameter data, using temperature data which is easy to measure. The temperature-based model was utilized to estimate solar irradiance to be used in the three PV power output models. The three power models were tested under the standard test condition and compared with the solar panel characteristics provided by the manufacturer. The study is based on the historic temperature data of 2019 collected from the South African University Radiometric Network (SAURAN), USAid Venda station in Vuwani, Limpopo. The results show a good correlation between the measured and calculated solar irradiance as supported by RMSE value of 1.84, MAE value of 1.39, MBE value of 1.29 and R2 statistics value of 0.84, which validated the temperature-based model and made it a reliable input for the three power output models. The average annual power output from the models were respectively, 1016.58 W, 1139.25 W and 910.17 W. The study has proven that the forecast of solar power output can be conducted in areas with limited weather data.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Applied Physics / **264**

High resolution Laplace deep-level transient spectroscopy characterization of radiation induced defects in germanium.

Author: Cambel Thaba[1]

Co-authors: Fatemeh Taghizadeh [1]; Danie Auret [1]; Mmantsae Diale [1]

[1] *Department of physics, University of Pretoria*

Corresponding Author: thabacambelrashia@gmail.com

In this study we used high resolution Laplace Deep-Level Transient Spectroscopy (L-DLTS) to study the electrical properties of the E and E´ defects in germanium (Ge) which are introduced by alpha particle radiation. Current-voltage and capacitance-voltage measurements reveal a decrease in the quality of the devices fabricated on the radiated samples. The activation energies for these defects were found to be 0.370eV and 0.375eV, respectively. The electric field dependence of these defects was measured, and the capture cross-sections were measured from varying pulse width.

Keywords: Alpha radiation induced defects in Ge; Laplace Deep-Level Transient Spectroscopy; Electric field; Capture cross-section.

Apply to be considered for a student ; award (Yes / No)?:

yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics for Development, Education and Outreach / **265**

The global Gender Gap project: fair treatment, and some recommendations for South Africa

Author: Irvy (Igle) Gledhill[1]

Co-authors: Gillian Butcher [2]; Silvina Ponce Dawson [3]

[1] *U. Witwatersrand*

[2] *University of Leicester*

[3] *Universidad de Buenos Aires*

Corresponding Author: igle.gledhill@wits.ac.za

The design of initiatives for reducing the gender gap should be based on evidence. The resolution on which the International Union of Pure and Applied Physics (IUPAP) Working Group on Women in Physics was founded was to "to survey the situation of women physicists in IUPAP member countries, to analyze and report the data collected along with suggestions on how to improve the situation...". A major step in this direction was the Global Survey of Physicists of 2010 [Ivie and Tesfaye, Physics Today **65** 47-50, 2012]. However, changes occur in the global academic, scientific and social environment, and in 2016 a successful application was made to the International Science Council for the project "A Global Approach to the Gender Gap in Mathematical, Computing, and Natural Sciences: How to Measure It, How to Reduce It?". The project was proposed by IUPAP, and involved seven additional international unions: mathematics, chemistry, astronomy, industrial and applied mathematics, biosciences, history and philosophy of science, and computing machinery, together with three international organisations: UNESCO, GenderInSITE, and the Organisation of Women in Science for the Developing World. The project undertook three tasks: a global survey to which there were 32 346 respondents, a data-backed study of publication patterns, and the collection of initiatives known to have successfully addressed the gender gap in science. When a statistically significant difference is seen between the responses of men and women in a multivariate model that includes discipline, geographic region, country development level, and employment sector, then it is likely that the difference in the men's and women's responses is due to gender and not to any other factors. The most significant difference was seen in reporting on sexual harassment, with 29% of women and 2% of men in physics indicating that they personally encountered sexual harassment at school or work. In this short paper the focus will be on fair treatment at work. In physics there is a statistically significant gap in response to the statement "My employer treats everyone fairly", with which 62% of women and 73% agree. Recommendations will be offered.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics for Development, Education and Outreach / 266

South Africa and the Joint Data-backed Study of Publication Patterns of the Global Gender Gap project

Author: Irvy (Igle) Gledhill[1]

[1] *U. Witwatersrand*

Corresponding Author: igle.gledhill@wits.ac.za

Peer-reviewed publications are the basis of the body of scientific knowledge and of acknowledgement of contributions to science. In many countries, authorship is also used in the evaluation of individual performance and institutional achievement, and has become a part of hiring and promotion practices. As the participation of women in physics changes, it is of interest to understand whether

a gender gap exists in publication. A Joint Data-backed Study of Publication Patterns was undertaken as a task within the Gender Gap in Science Project initiated through the International Science Council. This global project was a collaboration of eight scientific unions (mathematics, chemistry, physics, astronomy, industrial and applied mathematics, biosciences, history and philosophy of science, and computing machinery) together with three international organisations (UNESCO, GenderInSITE, and the Organisation of Women in Science for the Developing World). The bibliometric study of gender patterns was based on metadata available through publication databases, which allow inference of author gender from name strings using services that provide access to databases of names. Five such services were benchmarked. Results have been made available in an interactive online tool, from which the data available from South Africa have been drawn. Within the NASA Astrophysics Data System, the rise in South African publications in the field can be observed, together with the evolution of the proportion of authorships by women. Global results on fractional authorships by women in high-impact journals in theoretical physics shows average percentages of women near 10%, with little or no tendency to rise since 1999, while top journals in astrophysics and astronomy show steadily rising fractional authorships by women which have approximately doubled since 1999 [Mihalević and Santamaría, chapter in Roy, Guillopé and Cesa, eds., A Global Approach to the Gender Gap in Mathematical, Computing, and Natural Sciences, Int. Mathematical Union, Berlin 2020].

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Applied Physics / 267

Kinetics study of thiosulphate gold dissolution from primary leaching precipitates of refractory gold ores

Author: Danielle Owiredu[1]

Co-author: Antoine- Floribert Mulaba-Bafubiandi [1]

[1] *University of Johannesburg*

Corresponding Author: 218000893@student.uj.ac.za

The gold industry in South Africa, mainly based on the metal extraction through cyanide leaching and the use of microorganisms, has been among the top 10% country's main source of income. This results in a strong economy, emergence of new towns and new financial structures. The use of cyanide as a lixiviant raises serious environmental concerns as it negatively impacts on the biodiversity, humans, soil, water, air and surrounding flora. Additionally, gold extraction operational costs continue to grow because of the ore falling grades, increased mining depth in the reserves, and a drop in the gold price on the market, resulting in a gradual drop in gold production. As a result, enhanced productivity is crucial to the gold industry's sustainability in South Africa. In the search of alternative solutions, thiosulphate (copper ammonia system) is studied as a potential substitute to cyanide for the recovery of gold from its minerals. The paper discusses the kinetics of gold dissolution in a thiosulphate aqueous solution as lixiviant concentration is varied from 0.5 M to 3M and the contact time in the leaching vessel is maintained in the range between 30 minutes and 6 hours. The shrinking core model as well as the solution diffusion model exploiting the double layer concept elucidate the outcomes of the work justifying the kinetics models observed.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Nuclear, Particle and Radiation Physics / 268

Comparison of Indoor Radon Levels measured with three different Detectors (Passive and Active).

Authors: Cynthia Sethabela[None]; Ocwelwang Atsile [1]; Manny Mathuthu[2]

[1] *2Centre for Nuclear Safety and Security (CNSS), National Nuclear Regulator (NNR)*

[2] *North West University*

Corresponding Author: csethabela@gmail.com

Radon is a non-reactive, naturally occurring gas that is released during the decay of uranium-238 (238U) to radium-226 (226Ra) then radon-222 (222Rn). Radon is colourless, odourless and invisible and it can be found in air, soil, water and building materials. Its presence can only be detected by the use of detectors that can give out its concentration levels. This radioactive gas can be measured by following two different measurement techniques, the active or passive technique. In this study, three types of radon detectors (2 passive and 1 active) were deployed at the Centre for Applied Radiation Science and Technology (CARST), North-West University (NWU) Mafikeng Campus to measure the radon concentration in the laboratory waste room that stores radioactive waste materials.
The three radon detectors used were the AphaGUARD model PQ 2000 radon detector, Airthings radon detector and Solid-State Nuclear Track Detector (SSNTD). The detectors were deployed for the same duration of three months. Results showed that the AphaGUARD measured a minimum radon concentration of 37.98 Bq/m3, the SSTND measured a maximum of 76 with Bq/m3 and lastly, Airthings measured a maximum of 34 Bq.m3. The average radon levels obtained from the Airthings wave plus monitor and the AlphGUARD are within a comparable range compared to the passive SSTND results. Results from all measurements are however not displaying alarming levels as they are below the recommended World Health Organization (WHO) reference level of 100 – 300 Bq/m3.
Keywords: Indoor radon concentration, Radioactive Waste material, Gold/Uranium Mining dumps, Reference levels, Lung cancer.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

Masters

Theoretical and Computational Physics / 269

An alternative test of Bell's theorem?

Author: Thomas Konrad[1]

[1] *UKZN*

Corresponding Author: konradt@ukzn.ac.za

Inspired by the dual correspondence between measurement and preparation procedures, we discuss inequalities for observables of local realistic models which are violated according to the predictions of quantum mechanics, thus demonstrating the inability of classical physics to reproduce all quantum predictions (Bell's theorem). Such Bell inequalities test the statistical correlation between

different state preparations that lead to the same measurement result rather than vice versa as in previous Bell tests. The different perspective on quantum foundations leads to a new QKD protocol and hopefully paves the way to other applications of quantum mechanics.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Theoretical and Computational Physics / **270**

Quantum Entanglement and relativistic quantum mechanics.

Authors: Jonathan Hartman[1]; Simon Connell[1]; Christian Engelbrecht[1]; Francesco Petruccione[None]

[1] *University of Johannesburg*

Corresponding Author: hartman.jonathan2@gmail.com

Previously, we have discussed Bell correlations in a relativistic setting and the possibility of using these to detect weak forces between particles. Now a theoretical description of quantum entanglement in terms of relativistic quantum mechanics is presented. Essentially, in non-relativistic quantum mechanics, entanglement leads to a non-local correlation between 2 particles. This was shown by John Bell in 1964 when he derived an inequality that should hold for all possible correlations that could be described by classical local realism. However, it turns out that the predictions of quantum mechanics can violate this inequality and these predictions have subsequently been confirmed experimentally, hence these correlations must be non-local. Bell's original calculation was only done for non-relativistic quantum mechanics but there have been some recent authors who have tried to do the calculation for relativistic quantum mechanics. What they have found is that the Bell correlations in relativistic quantum mechanics are altered slightly from the non-relativistic case. For example, the measurement of the Bell correlations from a lab frame in a Lorentz boost perpendicular to the centre of momentum frame produces a correlation that differs from the maximum violation by the Wigner angle (i.e. the angle produced by combining 2 Lorentz boosts in special relativity). While at first sight, it appears as the the correlation is weakened, one can in fact recover the maximal violation of the Bell inequality by adjusting the directions of measurement relative to each other by this Wigner angle. So in fact, the maximal violation of Bell's inequality is preserved but in different directions. This effect was the centrepiece of our previous work published in SAIP conference proceedings because we showed that if there were accelerations between the entangled particles (probably due to forces between the particles), it could potentially produce a measurable effect. Now we're putting this work on a more theoretical footing, by calculating the effect in the language of relativistic quantum mechanics by making use of Dirac spinors and the Schwinger-Tomonaga equation.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

Phd

Poster Session / **271**

Impact of Experimentally Constrained Nuclear Level Density and Photon Strength Function of \(ˆ{182}\)Hf on the Nucleosynthesis Puzzle of \(ˆ{182}\)Hf

Author: Nomcebo Yende[1]

[1] *UJ*

Corresponding Author: yendenomcebo@gmail.com

The Nuclear level density and \(\gamma\)-ray Strength Function are primary ingredients for astrophysical reaction rate calculations based on the Hauser-Feshbach approach. These parameters need to be well understood to improve our understanding of \(ˆ{182}\)Hf production in astrophysical environments. The new experimentally constrained \(\gamma\)SF and NLD in \(ˆ{181,182}\)Hf were extracted, using the Oslo method first-order phase transition. In particular, a \(ˆ{181}\)Ta(d,X), at 15 MeV experiment was conducted at Oslo cyclotron in which the NaI(Tl) and silicon detectors were used to detect \(\gamma\)-rays and \(\alpha\) particles. The particle coincidence events were used to extract NLDs and \(\gamma\)SF of \(ˆ{179,180}\)Hf from which those of \(ˆ{181,182}\)Hf were inferred. Based on these experimental results the Maxwellian averaged (n, \(\gamma\)) cross-sections of \(ˆ{180}\)Hf(n,\(\gamma\)) and \(ˆ{181}\)Hf(n,\(\gamma\)) reactions were computed with the TALYS reaction code. These results can be used to shed some light on the nucleosynthesis puzzle of \(ˆ{182}\)Hf.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics for Development, Education and Outreach / **272**

Energy assessment in tertiary institution laboratory for a sustained learning and teaching experience during COVID-19 restrictions

Author: Pitsi Regan Selelo[1]

Co-authors: Motshidisi Gladys Manxila [1]; Antoine Floribert Mulaba-Bafubiandi [1]; Dakalo Vinoliah Maphangule [1]

[1] *University of Johannesburg*

Corresponding Author: seleloregan2112@gmail.com

Intense domestic resources utilisation might have been heavy weighing toward an increased electricity and water consumptions during the COVID-19 related lockdowns and people movement restrictions, while the routine energy consumption by technical instrumentations, and electronic and electrical appliance at institutions of higher learning would have been slightly reduced. Closely monitored access to laboratories by student groups and academic and technical staff compounded with a reduced frequency might be the root causes. Energy and resources utilisation are also tools used in the performance assessment of a tertiary programme or an academic department sustainability. The effective and efficient laboratory usages during the lockdowns imposed online learning and teaching activities have been assessed for the period between March 2020 to April 2021. Five laboratories (mineral processing, analytical techniques laboratory, heat treatment laboratory, wet chemistry laboratory, and coal processing laboratory) of a metallurgical engineering department at a local university were used. Bill of materials, water and related energy consumed were benchmarked with respect to the average consumption within the country while laboratory access by students

and student to staff ratio during the above-mentioned period served as supporting additional component into the sustainability criteria of the studied academic department. The paper discusses the modelling of the sustainability of the studied academic department using the Grey rationale analysis optimisation methodology. Multiple alternatives as sustainability pointers are discussed and the most desirable outcomes elucidated.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Theoretical and Computational Physics / **273**

B and D meson Suppression and Azimuthal Anisotropy in a Strongly Coupled Plasma at $\sqrt{s_{NN}} = 5.5$ TeV

Authors: Blessed Ngwenya[1]; William Horowitz[1]

[1] *University of Cape Town*

Corresponding Author: ngwble001@myuct.ac.za

We present predictions for the suppression and angular distribution of B and D mesons in $\sqrt{s} = 5.5$ TeV Pb+Pb collisions at the LHC for central, semi-central and peripheral collisions. Ultrarelativistic heavy-ion collisions produce an enormous amount of energy, resulting in the formation of a quark-gluon plasma (QGP). Studying the behaviour of particles (e.g. heavy quarks) propagating through the QGP enables us to probe the physics of the QGP and the many-body dynamics of QCD. B and D mesons are the decay products of heavy quarks i.e. bottom and charm respectively and their large mass implies that they are produced very early in the collision and act as ideal probes, since they navigate the whole evolution of the QGP medium. The suppression of heavy mesons is a result of interactions with the produced QGP medium and the angular distribution is due to the initial geometric asymmetry during the collision. These heavy flavour energy loss studies are crucial for understanding the properties of nuclear matter and we provide these predictions for comparison to future LHC measurements.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Photonics / **274**

Effect of Gold Nanoparticle-Hypericin Mediated Photodynamic Therapy on breast Cancer Cells.

Author: Dimakatso Mokoena[1]

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

[1] *UJ Laser Research Center*

[2] *University of Johannesburg*

Corresponding Author: drmokoena2@gmail.com

Cancer is a global emergency that needs instant intervention. Breast cancer is the second most common cancer after Lung, and the first most common cancer amongst women. Current treatments are linked with adverse side effects, treatment failure and cancer relapse. Photodynamic therapy (PDT) is one of the emerging cancer treatment options that is highly selective and specific towards cancer cells. Consequently, the use of gold nanoparticles (AuNP) further enhances the efficacy of PDT. In this study, gold-nanoparticle (AuNP) conjugated Hypericin (Hyp) mediated PDT was used for the treatment of MCF-7 human breast cancer cells by inducing cell death, in vitro. Cellular responses after treatment at 12 and 24 h incubation post PDT, and at different laser fluencies was observed. The morphological changes, viability, cytotoxicity and cell death analysis by Annexin V/PI staining was performed. The results showed activation of the apoptotic pathway with characteristic features of dying cells observed in their morphology and biochemical responses. Hence this study provided an insight into the application of advanced PDT in breast cancer treatment by actively targeting the apoptotic cell death pathway in vitro.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics of Condensed Matter and Materials / 275

Optical, structural and electrical properties of Zr doped CoSe for photovoltaic application.

Author: Faith Ochai-Ejeh[1]

Co-authors: Imosobomeh Ikhioya [2]; Ernest Ejeh [3]

[1] *University of Nigeria, Nsukka*

[2] *Department of Physics and Astronomy, University of Nigeria, Nsukka*

[3] *Department of Physics, University of Pretoria, South Africa*

Corresponding Authors: faith.ugbo@unn.edu.ng, ejehernest@gmail.com, imosobomeh.ikhioya@unn.edu.ng

CoSe and Zr doped CoSe thin film materials were successfully synthesized via spray pyrolysis technique. The optical, structural and electrical characterization where carried out using UV –visible spectrophotometer, XRD and four point probe at ambient temperature. The materials showed good optical, structural and electrical properties. The energy band gap of the of the material pepared at different Zr dopant concentration at 120OC substrate temperature displayed energy band gaps ranging from 1.2 -1.5 eV. The Zr dopant material improved the absorbance value of the as-prepared undoped CoSe thin materials indicating a good potential for photovoltaic applications

Apply to be considered for a student ; award (Yes / No)?:

NO

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics for Development, Education and Outreach / 276

Grey Rationale Analysis for the sustainable rural community project success in Manghweni community , Limpopo: A physics approach

Author: Ndzalama Heighten Maluleke[1]

Co-author: Antoine-Floribert MULABA-BAFUBIANDI [2]

[1] *University of Johannesburg*

[2] *School of Mining, Metallurgy and Chemical Engineering, University of Johannesburg*

Corresponding Author: heightenndzalama@gmail.com

Manghweni village in Limpopo as any rural area does not have enough job opportunities for its inhabitants. Community projects might be initiated and developed to provide community residents with opportunities to either start their own small businesses or work for part-time jobs under the municipality or the local leadership. This would contribute to the socio-economical survival. In the past 10 years, many community led project have been found failing and abandoned. The need to palliate the root causes of community project deliverables failure and abandonment and the necessity to set and successfully implement appropriate remedial strategies in Manghweni prompted this paper. The physics reasoning behind the grey rationale analysis methodology has been employed in this qualitative study where structured questionnaires were administered in a semi-structured interviews. Secondary data from recorded municipality information center were also used. Findings identified failure root causes as expressed by the Pareto diagrams. Based on the above, strategies for sustainability of future community led projects in Manghweni are discussed while the most suitable outcome alternatives are derived from the grey rationale analysis on the above.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics of Condensed Matter and Materials / 277

The influence of thermal annealing on defects induced in Xe implanted n-type 4H-silicon carbide

Authors: Ezekiel Omotoso[1]; Walter Meyer[2]; Danie Auret[2]; Aletta Prinsloo[3]; Charles Sheppard[1]

[1] *Department of Physics, University of Johannesburg*

[2] *University of Pretoria*

[3] *University of Johannesburg*

Corresponding Author: eomotoso@uj.ac.za

In this study, 4H-silicon carbide samples were bombarded with 167 MeV Xe ions to a fluence of 1×108 cm-2 at 300 K prior to the fabrication of Schottky contacts. The samples were also annealed at approximately 900 ℃ before thermal fabrication of the contacts. When compared current-voltage results with the as-grown device, generation-recombination occurred in the implanted samples. The presence of four deep level defects (0.10, 0.12, 0.16 and 0.65 eV) were observed in as-grown devices when characterized by deep level transient spectroscopy. In addition, two deep level defects with activation energies of 0.40 and 0.69 eV below the conduction band minimum were induced as a result of implantation. These two induced-defects have similar signatures to other defects observed by MeV

electron irradiation. It was observed that the two defects induced were annealed out at 400 ℃ which indicated the instability of the defects after annealing the implanted sample.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Photonics / **278**

EFFECTS OF ATMOSPHERIC TURBULENCE ON HERMITE GAUSSIAN MODES VIA CONVOLUTIONAL NEURAL NETWORKS

Authors: Kemi Adewale[1]; Yaseera Ismail[2]; Francesco Petruccione[3]

[1] *University of KwaZulu-Natal, Durban, South Africa*

[2] *University of KwaZulu-Natal*

[3] *University*

Corresponding Author: kemiadewale2@gmail.com

Hermite-Gaussian laser modes are a complete set of solutions to the free-space paraxial wave equation in Cartesian coordinates. They are often referred to as transverse electromagnetic modes and represent a close approximation to physically realizable laser cavity modes. Their applications ranges from enhancing optical communications information capacity to description of optical fields as well as in achieving high resolution imaging in microscopy. This study will propose and implement atmospheric turbulence effects on hermite Gaussian laser modes with orbital angular momentum.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Nuclear, Particle and Radiation Physics / **279**

Connecting multi-lepton anomalies at the LHC and Astrophysical observations

Author: Elias Malwa[1]

Co-authors: Geoff Beck [2]; Ralekete Temo [3]; Mukesh Kumar [4]; Bruce Mellado [4]

[1] *Wits HEP Group*

[2] *University of Witwatersrand*

[3] *School of Physics and Centre for Astrophysics, University of the Witwatersrand*

[4] *University of the Witwatersrand*

Corresponding Author: elias.malwa@cern.ch

The connection between the multi-lepton anomalies at the Large Hadron Collider and astrophysics can be described by a two Higgs doublet model with an additional singlet scalar (2HDM+S). We make studies on the interaction mechanism of singlet S to dark matter. This is achieved from the annihilation of Dark Matter (DM). We demonstrate that using this model we could also describe the excesses in gamma-ray flux from the galactic centre and the cosmic-ray spectra from AMS-02. Moreover, this study provides indirect searches for new bosons that have never been performed before at the LHC, namely the search for H⟶SS,S⟶invisible and S decaying into other particles.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Nuclear, Particle and Radiation Physics / **280**

Searches for heavy scalar resonance through hadronic jet reconstruction using ML techniques at e-p colliders

Author: Elias Malwa[1]

Co-authors: Mukesh Kumar [2]; Xifeng Ruan [3]; Bruce Mellado [2]

[1] *Wits HEP Group*

[2] *University of the Witwatersrand*

[3] *University of the Witwatersrand*

Corresponding Author: elias.malwa@cern.ch

Extending the Standard Model with second Higgs doublet populate the scalar particle spectrum. Here we take an opportunity to search heavy scalar H resonance of mass around double of Higgs boson, mH = [250 - 270] GeV at future electron-proton (e-p) collider in charged current process. We consider the hadronic decay of H⟶W+W−⟶jjjj and use machine learning tools to reconstruct the mass of H. Further isolation of scattered jets from the e-p collision helps to provide better signal to background significance. Different observable are studied in this work to investigate the nature of H.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Applied Physics / **281**

NUCLEAR-MEDICAL TECHNIQUES IN 4IR DIAMOND MINING

Author: Gideon Gideon Bentum[1]

Co-author: Thendo Nemakhavhani [2]

[1] *University of Johannesburg*

[2] *University of Johannesburg*

Corresponding Authors: tnemakhavhani@uj.ac.za, gbentum@uj.ac.za

Kimberlite rock has been activated with a high energy photon beam, following which high energy resolution spectra have been acquired in time differential mode. This enables a lifetime analysis of the isotopes that have been activated. An isotope identification is then performed using the dual information of characteristic gamma rays and lifetimes. This enables an unambiguous assignment of the isotope identification. The results have been made quantitative by the Monte Carlo modelling of the activation process to extract the product of the effective radiation field and integrate this over the energy dependence of the cross-section. The results are compared to the known composition of kimberlite as follows: The time differential activation code, FISPACT, is used to perform a pathway analysis to establish the various activation pathways, given the mixed radiation field and the ENDF / TENDL cross sections for the various nuclear reactions. The pathway analysis is then used to attribute the measured activity to specific parent isotope composition, and hence to the elemental analysis of the kimberlite. The experimental work was performed using the Aarhus 100 MeV electron microtron. The results have two roles. In the first place, they establish the radiological significance of the activation process of the MinPET method in sorting diamondiferous from barren kimberlite rock. In the second place, this is an interesting analysis technique capable of nuclear analysis of light elements (carbon and oxygen) and also differentiating various PET isotopes.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MPhil

Applied Physics / **282**

Growth and characterization of CZTS and CZTSSe for solar cell application

Author: Sibusisiwe Phindile Mzamo[1]

Co-authors: Mmantsae Diale [1]; Juvet Nche Fru [1]; Dolly Langa [1]

[1] *University of Pretoria*

Corresponding Author: phindilemzamo@gmail.com

In this study, copper zinc tin sulphide (CZTS) and copper zinc tin sulphur selenide (CZTSSe) thin films were deposited on molybdenum (Mo), indium tin oxide (ITO) and fluorine-doped tin oxide (FTO) by sputtering deposition and were annealed in nitrogen at 500℃ for 60 minutes. The XRD patterns on all substrates showed tetragonal kesterite CZTS with I4¯ space group and tetragonal kesterite CZTSSe with I4 space group. Raman spectra further confirmed CZTS and CZTSSe. Dominant peaks showing red shifts from 337.2cm-1 for Mo/CZTS to 335.8 and 329.8cm-1 for FTO/CZTS and ITO/CZTS, respectively. Similarly, red shifts were observed for Mo/CZTSSe from 334.3 cm-1 to 331.4 and 322.5 cm-1 for FTO/CZTSSe and ITO/CZTSSe, respectively. The presence of copper tin sulphide (CTS) and zinc sulphide (ZnS) residue on CZTSSe were also revealed by the Raman. UV-Vis analysis depicted the bandgaps of ITO/CZTS, ITO/CZTSSe, FTO/CZTSSe to be 1.26, 1.16 and 1.35 eV, respectively. The sheet resistance, resistivity and conductivity of the thin films was measured using a four point probe. The smallest value resistivity of 2.095 ×⊠10⊠ˆ(-6)Ω.m was obtained on Mo/CZTSSe while ITO/CZTS had the largest value (115.2 ×⊠10⊠ˆ(-3)Ω.m). These findings

shed light on the structural, optical and electrical properties of ITO/CZTS, ITO/CZTSSe, FTO/CZTS, FTO/CZTSSe as possible bottom layers of tandem solar cells.

Keywords: CZTS, CZTSSe, FTO, ITO, sputtering deposition, solar cell.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Nuclear, Particle and Radiation Physics / **283**

Reliability testing of the End-of-Substructure card for operation within the ATLAS Inner Tracker

Authors: Max van der Merwe[1]; Joash Naidoo[1]

Co-authors: James Keaveney [1]; Jane Wyngaard [1]

[1] *UCT*

Corresponding Author: vmrmax002@myuct.ac.za

This study presents the results of irradiation tests used to qualify the End-of-Substructure (EoS) card for operation within the ATLAS Inner Tracker (ITk) at the High Luminosity Large Hadron Collider (HL-LHC). The EoS card is responsible for interfacing the data, command, and power signals between on and off-detector electronics. The radiation environment within the ITk poses a challenge for electronics as energized particles are capable of upsetting the logic, referred to as Single Event Upsets (SEU), of the constituent components, resulting in corrupted data. The irradiation test setup at the University of Cape Town is outlined and the steps taken in the experiments are discussed. The results found indicate that one of the primary ASICs on the EoS card is susceptible to SEUs under experimental conditions.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / **284**

Computational Modelling Study of Structure and Stoichiometry of Ta Doped Tetragonal Li7La3Zr2O12 Oxide Garnet for Solid State Batteries.

Authors: Mallang Masedi[None]; Phuti Ngoepe[None]; Raesibe Ledwaba[None]; Refiloe Maphoto[None]

Corresponding Author: refiloe.maphoto@ul.ac.za

Due to the outstanding chemical stability against high voltage electrode, the oxide garnet with tetragonal structure Li7La3Zr2O12 (LLZO), is one of the most promising solid-state electrolytes for li-ion batteries. However, it has low ionic conductivity (˜10-6 S.cm-1) at room temperature, which limits

its practical application. Doping with a supervalent cation such as Ta on the Zr site of LLZO is an effective way to improve Li+ conductivity and further stabilize the tetragonal phase. To this end, the fundamental aspects regarding stability of most stable structural configuration of Ta-doped LLZO structures are still not entirely clear.
In this study, we have combined the first-principle calculations within the generalised gradient approximation (GGA) by determining the structural and thermodynamic properties of pure and doped t-LLZO for high ionic conductivity. The negative energy of formation in pure t-LLZO shows that the structure is thermodynamically stable. We further employed the substitutional search (SS) module to identify all possible structures and provide a better understanding of doped supervalent cation Ta on the octahedral 16c Zr site of LLZO. The substitutional search was used to replace a fraction of Zr atoms with Ta atoms, so that it can enable excess Li to occupy the disordered octahedral sites (occupied by Zr atoms), which could facilitate better li-ion transport and increase ionic conductivity. Furthermore, the substitutional search generated 3 new multi-component structures (monoclinic Li28La12Zr7TaO48, orthorhombic Li14La6Zr3TaO24 and triclinic Li28La12Zr7TaO48) of Ta doped LLZO. The calculated lattice parameters of doped LLZO are smaller than that of pure t-LLZO. The results show that the distance between Li-Li in doped Ta-LLZO is smaller than in pure t-LLZO, which indicates that the smaller the difference between the dopant ionic radius and the critical dopant radius, the higher the conductivity. Therefore, the structural properties of tantalum-doped structures are shown to improve, due to the smooth decrease in calculated lattice parameters. Hence, it is important to understand the stability of Ta doped LLZO for the development of all solid-state Li batteries.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics for Development, Education and Outreach / 285

Data Science Skills Development with Big Data Hackathons

Author: Nikhita Madhanpall[1]

[1] *Office of Astronomy for Development*

Corresponding Author: nikhita@astro4dev.org

The IAU Office of Astronomy for Development (OAD) and DARA Big Data (Development in Africa through Radio Astronomy), in partnership with the Inter-University Institute For Data Intensive Astronomy (IDIA) is implementing a number of Big Data Hackathons in Africa in order to promote data-intensive research skills development ahead of the Fourth Industrial Revolution (4IR). These hackathons are part of a multi-year programme that aims to provide data science and machine learning exposure through interesting real-world projects that are astronomy or development related. We present the programme initiatives thus far, as well as a preliminary impact analysis and future model implementations.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics for Development, Education and Outreach / 286

Inaugural Quantum Computing School in Lesotho: Its impact and the Lessons Learnt

Authors: Naleli Matjelo[1]; Makhamisa Senekane[2]

[1] *Lecturer*

[2] *Department of Physics and Electronics, National University of Lesotho, Roma, Lesotho*

Corresponding Author: makhamisa12@gmail.com

This paper reports events and impact of a two-day Physics Without Frontiers (PWF) quantum computing School that took place on the 14th and 15th of November 2020 at the National University of Lesotho (NUL). Sponsored by the International Centre for Theoretical Physics (ICTP) and aimed to run annually, the School was intended to introduce quantum computing; using existing open-source quantum computing platforms, to undergraduate students in Lesotho as well as to highlight how quantum computing can be used as a driver for the Fourth Industrial Revolution (4IR). The School was also intended to encourage students to consider furthering their study in quantum computing and related disciplines. This (hoped-to-be annual) event will potentially unite the NUL, the Lesotho government and the ICTP in a long-term relationship; to the benefit of young Basotho scientists and students. The November 2020 event was, in and of itself, a success on several response measures including good and consistent attendance over the two days, as well as being influential based on several students' requests for postgraduate reference letters following this event. The outreach approach used here can be replicated elsewhere, especially in Africa, in order to capacitate students with quantum computing skills. Challenges encountered in this event will also be discussed in the paper.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Applied Physics / 287

Density functional theory study of Ni doped NaMnO2 cathode material

Author: Tshifhiwa Steven Ranwaha[1]

Co-authors: Ratshilumela Steve Dima [2]; Nnditshedzeni Eric Maluta [1]; Rapela Maphanga [3]

[1] *University of Venda*

[2] *University of venda*

[3] *CSIR*

Corresponding Author: funawahau@gmail.com

Rechargeable sodium-ion batteries (SIBs) have attracted great attention for large-scale electric energy storage applications and smart grid owing to the abundance of Na resources and comparable performance with lithium-ion batteries. The use of organic electrode materials enables a sodium storage system with high energy/power density, metal-free, environmental friendliness, flexibility, lightweight, and cost-effectiveness, in this study Density functional theory (DFT) has been used to study the electronic (band structure & TDOS), Elastic properties and intercalation voltage of NaMnO2 doped with Ni.The generalized gradient approximation (GGA) was used in the scheme

of Perdew-Burke Ernzerhof to describe the exchange -correlation function as implemented in the CASTEP package in material studio of BIOVIA. Our findings show that NaMnO2 possess high voltage window and a good reversible capacity. The elastic properties shows that NaMnO2 doped with Ni is stable, while the electronic properties shows that metallicity of NaMnO2 gradually increases during Na extraction

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics for Development, Education and Outreach / 289

Leveraging Artificial Intelligence and Quantum Machine Learning for economic growth in Africa

Author: Keaotshepha Karabo[None]

Co-author: Mhlambululi Mafu

Corresponding Author: keaotshepha.karabo@studentmail.biust.ac.bw

Artificial Intelligence (AI) and Quantum Machine Learning (QML) have become the most promising significant tools for addressing the challenges of the Fourth Industrial Revolution (4IR). Besides its use in understanding physical and complex systems, these tools have demonstrated unmatched potential applications in numerous research disciplines and sectors such as banking, finance, social networks, cybersecurity, and health. Most importantly, recently, they play a critical role in addressing challenges related to the Covid-19 pandemic. While these developments are remarkable, Africa has been lagging. Therefore, this paper aims to identify opportunities behind the challenges of implementing AI and MLA in addressing this technology gap, especially in the sectors mentioned above, and to participate in the 4IR fully. While the "quantum difference" presents various opportunities, especially for industries and stakeholders, we examine which challenges can be addressed by these intelligent tools. Thus, this will allow the proper application of these techniques to provide solutions to Africa's long-standing problems.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics for Development, Education and Outreach / 290

Determining the water isotope compositions in the North West Province, South Africa

Author: Joseph Mathuthu[1]

Co-authors: Manny Mathuthu [1]; Naomi, Dikheledi Mokhine [1]; Samuel Nde Che [1]; Johan Hendricks [1]

[1] *North West University*

Corresponding Authors: dikeledi.mokhine@gmail.com, mp18797@gmail.com, manny.mathuthu@nwu.ac.za

This study examines the origin of the sources and the effect of the change in water isotope composition isotopic constituent of hydrogen (2H), oxygen (18O) and radioactive tritium (3H). The rare stable isotopes of hydrogen and oxygen (2H, 18O) which are the constituents of the water molecule (H2O) itself and the radioactive tritium (3H) are the classical tools of isotope hydrology. The aim of this study was to determine the water isotope composition in the North West Province of South Africa. About forty borehole water samples from selected villages in the Northwest Province of South Africa was collected to investigate the relationship between stable isotopes (δ 18O and δ 2H), climate, and topography from underground water aquifers. A cavity ring-down spectroscopy analyser with laser-current-tuned cavity resonance a Picarro L2130-i was used to measure high-precision triple water-isotope ratios at the Center for Applied Radiation Science and Technology. Results show that a plot of δ2H vs δ 18O (y = 8.2423x + 13.185) gives a line which is very close to IAEA Global Meteoric Water Line, defined by the IAEA to represent global meteoric water line. The study of the origin of groundwater and groundwater recharge In hydrogeology, is often described by the composition of δ18O and δ2H. This composition in local meteoric water can be applied to trace local relative humidity, study local climate and used as a tracer of climate change.

Apply to be considered for a student ; award (Yes / No)?:

YES

Level for award;(Hons, MSc, PhD, N/A)?:

Hons

Theoretical and Computational Physics / 291

Warm Inflation and Swampland Conjecture

Author: Haidar Sheikhahmadi[1]

[1] *North West University*

Corresponding Author: h.sh.ahmadi@gmail.com

The scenario of warm inflationary scenario is reconsidered where the tachyon field plays the role of inflaton which drives inflation and interacts with the radiation during inflation. The interaction term includes a dissipative coefficient, and the model is considered for two different and common choices of it. The main perturbation parameters are obtained for the strong dissipative regime, and by applying the latest observational data it is sought to find the best values for the free constants of the model which brings the model prediction in great consistency with data. Then, these results for the model are examined to find out whether they are in agreement with the fundamental conditions of the model. It is realized that they are always not in agreement with these conditions and we need to restrict them. After that, we are going to consider the recently proposed swampland criteria, which imposes two conditions on the inflationary models. Although warm inflation is assumed as one of the inflationary models that is able to satisfy the swampland criteria, the precise investigation determines that not for all cases it happens. In fact, for the second case of the dissipation coefficient, where it depends only on the scalar field, the model could come to an agreement with observational data, however, it is in direct tension with the swampland criteria. But, for the second case, where the dissipation coefficient depends on both the scalar field and the temperature, the model has a great agreement with observational data, and also it could properly satisfy the swampland criteria.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PostDoc

Physics of Condensed Matter and Materials / 292

The Mechanical Properties Study of Li1+XMn2O4, 0 ≤ X ≤ 1 Cathode Materials

Author: Shibiri Beauty[1]

Co-authors: Raesibe Sylvia Ledwaba [1]; Phuti Ngoepe [1]

[1] *University of Limpopo*

Corresponding Author: beautieshibiri@gmail.com

One of the major limitations associated with spinel LiMn2O4 despite its superior properties such as high voltage, great cycling performance, being environmentally friendly and cost-effective is the impact of the stress it endures through strain during the process of cycling. For that reason, this study seeks to understand the implications that come with stress-strain and how it affects the mechanical properties of a battery material; and eventually come with a better nanoporous structure that can withstand these harsh conditions.
Herein, the amorphisation and recrystallisation technique were used to simulate the Li-Mn-O nanoporous structures of different lattice sizes at 75, 69 and 67 Å and varying lithium concentrations, (Li1+XMn2O4, 0 ≤ X ≤ 1) using the DL_POLY code. Recrystallisation of the nanoporous structures resulted in single and multiple grained materials with microstructures that shows a profusion of point defects. Furthermore, the microstructures capture the spinel layered composites which are also validated by the X-ray diffraction patterns of these structures. The stress and strain analysis shows that nanoporous 69 Å has the highest yield strength compared to its nanoporous counterparts. This, therefore, implies that nanoporous 69 Å is more robust and can be a better candidate to help restrict battery hazards in the future as far as fracture is concerned.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics of Condensed Matter and Materials / 293

Magnetic properties of the layered structure compound Ce3Os4Al12

Authors: Redrisse Djoumessi Fobasso[1]; Baidyanath Sahu[1]; Andre M. Strydom[1]

[1] *Highly Correlated Matter Research Group, Physics Department, University of Johannesburg*

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

R-T-X (R= rare-earth, T= Transition element and X = p-block element) ternary intermetallic compounds have drawn considerable attention for their diversity of structural, electronic, and magnetic properties. R3T4X12 type of compounds are of particular interest among intermetallics because the crystal structure contains layers as well as triangular and distorted Kagomé lattice features. In this work, we have synthesized a polycrystalline Ce3Os4Al12 sample by argon arc-melting technique. The Rietveld crystal structure refinement of powder X-ray diffraction patterns with a full-profile refinement confirm that Ce3Os4Al12 crystallizes in the hexagonal Gd3Ru4Al12-structure type with space group P63/mmc. The temperature (T) dependent dc-magnetic susceptibility χ(T) and specific heat data reveals that the compound undergoes a ferromagnetic type ordering below 6 K. The χ (T) data obey the modified Curie-Weiss law above 6 K, with the calculated effective magnetic moment μeff = 0.54 μB/Ce, which is less than one quarter of the trivalent free-ion value for the Ce ion of 2.54 μB. The obtained positive paramagnetic Weiss temperature (θp = 5.33 K) indicates the dominant

presence of ferromagnetic interactions in the high temperature region. The study may contribute towards a better understanding of the physics in Kagomé structure compounds, since in a frustrated lattice system such as this, there are strict constraints imposed upon the occurrence of long-range magnetic order and the magnetic order parameter.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics of Condensed Matter and Materials / **294**

Studying limestone pores using Small Angle Scattering techniques

Author: Ntombizodwa Mosete[None]

Corresponding Author: ntombimosete7@gmail.com

Limestone is a calcareous rock and is among the common hydrocarbon reservoirs (others being dolostone, sandstone and unconsolidated sands). Carbonate reservoirs hold a significant percentage of the world's oil and gas reserves. This study explores the nanopore structure of calcitic and dolomitic limestone by virtue of them being abundant in the chosen area of study. The difference between these two types of limestones is their magnesium carbonate content, calcitic limestone has about 5% of magnesium carbonate while dolomitic limestone has about 40%. By characterizing the nanopore structure, the intent is to determine the fluid transport capabilities of the limestones under study. The results of the study will be beneficial to the energy resources exploration and add on to the understanding of pore systems in limestone.
A reservoir, body of porous rock that contains fluids (water and/or hydrocarbons) and in which these fluids can migrate, is controlled by two key properties, which are porosity and permeability. These properties are further influenced by other parameters such as pore size, pore diameter, pore throat radius, pore coordination number and pore size distribution.
This presentation gives an account of sample preparation of the limestones for analysis using small angle scattering (SAS) techniques, small angle light scattering (SALS) and small angle x-ray scattering (SAXS) in particular. SALS can structurally characterize materials with pore diameters in the sub-micron range and SAXS is effective in characterizing nano-range structured materials.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics for Development, Education and Outreach / **295**

Quantum Computing in the Industry 4.0: A Review and Applications

Author: Tshepiso Amber Gosenyang[1]

Co-author: Mhlambululi Mafu [1]

[1] *Botswana International University of Science and Technology*

Corresponding Author: tshepiso.gosenyang@studentmail.biust.ac.bw

Since the birth of quantum computing around 1982, when Richard Feynman envisioned a quantum computer that could mimic quantum physics using quantum mechanics laws to work and function, quantum computers have offered numerous powerful possibilities in solving complex problems. In particular, quantum computers take advantage of quantum mechanical properties such as entanglement and superposition to provide massive computational power for simulations of complex quantum systems. Quantum computing can outperform any modern supercomputer in terms of computational capability, raising the interest of both the computer science industry and academics to create the world's first quantum computer. Quantum computing has demonstrated numerous applications in the 4.0 industry, such as artificial intelligence and machine learning, computational chemistry, cybersecurity and cryptography, drug design and development, financial modelling, and weather forecasting. However, in all these technologies and applications, Africa has not been fully participating. Considering that technology is potentially a potent tool for economic development, this work unveils the challenges and opportunities faced by African research institutions and industries in using AI and ML techniques in Industry 4.0. Moreover, we review the progress in these areas especially relating to Africa and provide instances where these techniques have been applied. Lastly, we provide a roadmap on how these techniques can be used by stakeholders such as start-ups, research institutions, and industries for economic development.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / **296**

Evaluating the growth/evolution of Ti5 cluster in LiCl medium

Authors: Andile Mazibuko[1]; Phuti Ngoepe[1]; Hasani Chauke[1]

[1] *University of Limpopo*

Corresponding Author: andile.mazibuko@ul.ac.za

Titanium can be produced as both a metal and in powder form. It finds applications in various industries such as in medical and aerospace, where the fabrication of components with excellent corrosion and high-temperature performance are significant. The titanium metal also plays a significant role in the titanium production process due to its desirable physical and chemical properties. Also, this process occurs in the presence of alkali metal and alkali earth metal salt mediums. Recent experimental studies are on testing the lithiothermic part of the titanium formation process, however, the small titanium clusters are thermodynamically unstable. In this study, classical molecular dynamic calculations were performed to understand the growth/evolution of the small titanium Ti5 cluster after interactions with LiCl medium. The DL_POLY code was used to evaluate the temperature dependence of the structure. Furthermore, the stability of the cluster was evaluated using the CASTEP code. It was found that the cluster maintains its trigonal bipyramid geometry at the temperature range of 100 K – 2000 K. Moreover, the cluster was observed to show growth patterns, indicated by the absence of bonding between atoms. The results of this study might give us more insight into the growth/evolution of titanium in salt mediums.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics of Condensed Matter and Materials / 297

Influence of duration of annealing on thermoluminescence of natural quartz annealed at 1000 ℃

Authors: Damilola Folley[1]; Makaiko Chithambo[1]

[1] *Rhodes University*

Corresponding Author: damilolafolley@gmail.com

The influence of duration of annealing on thermoluminescence of natural quartz annealed at 1000 ℃ is reported. The study looks at samples annealed for 10 and 60 minutes. A glow curve measured at 1 ℃s-1 after beta irradiation to 50 Gy for the sample annealed for 10 minutes shows seven peaks at 68, 130, 176, 276, 300, 360, and 416 ℃ labelled I through VII. The sample annealed for 1 hour has five peaks at 70, 128, 176, 234, and 308 ℃ labelled I-V respectively. A study of dosimetric features and kinetic analysis was carried out on the two prominent peaks, peak I and III for both samples. The peaks show a sublinear dose response for irradiation doses between 10 and 300 Gy. The electron trap responsible for peak I depletes faster at high duration annealing between irradiation and measurement. In contrast, the electron trap for peak III was more stable for both samples. Kinetic analysis shows that peak I is a first-order peak and peak III a non-first-order peak. The activation energy obtained using the initial rise, whole glow peak, and curve fitting methods is between 0.904±0.004 and 1.07±0.10 eV for peak I and between 1.10±0.01 and 1.23±0.01 eV for peak III. In particular, the kinetic parameters obtained for both peaks decrease with annealing time. This suggests that the duration of annealing at 1000 ℃ has an effect on the trap parameters of natural quartz.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Photonics / 298

Determination of amplification characteristics in end-pumped solid-state amplifiers

Author: Justin Harrison[None]

Co-authors: Andrew Forbes [1]; Darryl Naidoo [2]

[1] *U. Witwatersrand*

[2] *Council for Scientific and Industrial Research*

Corresponding Author: jharrison@csir.co.za

Master Oscillator Power Amplifier (MOPA) systems have garnered considerable interest to power scale low power seed beams (from the Master Oscillator) to higher powers. These systems are favourable to obtain the desired laser beam performance when additional optical elements such as Bragg gratings are required. These elements do not have to endure high optical intensities inside high-power oscillators and do not affect the beam quality or power efficiency. Power amplifiers

consist of two primary architectures that include end-pumping and side-pumping. The latter offers greater amplification at the expense of increased thermally-induced beam distortions such as thermal lensing, while the former offers more controllable and efficient power scaling with a limit on the amplification potential. To date, the theoretical models describing the characteristics of end-pumped systems have been limited to two-dimensional crystal architectures with an approximation of the thermal lens as a two-dimensional element. In general, the optical pumping beam is over-simplified and does not reflect real-world spatial evolution over the entirety of the crystal rod length. These approximations hold for thin crystals operating under small-signal amplification, however, they are inaccurate for high signal amplification in long crystal rod geometries. In this work, we explore three-dimensional crystal rods in end-pumped configuration, using an infinitesimally sliced model, to study the amplification potential and thermal lens in end-pumped power amplifiers in greater detail while using beam shaping theory to model the pump beam transformation accurately over the length of the crystal. We verify our theoretical approach experimentally using a single amplifier stage in double-pass configuration for power scaling of Gaussian beams. We demonstrate over 95% correlation between our model and the corresponding experiment and show that this correlation extends over the small and high signal amplification regions. The improved model, experimental techniques and results outlined here will provide a valuable tool for advances towards optimizing high brightness amplifiers.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Photonics / 299

Amplification of structured light in end-pumped solid-state amplifiers

Author: Justin Harrison[None]

Co-authors: Andrew Forbes [1]; Darryl Naidoo [2]

[1] *U. Witwatersrand*

[2] *Council for Scientific and Industrial Research*

Corresponding Author: jharrison@csir.co.za

Structured light beams from the Laguerre-Hermite-Gaussian mode families with scalar or vector polarization structures have found applications in many diverse areas, particularly in high dimensional quantum communication, optical particle trapping and super-resolution microscopy. However, only a small subset of these structured beams, namely, the radially and azimuthally polarized annular modes, have been applied in the laser materials processing industry. The full spectrum of scalar and vector polarized structured light modes are easily accessible through devices such as the Spatial Light Modulator (SLM's) and Digital Micromirror Devices (DMD's), but due to their low-power handlining ability, direct generation at high power (>100W) is not possible. We propose a system that performs beam shaping (Gaussian -> Structured Mode) at low power with subsequent amplification to high-power using the Master Oscillator Power Amplifier (MOPA) strategy while preserving the complex spatial, phase and polarization properties of the beam. In this work, we explore amplification of vector and scalar polarized structured beams selected with a spatial light modulator using a detailed analytical model developed for double-pass end-pumped MOPA architecture. We demonstrate stable output power from the amplifier system and confirm the preservation of the beam characteristics using the modal decomposition and vector quality factor characterization techniques. This novel work will form part of an intermediate step towards the realization of Killo-watt level structured light beams for application in industrial laser material processing.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics for Development, Education and Outreach / 300

Evolution of the 3rd Year Major Project at WITS

Author: Jonathan Keartland[1]

[1] *University of the Witwatersrand*

Corresponding Author: jonathan.keartland@wits.ac.za

The Major Project has been an important component of the 3rd Year Physics curriculum at WITS for many decades. It has proven very popular with students, and has allowed academic staff to identify students with research potential as early as final year undergraduate level. In the original model each student chose a project offered by a member of the academic staff, and completed the work required during one of the first three quarters of the academic year. In 2015 the student numbers increased dramatically from approximately 25 students to approximately 50 students, and it became increasingly difficult to run the projects in their existing form. In 2018 the major project underwent a transformation, and since then students have completed an Independent Research Essay (IRE) under supervision of a member of the academic staff, with a student teaching assistant acting as a mentor for a small group of students. This presentation will provide a description of the evolution of the Major Project, paying particular attention to the components of the IRE as it is at present. In particular, it will be shown how the IRE may be used to inculcate or enhance essential skills for budding scientists.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Photonics / 301

Selection of a Vortex beam using a Sagnac Interferometer

Author: Maitshoko Mereotlhe[1]

Co-authors: Darryl Naidoo [2]; Andrew Forbes [3]

[1] *MSc Student*

[2] *Principal Researcher, Novel Lasers*

[3] *Professor*

Corresponding Author: pmereotlhe@csir.co.za

Optical fields with an embedded phase singularity are referred to as vortex beams as they carry and impart Orbital Angular Momentum (OAM). They have been found to be attractive in various applications such as optical trapping, quantum communications, laser ablation, manipulation of atoms and micro particles and surface structuring. Techniques to select vortex beams vary from spiral

phase plates to spatial light modulators to birefringent q-plates to name a few. One interesting approach is the use of interferometric techniques which are known to generate higher order modes from fundamental Gaussian modes. Here we demonstrate experimentally a technique combining a Sagnac Intereferometer and an Astigmatic Mode Converter (AMC) to generate a vortex beam. We exploit both the amplitude and phase difference of two superposing Gaussian beams to obtain a pure Hermite Gaussian mode of first order, then propagate it through an AMC to achieve a vortex mode. As a result, the technique presents a potential for high power applications in laser material processing.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Theoretical and Computational Physics / 302

Statistical and Thermal Models for Heavy Ion Collisions and Astrophysics

Authors: Chantel Mare[1]; Fulufhelo Mukosi[2]; Bradley Nemutudi[3]; Khodani Mafune[2]

Co-authors: Azwinndini Muronga [4]; Thuthukile Khumalo [5]

[1] *UP*

[2] *UNIVEN*

[3] *UL*

[4] *NMU*

[5] *Wits/iThemba LABS*

Corresponding Author: mafune.khodani@gmail.com

Relativistic heavy-ion collisions at high energies such as those at the Relativistic Heavy Ion Collider (RHIC), Brookhaven National Laboratory, Long Island, New York and at the Large Hadron Collider (LHC), CERN, Switzerland, Geneva produce new state of matter leading up to many new particles. One approach to understanding the properties of the produced hot and dense matter in these collisions is based on statistical thermodynamics. In this presentation we will show how using the knowledge of statistical thermodynamics from undergraduate physics one can describe the final stage of the evolution of heavy ion collisions. We will show this by comparing our theoretical calculations with data from heavy ion collider experiments.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics for Development, Education and Outreach / 303

Using the Arduino in the laboratory

Authors: Miriam Lemmer[1]; Nico Lemmer[2]

[1] *North-West University (Potchefstroom)*

[2] *North-West University*

Corresponding Author: miriam.lemmer@nwu.ac.za

Microprocessors and controllers are used everywhere: in microwave ovens, televisions, computers, cell phones, motor cars, traffic lights, satellites, etc. Therefore, Physics students need to gain basic knowledge about it, at least of how it works and can be used. The introductory physics laboratory is an appropriate environment and the Arduino a suitable tool to learn about it.
An Arduino contains a microcontroller and components that aid inputs and outputs of data. Digital and analog pins may be interfaced to breadboards with circuits and electronic components as well as sensors and actuators. Open-source software (mostly programmed in C++) is available for numerous applications.
Using the Arduino combines knowledge about electronics, control and programming. In the physics laboratory, it allows for student experimentation (e.g. Ohm's law and Hooke's law) with low cost instruments (e.g. for measuring temperature, pH, pressure, etc). Real world controlled systems can be planned, constructed and tested (e.g. alarm systems, cranes and robots). Additional educational advantages are the learning of scientific problem solving, critical thinking and collaboration.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics of Condensed Matter and Materials / 304

Synthetic process of cesium lead tri-iodide (γ-CsPbI3) perovskites thin-films using sequential physical vapor deposition method.

Authors: Sizwe Sibiya[1]; Sandile Thubane[2]; Nolwazi Nombona[3]; Mmantsae Diale[4]

[1] *Abstract*

[2] *none*

[3] *Department of Chemistry, Unirversity of Pretoria*

[4] *University of Pretoria*

Corresponding Author: drbheki636@gmail.com

In this study, sequential physical vapor deposition (SPVD) technique is used to grow high poly-crystalline yellow active orthorhombic γ-CsPbI3 structure with Pnma space group. Crystallographic parameters and the phase transition from as-deposited orthorhombic (γ-CsPbI3) to tetragonal (β-CsPbI3) on annealing at 100 ℃ are determined using Rietveld refined X-ray diffraction (XRD) patterns. Computed lattice constants are a= 4.88 Å, b= 9.96 Å, and c= 16.52 Å, with an average crystallite size of 169.46 nm and micro-strains of 10ˆ16. Field emission scanning electron (FESEM) micrographs show uniform surface coverage with polycrystalline natured grains. Average grain sizes increased from 168 to 235 nm as CsI thickness increased, resulting in large pin-hole-free and tightly packed grains. From a Tauc's plot, UV-Vis spectra reveal a growing pattern in the electronic band structure from 2.24 to 2.38 eV for both as-deposited and annealed thin-films. Due to their high diffusion length (>1 m), high absorption coefficient (10ˆ5 cm), excellent charge transport properties, and high photostability, inorganic cesium lead triiodide (CsPbI3) thin-films have an invincible potential for future low-cost photovoltaic devices as they participate in tandem solar cells [1, 2].

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Photonics / 305

Purity and Dimensionality measurements using Werner States

Author: Donovan Slabbert[1]

Co-authors: Isaac Nape [1]; Andrew Forbes [1]

[1] *University of Witwatersrand*

Corresponding Author: pietern@sun.ac.za

High dimensional entangled quantum systems are important in various applications such as quantum teleportation, secure quantum key distribution and cryptography. Such applications require a method to characterize the state density matrix. Conventional methods such a Quantum State Tomography work, however, can become computationally cumbersome if the dimension becomes too great. The method outlined, which is an extension of a proven method that uses isotropic states as model states, makes use of Werner states instead. Minimization techniques are used to extract key parameters that determine the state, rather than to necessarily reconstruct the state itself. Werner states are mixed entangled states and are good representations of bipartite quantum entangled systems. They consist of different weightings of projectors onto anti-symmetric and symmetric subspaces. The process involves using analyser matrices to probe Hilbert space. Chi-squared minimization using visibility calculations leads to the extraction of a symmetric weighting value and the dimensionality.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Theoretical and Computational Physics / 306

Factorization in Heavy Ion Collisions

Authors: William Horowitz[1]; Matthew Sievert[2]

[1] *University of Cape Town*

[2] *New Mexico State University*

Corresponding Author: wa.horowitz@uct.ac.za

We present our latest findings on the status of factorization in heavy ion collisions. In the first microsecond of the universe, space was filled with deconfined nuclear matter at a temperature of a trillion degrees. These conditions are recreated thousands of times a second at experiments in the US and Europe in which large nuclei such as gold and lead are collided at nearly the speed of light. Very high momentum particles that propagate through the fireballs generated in these heavy ion

collisions form one of the essential probes of the properties of the quark-gluon plasma (QGP) that permeated the early universe. In order for these high momentum particles to be a well-calibrated probe, we must ensure that the quantitative predictions for their behavior are well-controlled. The rigorous language for this control is known as factorization, which implies that the production and hadronization processes are independent of the interaction of the probe with the QGP medium. We show how previous energy loss calculations diagrammatically fail at factorization and point to a way forward for future progress.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics of Condensed Matter and Materials / 307

Incorporation of gold metal nanoparticles in organic solar cells

Author: Thapelo Seimela[1]

Co-authors: Justine Nyarige [2]; Nolwazi Nombona [3]; Mmantsae Diale [4]

[1] *None*

[2] *Student*

[3] *Department of Chemistry, Unirversity of Pretoria*

[4] *University of Pretoria*

Corresponding Author: teseimela@gmail.com

In this study, the plasmonic effect of gold nanoparticles (AuNPs) inside poly(3,4-ethylenedioxythiophene):poly(styrene sulfonate) (PEDOT:PSS) for improving light scattering of organic solar cells have been investigated. Chloroauric acid is capped with trisodium citrate in which the solution is heated to obtain Au NPs. Au NPs are deposited in PEDOT:PSS and spin coated on top of glass substrate followed by the blend poly(3-hexylthiophene):phenyl-C61-butyric acid methyl ester (P3HT:PCBM). The transmission electron microscopy (TEM) results show spherical shapes of Au NPs with grain size of 23.7±0.5 nm. The UV-Vis spectroscopy revealed that NPs are absorbing in the visible range by showing plasmonic resonance at around 534 nm along with peaks of PEDOT:PSS, PCBM and P3HT at 353, 333 and 445 nm respectively. The X-ray diffraction (XRD) confirmed the FCC structure of NPs with (111), (200), (220), and (310) phases in which the (111) peak was the most intense. Raman has also confirmed the existence of P3HT:PCBM, PEDOT:PSS and Au NPs by showing the peaks of each structure. From this study, Au NPs have a potential application in organic solar cells.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Theoretical and Computational Physics / 308

Correlations in Multiple Gluon Bremsstrahlung following a Hard Scattering Event

Author: Antonio Renecle[None]

Co-author: William Horowitz [1]

[1] *University of Cape Town*

Corresponding Author: rncant003@myuct.ac.za

We present for the first time a quantitative analysis of multiple gluon emission in hard scattering events in the soft and collinear emission limit. These calculations specifically include the non-trivial, non-Abelian QCD corrections. We base our numerics on derivations using the spinor helicity formalism, a natural framework for evaluating tree-level Feynman diagrams in $3+1$ dimensional quantum field theories of massless fermions. We employ, in particular, the novel maximal helicity violating (MHV) techniques and the Britto–Cachazo–Feng–Witten (BCFW) recursion relation, to go beyond 2 gluon emission associated with hard scattering in QCD.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Astrophysics / **309**

A Monte Carlo simulation study of the excitation of molecules in high mass star forming regions

Author: Lebogang Mfulwane[None]

Corresponding Author: mfulwane6@gmail.com

Astronomical maser emission occurs in various astrophysical environments and can be used to infer the physical properties of the regions where they are excited. An import part of interpreting the presence of maser emission associated with a specific astrophysical environment is knowing what the pumping mechanism (radiative or collisional) for a particular maser is. Based on calculations using the online RADEX facility, Baan et al (2017) recently concluded that the extragalactic 4.8GHz formaldehyde megamasers are radiatively pumped. This is contrary to the conclusion of van der Walt (2014) that formaldehyde masers associated with high mass star forming regions are collisionally pumped. Since much of the interpretation of the maser emission depends on pumping mechanism, we revisited the pumping of the formaldehyde masers (1) to try to understand the results obtained by Baan et al (2017) using the RADEX facility and (2) to extend the calculations of van der Walt (2014) to also include parts of parameter space considered by Baan et al (2017) but not by van der Walt (2014). Some preliminary results, which suggest that the formaldehyde masers are indeed collisionally pumped, are presented.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Theoretical and Computational Physics / 310

Cosmological Models in Gravitational Scalar-Tensor Theories

Author: Heba Abdulrahman[1]

Co-author: Amare Abebe [2]

[1] *North West University, South Africa*

[2] *North-West University*

Corresponding Author: heba@aims.edu.gh

In this work, a brief review of a new form of scalar-tensor theories of gravity, known as gravitational scalar-tensor theories (GST) in which the action is composed of the Ricci scalar and its first and second derivatives is made. Some of the cosmological applications that have been investigated in these new theories are discussed considering different models corresponding to the first non-trivial extensions of general relativity possessing 2 + 2 degrees of freedom. We show that the resulting cosmological behavior is in agreement with observations.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Theoretical and Computational Physics / 311

Jet transverse momentum broadening

Author: Hannah Clayton[1]

Co-author: William Horowitz [1]

[1] *University of Cape Town*

Corresponding Author: clyhan001@myuct.ac.za

In deeply inelastic lepton-nucleus scattering, hadron-nucleus and heavy-ion collisions; multiple scatterings of energetic partons in the nuclear medium lead to a broadening of the average jet transverse momentum. This jet broadening phenomenon offers a useful tool for probing the properties of nuclear media, including the quark-gluon plasma formed in high-energy heavy-ion collisions. Many theoretical frameworks have been developed in the study of multiple scatterings and their subsequent effects. For this work, we focus on the collisional and radiative parton energy loss formalisms, as well as the higher-twist collinear factorization framework. We compute the transverse momentum broadening of final hadrons in semi-inclusive deep inelastic scattering (SIDIS) at Twist-4, and compare to the broadening predictions calculated using the Djordjevic-Gyulassy-Levai-Vitev (DGLV) energy loss model. We aim to compare both sets of jet broadening predictions to experimental data, with a view to reconciling the DGLV energy loss techniques with the novel Twist-4 methods in SIDIS.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / **312**

Computational Modelling Study on Stability of Li₂MnO<sub>3</ Cathode Material for Lithium-Ion Batteries.

Author: Mamonamane Mphahlele[1]

Co-authors: Cliffton Masedi [2]; Phuti Ngoepe [2]; Raesibe Sylvia Ledwaba [2]

[1] *university of Limpopo*

[2] *University of Limpopo*

Corresponding Author: gratitude.mphahlele@ul.ac.za

The demand for lithium-ion batteries has increased in the last decades due to their broad applicability as power storage systems. However, their energy density is too low for high-power applications such as electric vehicles and renewable energy storage grids. The most substantial electroactive component of a battery is the cathode and thus much research has been devoted to improving them. In this regard, lithium-rich layered oxide Li₂MnO₃ has been considered as a promising cathode material for lithium-ion batteries due to their high theoretical specific capacity of 459 mA h/g, environmental friendliness and a high operating voltage. Therefore, it is necessary to investigate its properties to gain a better understating of the system. In the current study, density functional theory calculations with Hubbard Hamiltonian (DFT+U) were employed to explore stability, structural and electronic properties of bulk Li₂MnO₃. The calculated lattice parameters were found to be in good agreement with the experimental data, validating the approach employed. Furthermore, the negative heats of formation suggest that the structure is thermodynamically stable. The density of states revealed the presence of a bandgap at the Fermi level, implying that pristine Li₂MnO₃ is semiconducting, this agrees with what was found in literature. The system was found to mechanically unstable due to negative C₂₅ and C₄₆ elastic constants. There were no soft modes observed in the phonon dispersion curves, suggesting vibrational stability. These findings gave an insight into the bulk properties and stability of Li₂MnO₃.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Astrophysics / **313**

Assessing TeV Visibility of Pulsars

Author: Christo Venter[1]

Co-authors: Alice Harding [2]; Constantinos Kalapotharakos [3]

[1] *North-west University, Potchefstroom Campus*

[2] *Theoretical Division, Los Alamos National Laboratory*

[3] *University of Maryland and NASA*

Corresponding Author: christo.venter@nwu.ac.za

Recent detections of the Crab, Vela, Geminga pulsar as well as PSR B1706-44 by ground-based Cherenkov telescopes have created exciting prospects of many more such discoveries by the upcoming Cherenkov Telescope Array. Pulsed photons with energies in excess of 1 TeV detected from the Crab and Vela pulsars severely constrain the particle energetics, emission mechanisms, as well as spatial aspects of the dissipation regions within the pulsar magnetosphere. Within an extended slot-gap framework, we model the broad-band pulsar spectrum invoking force-free-like fields and multiple emission components, including synchro-curvature, synchrotron self-Compton (SSC) and inverse Compton (IC) radiation by both primary particles and pairs. IOn particular, we predict two TeV components: (i) SSC from pairs and (ii) IC from particles accelerated in the current sheet upscattering pair synchrotron radiation. We fit our predictions to available broadband data, indicating that it may now be possible to directly measure the maximum particle energy in pulsars.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics of Condensed Matter and Materials / **314**

The simulated synthesis of nanostructured Li2MnO3 cathode materials

Authors: Tshidi Mogashoa[1]; Raesibe Sylvia Ledwaba[2]; Phuti Ngoepe[2]

[1] *UL*

[2] *University of Limpopo*

Corresponding Author: tshidi.malibe@ul.ac.za

The realisation of advanced lithium-ion battery (LIB) technologies has been hindered by the slow progress in discovering high capacity cathodes. Considerable research is focused on the lithium-rich layered Li2MnO3 owing to its ability to reversibly intercalate more lithium. However, the cycling of this material results in capacity degradation due to complex phenomena such as the irreversible oxygen loss and phase transformation caused by lattice reconstruction. Herein, a series of nanostructured Li2MnO3 models have been generated via the simulated amorphisation and recrystallisation (A+R) technique and their internal microstructures interrogated during the cycling process. The charging process involved the concurrent removal of lithium (Li) and oxygen (O) ions to restrain the release of oxygen and resulted in Li2-xMnO3-x composites. Detailed analysis of these composites reveals that the models crystallised into multiple grains which increased with decreasing Li/O content along with stacking faults and vacancies thus leading to Mn ions migrating to the Li layers. The internal microstructures display a wealth of defects leading to the emergence of distorted cubic spinel LiMn2O4, Li2MnO3 and LiMnO2 polymorphs. Characterisation of the x-ray diffraction patterns revealed peak broadening along with the growing of 2Θ˜18-25 and 2Θ˜29^0 peaks associated with the spinel-like phase. These results shed insights on the mechanism that takes place during the cycling of the Li2MnO3 with complex structures and will help guide the optimisation of high-capacity energy storages.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / 315

First-Principles DFT Study on the Effect of Lithiation on the Spinel LixMn2O4 Structure: Calibration of CASTEP and ONETEP Simulation Codes.

Author: DONALD HLUNGWANI[1]

Co-authors: Phuti Ngoepe [2]; Raesibe Sylvia Ledwaba [2]

[1] *university of limpopo physics department*

[2] *University of Limpopo*

Corresponding Author: hlungdona@gmail.com

Li-Mn-O layered-spinel composites are among the promising and economically viable, high energy density cathode materials for improving the performance of lithium ion batteries. A number of studies have focused on the specific capacity of these composite materials. However, the complex internal structural changes affecting their performance during the discharge process (lithiation) are not yet fully understood. As such, we perform the spin polarised density functional theory DFT calculations using the CASTEP (traditional DFT) and the ONETEP (linear-scaling DFT) codes to elucidate the effect of lithiation on the electronic structure of spinel LixMn2O4 ($0 \leq x \leq 2$). The electronic structure calculations were performed under the generalized gradient approximation (GGA). Electronic structure analysis depicted semiconducting properties for delithiated-Mn2O4 with a band gap of ˜0.65 eV whilst, LiMn2O4 and lithiated-LiMn2O4 were found to be conductors. Furthermore, it was found that less amount of energy is required for electrons to occupy the eg orbitals of LiMn2O4 than of the eg orbitals of the delithiated-Mn2O4. This indicates that lithiation favours Mn3+ which is in line with what was observed experimentally. The LiMn2O4 Density of States (DoS) calculated with ONETEP clearly distinguish the dx2-y2 and dz2 orbitals. The dx2-y2 orbital is filled and the dz2 orbital is empty, which is consistent with the dual-existence of Mn4+ and Mn3+. We also performed a scaling test with ONETEP on supercells of LiMn2O4 spinel structure and the best performance was achieved by ensuring that the product of MPI processes and OMPI_THREADS are equivalent to the requested number of cores in the Lengau cluster. Our current findings forms a basis for moving from traditional DFT to linear-scaling DFT which will enable the study of the electronic properties of Li-Mn-O layered-spinel nanoarchitectures.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Applied Physics / 316

An experimental study of a combined solar cooking and thermal energy storage system for domestic applications

Author: Katlego Lentswe[1]

Co-author: Ashmore Mawire [2]

[1] *NWU*

[2] *North West University, Mafikeng Campus*

Corresponding Author: katlego.lentswe212@gmail.com

In this paper, a combined solar cooker with a sunflower oil storage tank is presented. The solar cooker consists of a 1.8 m parabolic dish that has an oil circulating copper spiral coil receiver embedded to a metallic cooking plate. The receiver is connected to a 50 L sunflower oil storage tank for the dual purpose of heat storage and cooking. A DC pump is used to circulate the oil during charging and discharging. The receiver has a circular metallic plate for cooking, while the copper coil is embedded below the plate to circulate sunflower oil that is heated up and stored during the cooking (charging) experiments. During charging, 1.5 L of water is boiled in a cooking pot with storage tank temperatures above 100 oC being achieved. During discharging, the pump is reversed and 1.5 L of water is heated up with the stored heat, however, heat transfer is poor with the water temperature only achieving temperatures just above 50 oC. Preliminary experiments are presented, and the charging process is seen to be more efficient than the discharging process with the charging pump reversed. The system can be used to cook food as well as provide heat for indirect cooking using insulated bag slow cookers. However, cooking food directly on the cooking plate using the reverse discharging progress is not efficient, and heat transfer should be enhanced to make the process more efficient and viable.
Keywords; Combined solar cooking and storage; Sunflower oil; Receiver; Thermal performance

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Astrophysics / 317

Shaken, not stirred: test particles in binary black hole mergers.

Author: Pieter Van der Merwe[1]

[1] *North-west University, Center for Space Research*

Corresponding Author: pietervdmerwejnr@gmail.com

In 2015 the advanced Laser Interferometer Gravitational-Wave Observatory (aLIGO) detected the first ever gravitational
event, gravitational wave event GW150914, with multiple new gravitational wave events, originating from both
binary neutron stars and binary black hole (BBH) mergers, detected in subsequent years. In light of these detections,
we simulate the dynamics of ambient test particles in the gravitational potential well of a BBH system close to its
inspiral phase with the goal of simulating the associated electromagnetic radiation and resulting spectral energy
density distribution of such a BBH system. This could shed light on possible detection ranges of electromagnetic
counterparts to BBH mergers. The potentials are numerically calculated using finite difference methods, under the
assumption of non-rotating black holes with the post-Newtonian Paczynski-Wiita potential approximation in tandem
with retarded time concepts analogous to electrodynamics. We find that the frequencies of potential electromagnetic

radiation produced by these systems (possibly reaching earth), range between a few kHz to a few 100kHz. The bulk
of radiation is distributed at frequencies below 100kHz.
Keywords: Binary black hole merger, binary black hole, binary black hole merger simulation, particle acceleration,
gravity.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Applied Physics / 318

COMPUTED TOMOGRAPHY RECONSTRUCTION FOR THE REDUCTION OF THE EFFECTS OF METALLIC INCLUSIONS

Author: Gideon Chinamatira[1]

Co-authors: Bhekumusa Mathe [1]; Kudakwashe Jakata [1]

[1] *University of the Witwatersrand*

Corresponding Author: gideonchinamatira@gmail.com

X-ray Computed tomography (XCT) is a technique that is used to generate 3D images of a sample which allows the observation of the internal structure 1. Projections are collected as the sample rotates through 360 degrees followed by a reconstruction step using algorithms such as the filtered back-projection. This technique has found widespread applications in fields such as medical diagnostics, palaeontology, geology, anatomical science and materials science. Samples with high-density inclusions can produce data with artefacts, such as streaks and noise 2. We report an investigation on the effects of adding an image processing step before performing computed tomography reconstructions. We have acquired projections with a micro-computed tomography scanner and carried out image processing functions for the improvement of the quality of the data output. We have obtained a paleontological specimen with a significant amount of iron inclusions which cause bright and dark streak artefacts. We have applied several filters to alter the projections before reconstruction. The results so far show that the minimum filter, median and median filter reduces the noise and streak artefacts in the specimen. The Gaussian smoothing filter also successfully reduces the noise in the images, but the streak artefacts are still significantly visible. The unsharp mask filter enhances the edges in the images and reduces the streak artefacts significantly. However, this filter in nature enhances other high-frequency components in an image, and as such, the noise is also accentuated. We also report the use of alternative reconstruction algorithms using the ASTRA toolbox to reduce the effects of high-density inclusions.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / 319

Characterization of defects in ZnO impanted with Ar+ ions using positron annihilation technique

Authors: Musawenkosi Khulu[1]; Thulani Jili[1]; Morgan Madhuku[2]; Cebo Ndlangamandla[1]

[1] *University of Zululand*

[2] *iThemba LABS*

Corresponding Author: musakhulu.mk@gmail.com

ZnO (wurtzite) samples were implanted with Ar+ ions to generate intrinsic defects within the samples for fluencies ranging from 10ˆ4 to 10ˆ18 per cm. Doppler broadening of the annihilation centroids were obtained to determine S- and W - parameters which are associated with a quantity of defects. X-ray diffraction (XRD) method was employed to determine any structural or phase change associated with Ar+ implantation. The positron annihilation spectroscopy results were correlated with Optical absorption spectra of the crystals to investigate various bands at different fluencies.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Astrophysics / 320

Monte-Carlo Applications for Partially Polarized Inverse External-Compton Scattering (MAPPIES)

Authors: Lente Dreyer[1]; Markus Bottcher[2]

[1] *North-West University*

[2] *University of North West*

Corresponding Author: lentedreyer@gmail.com

The spectral energy distributions (SEDs) of some blazars exhibit an ultraviolet (UV) and/or soft Xray excess, which can be modelled with different radiation mechanisms. Polarization measurements of the UV/X-ray emission from blazars may provide new and unique information about the astrophysical environment of blazar jets and could thus help to distinguish between different emission scenarios. I will present a new Monte-Carlo code – MAPPIES (Monte-Carlo Applications for Partially Polarized Inverse External-Compton Scattering) – for polarization-dependent Compton scattering. I will present the code by showing results of the polarization signatures in a model where the UV/soft X-ray excess arises from the bulk Compton process. Predictions of the expected polarization signatures of Compton emission from the soft X-ray excess in the SED of AO 0235+164, and the UV excess in the SED of 3C 279 are made for upcoming and proposed polarimetry missions.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Astrophysics / 321

Dark Coupling: Cosmological implications of interacting dark energy and dark matter fluids

Author: Marcel van der Westhuizen[1]

[1] *North-West University*

Corresponding Author: marcelvdw007@gmail.com

"The true nature of the dark sectors of the universe (dark matter and dark energy), and its implications for cosmology has eluded physicists for decades. In this study, we will consider some cosmological models where dark matter and dark energy are coupled fluids which may interact with each other. Assuming various dark couplings, we will use the background Friedmann equations to predict how these couplings affect the expansion history and age of the universe, as well as the evolution of the Hubble and deceleration parameters. The coupled models will then attempt to address the coincidence problem (regarding the current observed ratio of dark matter to dark energy today). These results will also be compared with the standard uncoupled ΛCDM model where dark energy is assumed to be a cosmological constant. Finally, since any good model should coincide with data, we will constrain these models with Type-Ia Supernovae data from a previously developed Markov Chain Monte-Carlo (MCMC) simulation"

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / 322

The effect of Sm3+ concentration on the structure, morphology and photoluminescence properties of co-doped CaAl2O4:0.1%Tb3+, x%Sm3+ ("0 ≤ x ≤ 2 ") nanophosphor prepared by the citrate sol gel technique.

Authors: Motlalepula Rebecca Mhlongo[1]; Lehlohonolo Fortune Koao[2]; Tshwafo Elias Motaung[3]; Setumo Victor Motloung[4]

[1] *Sefako Makgatho Health Sciences University*

[2] *University of Free State, Qwaqwa campus*

[3] *University of South Africa*

[4] *Walter Sisulu University*

Corresponding Author: rebsmhlongo@gmail.com

CaAl2O4:0.1%Tb3+, x% Sm3+ (0<x<2) nano-powders have been successfully prepared via sol-gel technique. Annealing temperature and time were kept constant at 900 oC and 2 hours (h), respectively for all samples. X-ray diffraction (XRD) analysis showed that all powder samples have a monoclinic structure without any impurities. Energy dispersive X-ray spectroscopy (EDS) results confirmed the presence of all expected elements and the EDS map showed that the elements were distributed homogeneously on the surface. Scanning electron microscopy (SEM) results revealed that the prepared powder morphology was influenced by doping. The ultraviolet-visible (UV-vis) spectra showed that doping with Tb3+ and varying the Sm3+ concentration influenced the effective band gap (Eg) of the host material. The photoluminescence (PL) results showed the emissions peaks at 430, 485,

548 and 601 nm attributed to the intrinsic defects within the host. The Tb3+ doped samples showed four emission peaks at 485, 546, 585 and 620 nm attributed to 5D4⟶7F3, 5D4⟶7F4, 5D4⟶7F5 and 5D4⟶7F6 transitions of Tb3+, respectively. The Sm3+ doped samples showed three emission peaks centered at 562, 600 and 647 nm attributed to 4G5/2⟶6H5/2, 4G5/2⟶6H7/2, 4G5/2⟶6H9/2 transitions of Sm3+, respectively.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Astrophysics / **323**

Satellite contamination on Single Dish HI Intensity Mapping with MeerKAT

Author: Brandon Engelbrecht[1]

[1] *University of the Western Cape*

Corresponding Author: engelbrechtbn@gmail.com

Neutral Hydrogen (HI) Intensity Mapping (IM) promises to open a new window for cosmology, probing Large Scales Structures (LSS) in the Universe over a wide range of redshifts. Unfortunately, HI IM is contaminated by several effects, one of these is the emission from artificial satellites. We aim to simulate the Radio Frequency Interference (RFI) emitted from the Global Navigation Satellite System (GNSS) for the MeerKAT Single Dish HI IM observations, focusing on the 1000-1500 MHz frequency range. We fit our satellite model to data taken using the MeerKAT telescope and study the impact of the residual contamination in the supposedly RFI free regions.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Astrophysics / **324**

Dark-fluid constraints of shear-free universes

Authors: Maye Elmardi[1]; Amare Abebe[1]

[1] *Center for Space Research, NWU*

Corresponding Author: maye.elmardi@gmail.com

We present the evolutionary constraints of shear-free cosmological solutions in the presence of a dark fluid. After describing the general evolution and constraint equations for *quasi-Newtonian* and *anti-Newtonian* spacetimes, we derive, at the level of linear perturbations, the conditions for the existence and consistent evolution of such spacetimes when they are endowed with the Chaplygin gas which mimics a unified description of dark matter and dark energy.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics of Condensed Matter and Materials / 325

Green Synthesis of Fe3O4 Nanoparticles: Structure and Magnetic Properties

Authors: Shobana Nagaraj[1]; PANKAJ MOHANTY[2]; Charles Sheppard[3]; Aletta Prinsloo[1]

[1] *University of Johannesburg*

[2] *University of Johanneburg*

[3] *Department of Physics, University of Johannesburg*

Corresponding Author: shobinagaraaj@gmail.com

Magnetite (Fe3O4) has drawn interest since its discovery since it is one of the naturally occurring minerals that has importance in paleomagnetic measurements used to study continental drift 1. The compound is also found in the mantle wedge of subduction zones 1. Magnetically, Fe3O4 orders ferrimagnetically with a Curie temperature of 850 K having an inverse spinel structure, AB2O4, with the A site occupied by Fe3+ and the B sites populated equally by Fe3+ and Fe2+ at room temperature 2. As a result, A site contributes +5 μB, and the B sites contributing −5 μB and +4 μB, respectively, yielding a total spin moment of 4μB with no orbital moment 2. Interestingly, Fe3O4 demonstrates a metal-insulator transition, popularly known as the Verwey transition, at a temperature TV = 120 K, below which two-fold increase in the resistivity occurs 2. Fe3O4 plays an important role as a catalyst in inorganic processes such as the synthesis of ammonia and in organic methods such as the dehydrogenation of ethyl benzene to styrene 3. The high demand for magnetic recording media coupled with the possibility of imaging the atomic structure and the electronic properties of the surface made it the potential candidate 3 for this use. Specifically, attention was focused on the study of the surface reconstruction of magnetite and its magnetic properties 3. The inverse spinel structure is stable and can be retained even by application of pressures up to 10 GPa [4]. As a consequence, the B sites are randomly occupied by Fe2+ and Fe3+ even at high pressure. Charge ordering can therefore not be precluded to explain the Verwey transition under high pressure and low temperatures [5]. Looking at the importance of Fe3O4, the present work aimed at the synthesis of Fe3O4 nanoparticles using a novel green synthesis approach. For the green synthesis, native Aloe arborescens plant extract was used in the co-precipitation method. The average crystallite size was found to be 22.20 nm from the X-ray diffraction (XRD). Temperature and applied field dependent magnetization measurements confirm the retention of ferrimagnetic behavior up to 300 K. To manipulate the magnetic ordering Cr3+ was substituted at Fe3+ site. Effect of synthesis method, particle size and Cr doping on crystal structure and magnetism will be discussed in this work.
References
1 A. Bengtson, D. Morgan, and U. Becker, Phys. Rev. B, 87 (2013) 155141.
2 J. A. Duffy, J. W. Taylor, S. B. Dugdale, C. Shenton-Taylor, M. W. Butchers, S. R. Giblin, M. J. Cooper, Y. Sakurai, and M. Itou, Phys. Rev. B 81, (2010)134424.
3 G. Mariotto, S. Murphy, and I. V. Shvets, Phys. Rev. B. 66 (2002) 245426.
[4] S. Klotz, G. Steinle-Neumann, Th. Strässle, J. Philippe, Th. Hansen, and M. J. Wenzel, Phys. Rev. B, 77 (2008) 012411.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Theoretical and Computational Physics / 326

Equation of State of Neutron stars

Authors: Sumeera Gopal[1]; Bhuti Nkosi[2]; Tebogo Motsei[None]; Pebetsi Thokwane[None]

Co-authors: Thuthukile Khumalo [3]; Azwinndini Muronga [4]

[1] *UWC*

[2] *Wits*

[3] *Wits/iThemba LABS*

[4] *University of Johannesburg*

Corresponding Author: 3982649@myuwc.ac.za

Neutron stars provide a laboratory environment where we can study nuclear matter under extreme conditions of super-density, super magnetic field as well as super-gravity. This is a laboratory where the four forces of nature namely, gravity, the weak force, electromagnetism and the strong force can be studied. Studying nuclear matter under extreme conditions in neutron stars can be used to constrain the properties of the nuclear matter produced heavy-ion collisions in facilities like Relativistic Heavy-Ion Collider (RHIC) Brookhaven National Laboratory, Long Island, New York and at the Large Hadron Collider (LHC), CERN, Switzerland, Geneva and Compressed Baryonic Matter (CBM) experiment at Facility for Antiproton and Ion Research (FAIR) Darmstadt, Germany. We will use classical mechanics, statistical thermodynamics and general relativity to study the mass, pressure and radius of a pure neutron star using different types of equation of states. In this talk, we will present the work done during the 2020 NITheP internship program.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

No

Physics of Condensed Matter and Materials / 327

Synthesis and characterization of iron doped sodium and potassium titanates using the Pechini sol-gel method

Authors: Aluwani Guga[1]; Jaco Olivier[1]

[1] *Nelson Mandela University*

Corresponding Author: aluwaniguga@gmail.com

Iron doped (FE:5Ti) sodium and (FE:10Ti) potassium titanates were prepared by the Pechini sol-gel method and calcined at 800 . X-ray diffraction (XRD), Scanning electron microscopy (SEM), Transmission Electron Microscopy (TEM), Energy Dispersive X-ray spectrometry (EDS), FTIR and Raman spectroscopy were used to characterize the titanate nanomaterials. A quantitative XRD analysis using Rietveld refinement of the titanates confirmed the powders to consist of crystalline phases with the Na2Ti7O15 and K2Ti8O17 phases predominant for the sodium and potassium titanate, respectively. This was further confirmed using selected area electron diffraction (SAED) in the TEM. SEM analysis indicated the titanates consistent with a nanostructured material exhibiting rod like morphology. The elemental compositions of the titanites were examined by SEM-EDS and TEM-EDS

and found to agree well with the targeted Fe to Ti ratio from synthesis. Limited evidence for the segregation of iron in the titanate regions were found indicating the iron to be incorporated within the titanate lattice. Electron energy loss spectroscopy (EELS) fine-structure analysis of the Fe L2,3 core-loss edge was successfully used to match the Fe to a 3+ or 4+ valence state. Finally, Fourier transform infrared spectroscopy (FTIR) was used to classify the stretching and bending vibration modes of the functional group of sodium and potassium titanates along with Raman spectroscopy.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Space Science / 328

DAILY GLOBAL SOLAR RADIATION ESTIMATION USING AN ARTIFICIAL INTELLIGENT APPROACH

Author: Yetunde Olorunfemi[1]

Co-authors: Olanrewaju B. Wojuola [2]; Joseph A. Adeshina [2]

[1] *North West University*

[2] *North West University, South Africa*

Corresponding Author: olorunfemiyetundet@gmail.com

Daily solar radiation (DSR) is sparsely measured in meteorological stations in South Africa. The prediction of DSR is very crucial to solar energy conversion systems (design, modeling, and operation) as well as decision making of potential energy policies. The need for these solar system designs vary from the use of power and water supply for industrial purposes to agricultural and domestic uses. This paper employed the use artificial neural networks in predicting DSR from the Capes of South Africa using NASA satellite data for 30 years. Daily values of minimum and maximum temperature, relative humidity, precipitation, wind speed, atmospheric temperature and earth's temperature are used as the independent variable and the solar radiation as the dependent variable when training the model. Statistical metrics was used in comparing the predicted solar radiation with the observed solar radiation. ANN model recorded a better root mean square error (RMSE), mean absolute percentage error (MAPE) and correlation of determination (R2) values of 0.79 , 11.41 and 0.83 respectively in the Northern Capes compared to the Eastern Cape of RMSE, MAPE and R2 values of 1.06 , 18.89 and 0.75 respectively and Western Cape of RMSE, MAPE and R2 values of 1.57 , 27.34 and 0.60 respectively. The results show that the data form the Northern Cape has high predictive strength than its counterpart as its regression value tends closer to 1 than others.

Keywords: Artificial neural network; solar radiation; meteorological variables; MAPE.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics of Condensed Matter and Materials / 329

Analysis of varying Tb3+ concentrations on the structural and optical properties of mixed phases of CaAl2O4/Ca1.02Sr1.98Al2O4/SrAl2O4/SrO/Al2O
(0 ≤ x ≤ 2) prepared by sol-gel method.

Authors: Tshepo Mabelane[1]; Lehlohonolo Fortune Koao[2]; Setumo Victor Motloung[3]; Tshwafo Elias Motaung[4]; Motlalepula Rebecca Mhlongo[1]

[1] *Sefako Makgatho Health Sciences University*

[2] *University of Free State, Qwaqwa*

[3] *Walter Sisulu University*

[4] *University of South Africa*

Corresponding Author: mabelanetshepo1997@gmail.com

Mixed phases of Tb3+ doped CaAl2O4/Ca1.02Sr1.98Al2O4/SrAl2O4/SrO/Al2O3 (CCSSA:x%Tb3+ (0 ≤ x ≤ 2)) nanophosphors were successfully prepared using sol-gel method. X-ray diffraction (XRD) patterns revealed that all the annealed samples resembled the mixed phases of monoclinic (CaAl2O4 and SrAl2O4), cubic (Ca1.02Sr1.98Al2O4 and SrO) and hexagonal (Al2O3) crystal structures, which were not influenced by variation the Tb3+ concentration. Scanning electron microscopy (SEM) images showed that the morphological features of the prepared nanophosphors were influenced by the Tb3+ concentration. Transmission electron microscopy (TEM) confirmed that the prepared materials were on the nanoscale region. Ultraviolet–visible (UV–vis) diffuse reflection spectroscopy showed that the band gap energy can be tuned in the range 4.90- 5.35 eV. Photoluminescence (PL) results showed four emission peaks located at around 490, 544, 583 and 622 nm and they were respectively ascribed to 5D4 ⟶ 7F6, 5D4 ⟶ 7F5, 5D4 ⟶ 7F4 and 5D4 ⟶ 7F3 transitions of Tb3+ ions.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Physics of Condensed Matter and Materials / **330**

Effect of annealing time on the structure, morphology and optical properties of mixed phases of barium and strontium aluminates doped with 0.1% Tb3+ prepared by citrate sol-gel method

Authors: Mpho Maluleka[1]; Setumo Victor Motloung[2]; Lehlohonolo Fortune Koao[3]; Tshwafo Elias Motaung[4]; Motlalepula Rebecca Mhlongo[1]

[1] *Sefako Makgatho Health Sciences University*

[2] *SMU*

[3] *University of Free State (Qwaqwa)*

[4] *University of South Africa*

Corresponding Author: mphomaluleka96@gmail.com

Citrate sol-gel method was used to successfully prepare mixed phases of strontium and barium aluminate powders doped with 0.1% Tb3+. All powders were annealed at 1000 oC while varying the annealing time (AT) from 0.5 – 4 hours (h). The X-ray powder diffraction (XRD) results revealed that the prepared powders is the mixture of phases consisting of cubic (Sr3Al2O6, Ba3Al2H12O12), monoclinic (SrAl2O4, SrAl4O7), hexagonal (Ba0.6Sr0.4Al2O4, SrO, BaAl2O4) and orthorhombic (BaH4O3) crystal structures. Tb3+ did not influence the structure of mixed phases of BaAl2O4/BaH4O3/Ba3Al2H12O12/Ba0.6Sr0.4Al2O4/SrAl2

Sr3Al2O6/SrO (BBBBSSSS). The energy dispersive X-ray spectroscopy (EDS) mapping showed homogeneous distribution of elements on the surface. The scanning electron microscopy (SEM) images showed that as the AT increases the particle becomes more agglomerated and smoother. Transition electron microscopy (TEM) images suggested that the particle sizes were not influenced by the AT. Ultraviolet–visible (UV–vis) diffuse reflection spectroscopy confirmed that AT influenced the energy band gap (Eg) of the prepared nanophosphor. The Eg can be tuned between 5.1 and 5.7 eV. Photoluminescence (PL) results showed four emission peaks located around 489, 546, 589 and 618 nm which are attributed to 5D4 →7F6, 5D4 →7F5, 5D4 →7F4, and 5D4 →7F3 transitions of Tb3+ ions, respectively.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Photonics / **331**

Stokes polarimetry performed with a digital micromirror device

Author: Angela Dudley[1]

Co-authors: Keshaan Singh ; Nape Isaac ; Forbes Andrew

[1] *CSIR National Laser Centre*

Corresponding Author: angelajvr@gmail.com

In this work, Stokes polarimetery is used to extract the polarization structure of optical fields from only four measurements as opposed to the usual six measurements. Here, instead of using static polarization optics, we develop an all-digital technique by implementing a Polarization Grating (PG) which projects a mode into left- and right-circular states which are subsequently directed to a Digital Micromirror Device (DMD) which imparts a phase retardance for full polarization acquisition. We apply our approach in real-time to reconstruct the State of Polarization (SoP) and intra-modal phase of optical modes.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics for Development, Education and Outreach / **332**

Astronomy as a tool for human capacity development: the Namibian example

Authors: Hannah Dalgleish[1]; Marc Klein Wolt[2]; Joanna Holt[3]; Amanda Schut[2]; Michael Backes[1]; Marieke Baan[3]; Garret Cotter[4]; Eli Kasai[1]

[1] *University of Namibia*

[2] *Radboud University*

[3] *Nova Informatie Centrum*

[4] *University of Oxford*

Corresponding Author: hannah.dalgleish@physics.ox.ac.uk

Astronomy for development is making great strides in Namibia. As a country renowned for its dark and pristine skies, Namibia offers the perfect landscape for the construction of ground-based observatories. The benefits of developing astrophysics infrastructure are not only limited to solving the mysteries of the Universe, however. Numerous research has shown that astronomy projects around the world lead to many other benefits – societal, cultural, economic, and environmental.

The High Energy Stereoscopic System (H.E.S.S.) is so far the first and only large-scale telescope to arrive in Namibia, in operation since 2002. Plans of building more telescopes in the country, such as the African Millimetre Telescope (AMT) and a part of the African Very Long Baseline Interferometry Network (AVN) of telescopes are currently underway.

The AMT will bring with it many more opportunities for capacity-building, and our multi-disciplinary collaboration is working on a Social Impact Plan to maximise the societal benefits brought about by the future observatory. This Plan takes a multi-disciplinary approach to setting the scene for astronomy and sustainable development in Namibia. Looking at education more closely, we outline plans for the Mobile Planetarium; the materials we will create for schools; teacher training; bringing international astronomy training programmes to Namibia; mentorship, scholarship, and fellowship programmes; and the inclusion of indigenous knowledge. In all, sustainability is our utmost priority and by incorporating these different efforts we hope to inspire a new generation of scientists in Namibia.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

n/a

Theoretical and Computational Physics / 333

Bjorken Hydrodynamics for Heavy Ion Collisions

Authors: Magdeline Mohlao Seabi[1]; Ronewa Nemalili[2]; Mpho Phakoe[1]; Rendani Netshikweta[3]; Brian Ramogayana[4]; Mohammed Younus[5]; Azwinndini Muronga[6]

[1] *University of the Western Cape*

[2] *University of Witwatersrand*

[3] *University of Venda*

[4] *UL*

[5] *Seacom Skills University*

[6] *Nelson Mandela University*

Corresponding Author: 3868098@myuwc.ac.za

High energy heavy ion collisions such as those at the Relativistic Heavy Ion Collider (RHIC), Brookhaven National Laboratory (BNL), Long Island, NY and those at the Large Hadron Collider (LHC), CERN, Geneva have produced a new state of matter called Quark-Gluon Plasma (QGP). This QGP filled the entire early Universe for a few microseconds (˜10 μs) after the Big Bang. This state of matter is also believed to exist in the central core of the neutron stars. In the QGP phase, the number of degrees of freedom increases drastically. Therefore, one can expect the produced matter to flow. Indeed, strong collective flow patterns have been measured at RHIC and LHC, which suggests that the hydrodynamical models are well justified during the QGP stage of the reaction: from the time when

local equilibrium is reached until the hadronization. In this study, a scaling solution also known as Bjorken hydrodynamics was used to study thermodynamic properties such as number density, energy density, entropy density and temperature as functions of proper time. We also compared particle rapidity distribution from Bjorken hydrodynamics with that from Landau hydrodynamics. From the time evolution of thermodynamic quantities, it was found that the QGP expands like the Hubble expansion of the Universe.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Astrophysics / **334**

Eliminating single-band dominance in dual-band pulsar light curve fitting

Author: Albertus Seyffert[1]

Co-authors: Alice Harding [2]; Christo Venter [3]

[1] *Centre for Space Research, North-West University, Potchefstroom Campus, 2520 Potchefstroom, South Africa*

[2] *Theoretical Division, Los Alamos National Laboratory, Los Alamos, NM 58545, USA*

[3] *Centre for Space Research, North-West University, Potchefstroom campus, South Africa*

Corresponding Author: 20126999@nwu.ac.za

The wealth of multiwavelength pulsar data has stimulated the development of emission models that predict light curves (LCs) over multiple wavebands, most notably radio and gamma-ray. Using established statistical methods to fit these model LCs to data can prove ineffectual if the data from one waveband are substantially more precise. This waveband—typically radio—dominates the fit and biases inferred parameters. We re-examine the use of Pearson's chi-squared statistic for joint fits, and introduce a new, derived statistic. The core insight that this statistic encodes is that the component single-band chi-squared values implicitly express goodness of fit in units of the respective LC uncertainties. The resulting implicit weighting the dual-band chi-squared carries is eliminated by expressing these values in a shared unit before calculating their sum, derived by effectively standardizing the scaled pulsar-associated flux across the two wavebands. Importantly, chi-squared and our new statistic converge to the same constraints as the precision disparity dissipates. As a first test, we fit two amalgamated dual-band models to 23 Fermi LAT pulsars and compare the resulting constraints to earlier results derived using the same data and similar models. Our fits consistently show no radio dominance, and our constraints more strongly correlate with those derived by eye.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics for Development, Education and Outreach / **335**

Modular logic gate emulator for online laboratory

Author: Marco Mariola[1]

[1] *University Of Kwazulu Natal*

Corresponding Author: mariolam@ukzn.ac.za

The pandemic year represented a challenging time for educators, a time where the classical way of teaching change from contact to remote learning. While contact lectures can be replaced by videos or video conferences, the laboratory can be replaced with simulations or by instructing the students to buy and build ad hoc systems by supplying the essential instructions. A remote assisted experiment requires to be conducted safely, the components readily available, and possibly low-cost. Technical High Schools and universities teach the logic gates and how to assemble a circuit to solve a specific function. Several licensed and free software are available for simulation, and for a hypothetical real experiment, it is necessary to supply the students with several components and tools. This project proposes performing several digital electronics experiments by using a building block, a logic gate emulator. This device can be modified according to the teacher's needs and sent to the students to do remote experiments.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics for Development, Education and Outreach / **336**

First year physics students perception of online learning

Authors: Mark Herbert[1]; Bako Audu[None]

[1] *University of the Western Cape*

Corresponding Author: dr.ms.herbert@gmail.com

The COVID-19 pandemic has impacted teaching and learning at the University of the Western Cape, in particularly the first year students from high schools. These students who traditionally received their teaching and learning through face-to-face teaching and learning method now receive their teaching and learning via online (electronic teaching and learning) because the university has decided to make online teaching and learning the core method to deliver the curriculum during the pandemic.
After the first term of online teaching and learning, an online survey was conducted to investigate the perception of online teaching and learning among the first year main stream physics students in the department of Physics and Astronomy at the University of the Western Cape. In this presentation the results of the survey will be presented and discussed.

Apply to be considered for a student ; award (Yes / No)?:

N/A

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics for Development, Education and Outreach / **337**

Natural Sciences and Physical Sciences teachers' professional development programme at the Department Physics and Astronomy, University of the Western Cape

Authors: Mark Herbert[1]; Bako Audu[None]

[1] *University of the Western Cape*

Corresponding Author: dr.ms.herbert@gmail.com

For Natural Sciences and Physical Sciences teachers' to deliver the physics component of the CAPS curriculum as required by the National Curriculum Statement implies that teachers have a deep understanding of the content knowledge as well as the pedagogical content knowledge to transmit the content for effective teaching. However, research findings have indicated that teachers find the curriculum challenging and that they were concern that they did not have the necessary skills to deal with the content.
The South Africa Institute of Physics (SAIP) in her recommendation in the draft document "Strategic Plan on the enhancement of Physics Training in South Africa" stated that Physics Departments at South Africa Universities should plays a more active role in teacher training. In this presentation and overview of the Natural Sciences and Physical Sciences teachers' professional development programme at the department of Physics and Astronomy, University of the Western Cape will be given and a survey of teachers perception of the programme.

Apply to be considered for a student ; award (Yes / No)?:

N/A

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Physics for Development, Education and Outreach / **338**

The SAIP Benchmark Statement and Physics Graduate Preparedness: A Case Study of University of the Western Cape.

Authors: Bako Nyikun AUDU[1]; Delia Marshall[2]; Mark Herbert[2]

[1] *University of the Western Cape*

[2] *UWC*

Corresponding Author: bakoaudu@hotmail.com

In line with current realities and best practices across the world, preparing physics students and graduates is beyond the usual physics career bracket. Preparation of Physics students in the now is beyond the standard model, where preparation now include working well in teams, understanding how science and technology are used in real-world settings, writing, and speaking well, and understanding the context in which work is now done; where use and value of knowledge and graduate skills go beyond the knowledge of physics is often engaged. These concerns led the researchers to draw on various education theories in to order to understand, investigate and relate how preparedness in terms of graduate skills will benefit physics graduates. In this study, the researchers will focus on the Benchmark Statement on BSc Physics and BSc (Hons) Physics programs in South Africa as articulated by SAIP, graduate attributes (transferable skills and citizen skills) in the context of Physics Graduate Attributes (PGAs), the physics curriculum from a progressive university in South Africa in answering "How are intended physics graduate attributes (as specified by SAIP and Charter of graduate attributes) embedded in the BSc and BSc (Hons) physics curriculum?". The study will assess the stand of SAIP regarding how Universities adopt the Benchmark Statement and recommend suggestions for further oversight by SAIP.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics for Development, Education and Outreach / **339**

Creating the Support for High School After-Hour-Tutorial Programme: A Pilot Study

Authors: Bako Nyikun AUDU[1]; Mark Herbert[2]

[1] *University of the Western Cape*

[2] *UWC*

Corresponding Author: bakoaudu@hotmail.com

There seems to be problems in South African schools regarding Science and Mathematics at the GET and FET phases in parts of Cape Flats where crime and other vices thrive. The security, social and economic effect cannot be overemphasized as whatever choice learners make in school regarding mathematics and the sciences impact the very society they live in. This problem will have economic implications in the long run if South Africa wants to be a global player in the 4th Industrial Revolution. That is because, South Africa will need to produce students who can follow careers in the Sciences, Technology, Engineering and Mathematics (STEM) stream, to foster skills relating to the 4th Industrial Revolution and to lead life in the global village. For the STEM career paths, learners with good foundation in Mathematics will always be needed and will always be in short supply. The North High School is a technical school with great potential of meeting a small portion of the supply chain for learners that are needed for the STEM field in South Africa and it stands to develop individuals to attain their full potentials in life. The pass rate for grades 8 and 9 mathematics for 2017/2018 was about 10% respectively, thus the need for this intervention. The overall goal of the intervention is at the community level with high schools is to ensure significant growth and improvement in learners' achievement, learners' interest and learners' participation in Mathematics. The study sought to identify factors that encourages learners' retention in such programme.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics for Development, Education and Outreach / **340**

First year physics students perception of problem solving

Authors: Mark Herbert[1]; Bako Audu[None]

[1] *University of the Western Cape*

Corresponding Author: dr.ms.herbert@gmail.com

First year main stream physics students at the department of Physics and Astronomy, University of the Western Cape from high schools has poor problem solving skills and coupled with poor attitudes towards learning physics.

After the start of the first term, an online survey was conducted to investigate the perception of problem solving in physics among the first year main stream physics students in the department of Physics and Astronomy at the University of the Western Cape. In this presentation the results of the survey will be presented and discussed.

Apply to be considered for a student ; award (Yes / No)?:

N/A

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Astrophysics / **342**

The Effect of Dark Matter in the Epoch of Reionization

Author: Mpho Kgoadi[1]

[1] *Wits University*

Corresponding Author: kgoadimpho16@gmail.com

The problem of dark matter has been of great importance in modern physics since its inception. Many theories have been proposed about the nature of dark matter but perhaps the most studied is the WIMP (Weakly Interacting Massive Particle). This particle has been favoured because it has the properties of dark matter that have been measured experimentally, so far. In this work we present an argument for studying the properties of dark matter in the Epoch of Reionization (EoR) using the redshifted 21 cm background. The 21 cm line of hydrogen provides great potential in studying the Universe at an early stage. This could provide rich information about the thermal and ionization history of the Universe as well as understanding the physics behind the formation of the first stars and galaxies. This will allow us to have a full picture of the global 21 cm background including the effects of WIMPs, if there are any. We also will demonstrate the potential power of HERA and the SKA to probe the high redshift Universe, being able to produce constraints that are highly competitive against current benchmark models of indirect detection of dark matter.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Theoretical and Computational Physics / **344**

Imaging with moving detectors

Author: Nicholas Bornman[1]

Co-authors: Achim Kempf [2]; Andrew Forbes [3]

[1] *University of the Witwatersrand*

[2] *University of Waterloo*

[3] *University of Witwatersrand*

Corresponding Author: nicholas.bornman1@students.wits.ac.za

The theoretical framework behind modern-day quantum optics has been successful in explaining a number of interesting phenomena. However, since it is traditionally formulated using ordinary quantum mechanics and Fourier optics, it cannot account for relativistic notions such as different reference frames (including non-inertial ones) or curved classical gravitational backgrounds. In an attempt to understand the quantum imaging process within a more complete quantum field theory (QFT) framework, a novel analogy is proposed: so-called Unruh-DeWitt (UDW) detectors can be used to model both the object one wishes to image as well as the pixelated imaging device itself. As an example, after coupling a QFT version of a biphoton state created via spontaneous parametric down-conversion (which is one of the principal processes used to create entangled photons in the laboratory) with arrays of Unruh-DeWitt detectors, we investigate quantum ghost imaging under both inertial and accelerating conditions. Given that the reconstructed images can be discerned better than a pure guess, the formalism appears capable of describing the quantum imaging process in non-trivial reference frames.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Astrophysics / **346**

Simulations of Stochastic Long-Term Variability in Leptonic Models for External-Compton and Synchrotron Self-Compton Dominated Blazars

Author: Hannes Thiersen[1]

[1] *NWU*

Corresponding Author: hannesthiersen@gmail.com

In this talk we present an investigation into the nature of multi-wavelength variability of blazars from a purely numerical approach. We use a time-dependent one-zone leptonic blazar emission model to simulate multi-wavelength variability by introducing stochastic parameter variations in the emission region. These stochastic parameter variations are generated by Monte Carlo methods and have a characteristic power law index, $\alpha = -2$ in their power spectral densities (PSDs). We include representative blazar test cases for a flat spectrum radio quasar (FSRQ) and a high synchrotron peaked BL Lacertae object (HBL) for which the high energy component of the Spectral Energy Distribution (SED) is dominated by external Compton (EC) or synchrotron self-Compton (SSC) emission respectively. The simulated variability is analyzed in order to characterise the distinctions between the two blazar cases and the type of progenitor variations. We show that the variability's power spectrum is closely related to underlying progenitor variations for both cases. Distinct differences between the different progenitor variations are present in the multi-wavelength cross-correlation functions.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Astrophysics / **347**

A hadronic synchrotron mirror model for blazars - application to 3C279

Authors: Laenita Oberholzer[1]; Markus Boettcher[1]

[1] *North West University*

Corresponding Author: laenitaoberholzer@gmail.com

Blazars are a class of Active Galactic Nuclei (AGN) that are radio loud and have a small angle between the jet and the observer's line of sight. In some cases, flaring events in one frequency band are not accompanied by flaring in other bands. Such events are termed orphan flares. The causes of this variability and conditions in and location of the high energy emission region are not completely understood. As a possible explanation for rapid gamma-ray variability, the hadronic synchrotron mirror model is suggested. A TeV orphan flare without Fermi-LAT counterpart was observed on the 28th of January 2018 by the H.E.S.S. observatory from 3C 279. A primary flare was observed 11 days earlier by Fermi-LAT. The Fermi-LAT spectrum is used to constrain model parameters able to reproduce the proton-synchrotron SED through an analytical fit to the data. The flaring very-high-energy emission is modeled by the hadronic synchrotron mirror model. First-principle analytical estimates predict a dense enough target photon field that is sufficiently efficient for photohadronic interactions to take place. Our numerical evaluation of this scenario reproduces a photo-pion induced very-high-energy gamma-ray flare without significant enhancement of the Fermi-LAT flux. The photo-pion component of the spectrum is comparable in flux to that of the proton-synchrotron component.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

MSc

Nuclear, Particle and Radiation Physics / **350**

Activity Concentration Measurement of Naturally-Occurring Radionuclides in Various Vegetation plots in Rustenburg, North-West Province, South Africa

Corresponding Author: olagbajupetero@gmail.com

Nuclear, Particle and Radiation Physics / **351**

Assessment of NORM in fruits and vegetables from local markets in Hartbeespoort, Mahikeng and Pretoria

Corresponding Author: veronika3@tpu.ru

Nuclear, Particle and Radiation Physics / 352

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Apply to be considered for a student ; award (Yes / No)?:

Level for award;(Hons, MSc, PhD, N/A)?:

Nuclear, Particle and Radiation Physics / 354

Measurements of neutron energy spectra up to 200 MeV at the iThemba LABS fast neutron beam facility

Corresponding Author: kutullo.maibane@uct.ac.za

Apply to be considered for a student ; award (Yes / No)?:

Level for award;(Hons, MSc, PhD, N/A)?:

Nuclear, Particle and Radiation Physics / 355

Investigation of limit of detection using standard radioactive sources with a LaBr3(Ce) detector

Corresponding Author: fvniekerk@tlabs.ac.za

Nuclear, Particle and Radiation Physics / 356

Multi-photon decay mode spectroscopy of positronium

Corresponding Author: sjohnson@tlabs.ac.za

Nuclear, Particle and Radiation Physics / 357

Optic Fibre Sensors for Temperature Sensing in Pressurized Water Reactors

Corresponding Author: bmaqabuka77@gmail.com

Apply to be considered for a student ; award (Yes / No)?:

Level for award;(Hons, MSc, PhD, N/A)?:

Nuclear, Particle and Radiation Physics / **358**

Measurement of the photoabsorption cross section of 24Mg.

Corresponding Author: 1390529@students.wits.ac.za

Nuclear, Particle and Radiation Physics / **359**

Study of the 44Ti(alpha,p)47V reaction rate using high-precision 50Cr(p,t)48Cr measurements

Corresponding Author: sifundobinda1@gmail.com

Nuclear, Particle and Radiation Physics / **360**

Development of (p,p'γ) detection capabilities at iThemba LABS through the study of low-lying E1 strength in 58Ni

Corresponding Author: 1511527@students.wits.ac.za

Apply to be considered for a student ; award (Yes / No)?:

Level for award;(Hons, MSc, PhD, N/A)?:

Nuclear, Particle and Radiation Physics / **361**

The scissors resonance in 151Sm

Corresponding Author: 1113601@students.wits.ac.za

Nuclear, Particle and Radiation Physics / **362**

Impact of Experimentally Constrained Nuclear Level Density and Photon Strength Function of 182Hf on the Nucleosynthesis Puzzle of 182Hf

Corresponding Author: yendenomcebo@gmail.com

Nuclear, Particle and Radiation Physics / **363**

Statistical properties of 133Xe from inverse kinematics Reactions extracted using the Ratio Method

Corresponding Author: teffoseakamela@gmail.com

Apply to be considered for a student ; award (Yes / No)?:

Level for award;(Hons, MSc, PhD, N/A)?:

Nuclear, Particle and Radiation Physics / **364**

Fine structure of the ISGMR in 90Zr, 120Sn and 208Pb

Corresponding Author: armand.bahini@wits.ac.za

Nuclear, Particle and Radiation Physics / **365**

Transfer reactions to populate the PDR in 96Mo

Corresponding Author: thuthukilekhumalo87@gmail.com

Apply to be considered for a student ; award (Yes / No)?:

Level for award;(Hons, MSc, PhD, N/A)?:

Nuclear, Particle and Radiation Physics / **366**

Validation of the Monte Carlo model for 6 and 15 MV photon beams of VARIAN CLINAC IX Linac

Corresponding Author: khomboeunice.dumela@netcare.co.za

Nuclear, Particle and Radiation Physics / **367**

Application of tagged neutron method for detecting diamonds in kimberlite.

Corresponding Author: sm19100047@studentmail.biust.ac.bw

Nuclear, Particle and Radiation Physics / **368**

A compact neutron spectrometer for neutrons produced by cosmic rays

Corresponding Author: jrveri002@myuct.ac.za

Apply to be considered for a student ; award (Yes / No)?:

Level for award;(Hons, MSc, PhD, N/A)?:

Space Science / **369**

Maximum Usable Frequency current forecast verification and new local prediction model development

Author: sahil brijraj[1]

Co-author: Michael Kosch [2]

[1] *university of kwazulu natal*

[2] *SANSA*

Corresponding Author: sahilbrijraj@gmail.com

An important service that Space Weather Centres offer is HF propagation predictions for use by airlines, other users of long-distance radio communication and, especially, in the case of the military. One aim of this project is to report on the verification of Maximum Usable Frequency (MUF) predictions, given by the Ionospheric Communication Enhanced Profile Analysis and Circuit Prediction Program (ICEPAC) and the analysis of large deviations from the predictions. We compared measured near vertical incidence skywave (NVIS) MUF profiles, which is essentially the F-region critical frequency (foF2), to the predicted ICEPAC profiles for the ionosonde located in Grahamstown, South Africa. The study period considered long-term predictions from 2010 to 2019. Using the RMSE skill score as the primary metric to quantify the performance of the prediction model, we found that the average daily skill score was found to be 0.57, with a standard deviation of 0.16.
The majority of days lie within two standard deviations. However, 37% of days that fell below 2 standard deviations could not be reasonably connected to solar storm activity. The results of this study provide a baseline for future models to evaluate the accuracy of HF propagation predictions.
The second larger aim is to develop a more suitable and focused prediction model of MUF profiles for Southern Africa, using local conditions. We have found that solar zenith angle, 10.7 cm solar radio flux and the Kp index are the strongest drivers to reproduce MUF profiles to a correlation > 0.81. We will focus on a combination of these input parameters as they are highly established to be accurately forecasted themselves.

Apply to be considered for a student ; award (Yes / No)?:

Yes

Level for award;(Hons, MSc, PhD, N/A)?:

Postdoc

Applied Physics / **370**

Non Specialist Presentation: Bridging scales in materials simulations - Quantum versus classical simulations

Physics for Development, Education and Outreach / **371**

Advanced Electronics in South Africa : Speaker: Benjamin Hlope, Director of Technology Operations at Kutleng Engineering Technologies

Corresponding Author: iyabo.usman@wits.ac.za

Speaker: Benjamin Hlope, Director of Technology Operations at Kutleng Engineering Technologies

Physics for Development, Education and Outreach / **372**

Data Convergence, a showcase of incubation in Artificial Intelligence: Speaker: Dominque Adams, Project manager at Data Convergence

Corresponding Author: iyabo.usman@wits.ac.za

Speaker: Dominque Adams, Project manager at Data Convergence

Physics for Development, Education and Outreach / **373**

Bridging the gap between academia and industry : Speaker: Rinae Nnduvheni, Intelligence and Insights Lead at EY Consulting

Corresponding Author: iyabo.usman@wits.ac.za

Speaker: Rinae Nnduvheni, Intelligence and Insights Lead at EY Consulting

Plenary 1: Theoretical and computational physics / **374**

Relativistic Fluid Dynamics for Nuclear Matter under Extreme Conditions in Heavy-Ion Collisions and Astrophysics

Plenary 2: Physics of Condensed Matter and Materials / **375**

Vibrant Color Centers in Diamond Particles: Production and Perspective Applications

Plenary 3: Astrophysics and Space Science / **376**

Can MeerKAT unveil the last of the secrets about galaxy overdensities obscured by the Milky Way

Plenary 4: Photonics / 377

TBC

Plenary 5: Physics for Development, Education, and Outreach / 378

Transduction: towards a better understanding of how students learn physics

Apply to be considered for a student ; award (Yes / No)?:

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Plenary 6: Nuclear and Particle Physics / 379

Quick and Quirk with Quarks: Using new ideas in AI to search for Dark Matter

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Plenary 7: Applied Physics / 380

Layered Inorganic Nanostructures – Electronic and Structural Properties

Plenary 8: SAIP 2020 Gold medal winner / 381

Structured light: from fundamentals to applications

Physics of Condensed Matter and Materials / 382

MOLECULAR DYNAMICS STUDY OF STRUCTURAL PROPERTIES OF Ti57 NANOCLUSTER

Authors: Tshegofatso Michael Phaahla[1]; Hasani Chauke[2]; Richard Charles Arthur Catlow[3]; Phuti Ngoepe[2]

[1] *Physics Masters Student*

[2] *University of Limpopo*

[3] *University College London*

Corresponding Author: phaahlatshegofatso@gmail.com

Recently, there has been a renewed interest in the experimental and theoretical studies of atomic molecular clusters. Small nanoclusters exhibit physical and chemical properties that are often different from the bulk phase due to the large fraction of surface atoms. It is in this context that we initiated this study to investigate how the nanocluster behaves concerning an increase in temperature. Particularly, the titanium metal clusters have not been extensively studied. Molecular dynamics simulations were carried out for Ti57 nanoclusters in a vacuum using Gupta potentials for metal-metal interactions potentials. The classical molecular dynamics simulation software (DL_POLY) was used to investigate the temperature effects on pure Ti57 metal nanocluster. The dynamical properties vacuum environment were interrogated by subjecting the nanoclusters to various temperatures in the range of 300 – 2400 K. The radial distribution functions (RDFs), diffusion coefficient, density profiles and Mean square displacement (MSD) were examined to study the structural changes as a function of temperature. It was found that the vacuum structures melting point reasonably correspond with the experimental data. The phase transitions from solid to liquid have been identified by a simple jump in the total potential energy curve. Furthermore, the RDFs and density profile peaks decrease as the temperature is increased and the potential energy increases as a function of temperature. The density profiles depicted the solid-like features indicated by the distinct peaks at lower temperatures.

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Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Physics of Condensed Matter and Materials / 383

Computational modelling of Ti50Pd50-xCux (0≤x≤25) high temperature shape memory alloys

Author: Ramogohlo Diale[1]

Co-authors: Rosinah Modiba [2]; Phuti Ngoepe [1]; Hasani Chauke [1]

[1] *UL*

[2] *CSIR*

Corresponding Author: refiloe289@gmail.com

Ti50Pd50 system is considered as one of the potential high temperature shape memory alloy (HTSMA) due to their high martensitic transformation temperature at 823 K. Previous studies showed that this alloy is unstable displaying a negative shear modulus (C′) at 0 K. In order to improve the properties, partial substitution of Pd with Cu are being investigated. The equilibrium lattice parameters, elastic properties and the phonon dispersion curves were calculated using first-principle calculations within the generalized gradient approximation based on density functional theory. The independent elastic constants result revealed that stability is attained at above 25 at. % Cu (Ti50Pd25Cu25). The calculated moduli confirm that alloying with Cu effectively increases hardness and ductility in Ti50Pd50

systems. Partial substitution of Pd with Cu was found more effective in enhancing mechanical properties. Furthermore, the addition of Cu may enhance the martensitic transformation temperature of the Ti50Pd50 alloy. These findings can have important implications for future materials design in aerospace industries.

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Yes

Level for award;(Hons, MSc, PhD, N/A)?:

PhD

Astrophysics / 384

MeerKAT's view of the interaction between intra-cluster magnetic field and jets of a radio galaxy

Author: James Chibueze[1]

Co-authors: Haruka Sakemi [2]; Tsutomu Takeuchi [3]; Takumi Ohmura [4]; Mami Machida [2]; Hiroki Akamatsu [5]; Takuya Akahori [2]; Ruby van Rooyen [6]; Viral Parekh [6]; Hiroyuki Nakanishi [7]

[1] *N/A*

[2] *NAOJ*

[3] *Kyushu University*

[4] *University of Tokyo*

[5] *SRON*

[6] *SARAO*

[7] *Kagoshima University*

Corresponding Author: james.chibueze@gmail.com

Galaxy clusters are known to harbour magnetic fields, the nature of which remains unresolved. Intra-cluster magnetic fields can be observed at the density contact discontinuity formed by cool and dense plasma running into hot ambient plasma, and the discontinuity exists near the second brightest galaxy, MRC0600-399, in the merging galaxy cluster Abell 3376 (redshift 0.0461). Elongated X-ray emission in the east–west direction shows a comet-like structure that reaches the mega-parsec scale . Previous radio observations detected the bent jets from MRC 0600-399, moving in same direction as the sub-cluster, against ram pressure. Here we report radio observations of MRC 0600-399 that have 3.4 and 11 times higher resolution and sensitivity, respectively, than the previous results. In contrast to typical jets, MRC 0600-399 shows a 90-degree bend at the contact discontinuity, and the collimated jets extend over 100 kiloparsecs from the point of the bend. We see diffuse, elongated emission that we name 'double-scythe' structures. The spectral index flattens downstream of the bend point, indicating cosmic-ray re-acceleration. High-resolution numerical simulations reveal that the ordered magnetic field along the discontinuity has an important role in the change of jet direction. The morphology of the double-scythe jets is consistent with the simulations. Our results provide insights into the effect of magnetic fields on the evolution of the member galaxies and intra-cluster medium of galaxy clusters.

Apply to be considered for a student ; award (Yes / No)?:

No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

Applied Physics / 386

Carbon Nanostructures beyond Graphene

Author: Gotthard Seifert [1]

[1] *Theoretische Chemie, Technische Universität Dresden, D-01062 Dresden, Germany*

Corresponding Author: gotthard.seifert@tu-dresden.de

Carbon based nanostructures have a long history, dating back to the 30ies and 40ies of the 20th century. They got a strong boost with the discovery of the fullerenes and nanotubes, and they were crowned by the research on graphene. The investigations on these nanostructures are of both fundamental and technological interest due to the interesting electronic and physical properties intrinsically associated with their low dimensionality and quantum confinement effects. With the successful synthesis of graphene nanoribbons and functionalization of graphene layers some shortcoming of 2D graphene could be overcome, opening extremely promising applications in the future nanoscale electronic devices. The intrinsic physical and chemical properties of such modified graphene based systems, will be discussed in comparison with graphene. Especially, the electronic, magnetic and mechanical properties of such structures in terms of their functionalization will be discussed on the basis of theoretical investigations.

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No

Level for award;(Hons, MSc, PhD, N/A)?:

N/A

387

Investigation of energy transfer mechanism in Sm3+ and Eu3+ doped Na6Mg(SO4)4 nanophosphors prepared by solution combustion technique

Authors: Balakrishna Avula[1]; Paulus Masiteng[1]; Reddy L. [1]; Morebodi K.B. [1]

Co-authors: Letswalo M.L.A. [1]; Erasmus Lucas [2]; Hendrik Swart [3]

[1] *University of Johannesburg*

[2] *University of the Free state*

[3] *University of the Free State*

Corresponding Authors: balakrishna.veera@gmail.com, karabom560@gmail.com

A series of singly ions Sm3+(1.0 mol%), Eu3+(1.0 mol%) doped and co-doped Na6Mg(SO4)4:(1.0 mol%)Sm3+/xEu3+ (where x= 0.5%, 1.0 and 1.5 mol%) nanophosphors were prepared using solution combustion technique. Crystalline, morphological and optical measurements were done using different characterization techniques. X-ray diffraction patterns of Na6Mg(SO4)4 nanophosphors confirmed the monoclinic structure with space grouping of p21/c. The optical bandgap of the prepared nanophosphors was estimated using the Kubelka-Munk (K-M) function and found a decrease in the bandgap values after adding Sm3+ and Eu3+ ions. The photoluminescence excitation and emission spectra were measured for both the Sm3+ and Eu3+ ions using two different 404 and 395 nm excitation wavelengths, respectively doped in Na6Mg(SO4)4 nanophosphors. An improvement of the photoluminescence emission color was observed in the co-doped Na6Mg(SO4)4:Sm3+/Eu3+ nanophosphors, with an energy transfer mechanism from Sm3+ to Eu3+ ions. The color coordinates of all the nanophosphors was analyzed using the CIE-1931 color chromaticity, which all confirmed

lied in red color region. These photoluminescence results identified that the studied nanophosphors are potential candidate for application in display and light emitting diodes (LED) technology.

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YES

Level for award;(Hons, MSc, PhD, N/A)?:

MSC

388

Testing 2

Corresponding Author: brian.masara@saip.org.za

Just testing

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Level for award;(Hons, MSc, PhD, N/A)?:

389

The "Nanotechnology Innovation Diamond", a model for successful nanoscience research and development

Authors: Tebogo Mokhine[1]; Brian Masara[1]

[1] *SAIP*

Corresponding Author: tebogo.mokhine@saip.org.za

Although technology innovation management has been extensively studied, little research has been conducted in nanotechnology-focused innovation management. No model currently exists on nanotechnology innovation management and the related critical success factors. Based on a literature review of nanotechnology characteristics and reported successful nanotechnology research, six essential factors of success were identified. These factors are consumer acceptance

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No

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N/A

392

SAIP POPIA ACT

Author: Tebogo Mokhine[1]

[1] *SAIP*

Corresponding Author: tebogo.mokhine@saip.org.za

This is a test abstract

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N/A