NELSON MANDELA UNIVERSITY

SOUTH AFRICAN INSTITUTE OF PHYSICS

100 years
of Physics in Africa
Past, Present and Future

Gqeberha
formerly Port Elizabeth

Date:
4-8 July 2022

ANNUAL CONFERENCE OF THE SOUTH AFRICAN INSTITUTE OF PHYSICS (SAIP 2022)

Virtual Conference

PV Modules from the Physics Department
PV Outdoor Research Facility (ORF)

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PROCEEDINGS

Abbreviations

CERN	European Organization for Nuclear Research
CSIR	Council for Scientific and Industrial Research
DUT	Durban University of Technology
FHIT	Fort Hare Institute of Technol
HartRAO	Hartebessthoek Tadio Astronomy Observation
LRI	Laser Research Institute
NECSA	Nuclear Energy Corporation of South Africa
NITheP	National Institute for Theoretical Physics
NITheCS	National Institute for Theoretical and Computational Sciences
NLC	National Laser Centre
NMISA	National Metrology Institute of South Africa
NMU	Nelson Mandela University
NWU	North-West University
RU	Rhodes University
SAAO	South African Astronomical Observatory
SANSA	South African National Space Agency
SKA	Square kilometre Array
SU	Stellenbosch University
TUT	Tshwane University of Technology
UCT	University of Cape Town
UFS	University of the Free State
UJ	University of Johannesburg
UKZN	University of Kwa-Zulu Natal
UL	University of Limpopo
UNISA	University of South Africa
UniVen	University of Venda
UP	University of Pretoria
UWC	University of Western Cape
UNIZULU	University of Zululand
WiPiSA	Woman in Physics in South Africa
Wits	University of Witwatersrand
WSU	Walter Sisulu University

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Welcome Notes

Prof Sibungile Muthwa on the Mandela Bench, South Campus

Vice-Chancellor of Nelson Mandela University

Nelson Mandela University carries the name of our namesake with great humility. We are also deeply cognisant of the responsibility that this places upon us to continuously live up to the ideals and principles that Nelson Rolihlahla Mandela worked to achieve throughout his life. We recall his words when he said: "It is in your hands to create a better world for all who live in it". This is particularly relevant during these times, as all of our lives are increasingly impacted upon by global sustainability challenges. It is a rallying call to scientists, researchers, academics and intellectuals to strive to pioneer and discover new ways to contribute to the sustainability of communities across the world.

> **I proudly welcome you all to this year's SAIP conference where we will be celebrating the role of the fundamental sciences in achieving the global sustainability goals.**

With this at the forefront of our minds, I proudly welcome you all to this year's SAIP conference where we will be celebrating the role of the fundamental sciences in achieving the global sustainability goals. Ours is an outward-facing university, primarily focused on being in service of society. One of our main goals is to use our scientific knowledge to solve real world problems in partnership with the industries and communities that they impact. Our physics department, with their strong focus on energy materials and fibre optics applications, is no exception. I trust that the conference will generate innovative ideas and stimulate possibilities for collaborative initiatives in our mutual quest to "CHANGE THE WORLD" for the betterment of all.

I trust that you will enjoy and benefit from this year's scientific programme. I look forward to being informed about the outcomes of your hard work and scientific endeavours.

Professor Sibongile Muthwa
Vice-Chancellor of Nelson Mandela University

SAIP President

I am delighted to welcome you to the 66th Annual Conference of the South African Institute of Physics (SAIP), hosted by the Department of Physics, Nelson Mandela University (NMU). The conference will run online between 4-8 July 2022.This is the second time NMU has hosted this conference in 7 years. The circumstances this time round could be better but the generosity of NMU to step up once more is not lost on us. On behalf of the council of SAIP, I extend our gratitude to NMU in accepting our invitation to host the 2022 conference. We look forward to a conference full of stimulating presentations.

The conference organisers have prepared a diverse programme of talks, poster sessions and plenaries representative of all divisions of our institute. Please do inspect the programme for detail at your leisure.

SAIP2022 coincides with and will celebrate three main events, namely, the International Year on Basic Sciences for Sustainable Development (IYBSSD2022), the 100th anniversary of IUPAP to which South Africa is a founding member and the 10th anniversary of the discovery of the Higgs boson, the elementary particle eponymous to Peter Higgs, Emeritus Professor at the University of Edinburgh. Several activities aligned to these three big commemorations have been planned. One of the plenaries will be devoted to the 10th anniversary of the Higgs Boson.

In view of the IYBSSD I would also like to single out the Winter schools whose topics, one on bridging the gap between industry and academia and the other, on use of biophysics to tackle public health problems, are topical and pick up on the theme of sciences for sustainable development.

There will be a supplementary event consisting of the physics in industry day on how physics improves quality of life. In view of the 100th anniversary of IUPAP, we invite you to the SAIP Day which will offer us an opportunity to look back, look ahead and consider the contemporary contribution of the SAIP to the national development of physics in South Africa.

The SAIP annual conference is a fixture in our national physics calendar. The high number of registrations this year reflects its enduring appeal. I am particularly pleased at this because we have given much effort in the past months promoting the SAIP. Matters of common interest to all members will be discussed at the SAIP Annual General Meeting (AGM) on the final day of the conference. Please do attend. The meeting will be followed by the Prize Giving Ceremony to reward those who will excel.

Finally, I want to express my gratitude to the organising and scientific programme committees of SAIP2022 led by Dr Lindsay Westraadt who have worked tirelessly to organise an excellent scientific programme and conference in difficult circumstances. In addition, I would also like to sincerely thank the SAIP Office, the Division and Forum Chairs, the Council of the SAIP and all else that have contributed towards the organisation of SAIP2022.

Professor Makaiko Chithambo
President: South African Institute of Physics

Local Organizing Committee and Scientific Organizing Committee

On behalf of the Nelson Mandela University Physics department, we extend a warm Mandela welcome to you, the delegates of the 66th annual SAIP conference! This will be SAIP's second virtual conference. While it was our full intention to meet in person this year, the lingering uncertainties surrounding COVID-19 have determined otherwise. Nevertheless, following last year's successful conference and the fantastic foundation laid by the SAIP Office and the 2021 LOC, we confidently look forward to an engaging and productive conference with minimal hiccups!

This year's conference is dedicated to the two-fold observance of the International Union of Pure and Applied Physics centenary celebrations (IUPAP 100) as well as the International Year of Basic Sciences for Sustainable Development (IYBSSD 2022). As such, the theme of the conference is **"100 Years of Physics in Africa: Past, Present and Future"**, where we aim to celebrate the growth of physics in Africa over the last 100 years and, at the same time, look to the present and future, and unpack how Physics can address the sustainability challenges facing Africa. As a Physics department, it brings us great pleasure to address this theme, as the principles of sustainability underlie much of what we do at Mandela.

Some of the highlights of the conference include two virtual winter schools, SAIP Day celebrations, Physics in Industry Day, a teachers' programme run in partnership with the DSI, and a full programme of world-class plenary and non-specialists talks. All these activities have been carefully and intentionally planned to appease both purists and applied physicists alike. Topics range from the discovery of the Higgs Boson to those addressing various aspects of sustainability including industry engagement and innovation, good health and well-being, quality education, gender equality and clean energy.

We hope that you enjoy this conference and take advantage of the networking opportunities on offer. Despite their challenges, the last two years have shown us how resilient we are, both personally and as a society. Let's not wait for life to return to normal, let's thrive in the new normal. After all, that is what sustainability is all about.

Best wishes,

Doctor Lindsay Westraadt
(LOC Chair)
Professor JR Botha
(SOC Chair)

Dean of the Faculty of Science Nelson Mandela University

On behalf of the Faculty of Science at Nelson Mandela University, it is an honour and privilege for me to welcome you to the 66th Annual Conference of the South African Institute of Physics (SAIP 2022). In celebrating the International Year of Basic Sciences for Sustainable Development (IYBSSD 2022/23) and the Centenary of the International Union of Pure and Applied Physics (IUPAP) the Faculty of Science will be hosting a suite of activities including the hosting of SAIP 2022, the African School of Fundamental Physics and Applications (ASP 2022) at the end of the year, as well as the African Conference on Physics and Applications (ACP 2023).

Sustainability is engraved in the core ideology of our Faculty, and our institution at large. The University's recent stellar performance in the 2022 Times Higher Education Impact Rankings is a testament to the institution's commitment to addressing the sustainability challenges faced by the world and South Africa in particular. Our faculty is proud to have played a major role in this achievement.

As a faculty, our 15 departments are making significant contributions to achieving the SDGs of Quality Education, Innovation, Good Health, Clean Energy, Clean Water, Life on Land, and Life Below Water. Our Physics department is playing a leading role in the fields of innovation and clean energy.

On Education, the Science Faculty has established a Science Education Forum to address challenges of quality education from Foundation Phase up to postgraduate training. Our local outreach activities are building capacity in rural areas, while our involvement in the ASP programme is making contributions to the science education of the continent.

> **Our Physics department is playing a leading role in the fields of innovation and clean energy.**

The SAIP conferences are necessary for capacity building, networking and sharing of cutting-edge knowledge by local and international physicists. We are honoured to have played our part in ensuring the continuation of this important annual event. I know you will enjoy the SAIP 2022 Conference. I look forward to your presentations and discussions during the conference.

Best wishes,

Professor Azwinndini Muronga
Executive Dean of the Faculty of Science at Nelson Mandela University

Prof Azwinndini Muronga on an outreach excursion to Vhembe, Limpopo

NELSON MANDELA
UNIVERSITY

Department of Physics

Photovoltaics

Sustainable Energy for the Future

The Photovoltaics Research Group focusses on the characterisation of Photovoltaics (PV) materials, devices and systems. The facilities include:

- Photovoltaic Research Laboratory (PV Lab) for advance solar cell and PV module characterisation
- Outdoor Research Facility (ORF) for PV module and system monitoring and characterisation
- ISO17025 accredited Photovoltaic Test Laboratory (PVTL) – PVinsight (Pty) Ltd

The following Applied Physics skills are also acquired:

- Advance solar cell and PV module characterisation and evaluation
- Data acquisition an analysis, including curve fitting and parameter optimisation
- LabView programming and computer interfacing
- Data acquisition system design

For further information on student projects please contact the PVRG.

Prof Ernest van Dyk
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Optical Fibre Telecommunication Research

Escalating bandwidth demands fuelled by smartphones, tablet computers, social media and cloud computing makes Telecommunications an extremely challenging and rewarding field.

Nelson Mandela University has one of the best equipped Optical Fibre Research laboratories in Africa.

We offer an exciting range of MSc and PhD projects featuring:

- Dispersion measurement, compensation and emulation
- Fibre-to-the-home (FTTH) technologies
- Square Kilometer Array related optical fibre topics
- Polarization effects, wavelength division multiplexing, non-linear effects
- Modelling and simulation, OTDR, fusion splicing, bit error rate testing

The Optical Fibre Research Unit is part of the Telkom-sponsored Centre of Excellence.

Scholarship opportunities are available for good, motivated students.

Prof Tim Gibbon
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NELSON MANDELA
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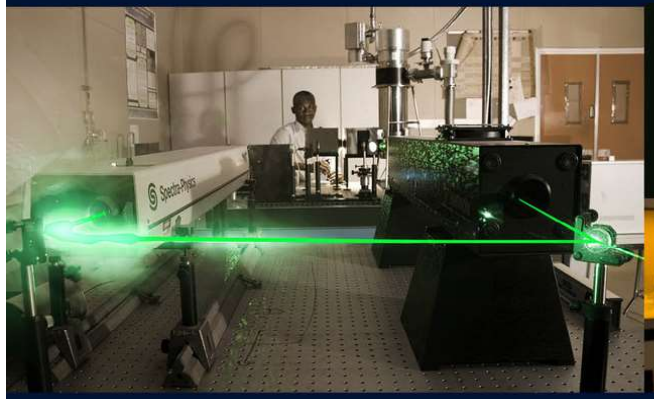

Department of Physics

Electron Microscopy for Materials Research

The Centre for High Resolution Transmission Electron Microscopy (Centre for HRTEM) at Nelson Mandela University houses four state-of-the-art electron microscopes including the only aberration-corrected atomic resolution electron microscope in Africa. The wide range of research projects and MSc and PhD
topics include:

- HRTEM and in situ HRTEM investigation of nanoparticle catalysts
- Irradiation damage and fission product transport in nuclear reactor materials
- Corrosion resistant nuclear reactor materials
- Refining of weldability limits of creep-aged power plant stainless steel
- Lifetime assessment of high value power plant components
- Characterisation of diamond, Pt, Ti and Al alloys, compound semiconductor structures and gold and platinum bearing ores

HRTEM
E **HRTEM@mandela.ac.za**

Semiconductor Materials Development

This research focuses on vapour phase and solution-based deposition of semiconductors for opto-electronic devices.

The Physics Department has unique equipment for the synthesis and characterization of semiconductor thin films and nano-structures, including a state-of-the-art reactor for compound semiconductor deposition.

We currently develop:

- Epitaxial InAsSb and related compounds for infrared detectors
- ZnO nanorods for high efficiency white LEDs and hybrid solar cells
- Nanostructured TiO2 for solar water splitting

Our active collaborations with several local and overseas universities over many years, including groups in Sweden, Germany and the UK, have forged excellent academic links. For information on these exciting research topics contact:

Prof Reinhardt Botha
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Plenary Speakers

Nurse administering COVID-19 vaccine on Nelson Mandela University, North Campus

Dr Tjaart PJ Krüger

Department of Physics,
University of Pretoria,
South Africa

Tjaart was fascinated with the complexity of biological systems and the possibility that physics provided one of the best toolkits to examine the processes of life at the fundamental level. He started with a solid foundation in Physics, Mathematics, and Applied Mathematics, capped with an MSc in Space Physics in Potchefstroom, before he switched to the field of Biophysics. He completed a PhD in Biophysics (cum laude) and a postdoctoral fellowship at the Vrije Universiteit Amsterdam in The Netherlands, after which he came back to South Africa to establish biophysics research at the University of Pretoria. His research focusses mainly on the primary processes of photosynthesis, which he investigates using various laser spectroscopy techniques and some theoretical approaches. He is particularly interested in the design principles of photosynthetic light-harvesting complexes and how these principles may be applied to improve the design and performance of organic solar cells. Another interest is to find ways to control light-harvesting processes using tools such as shaped light and metallic nanoparticles.

His scientific contributions have received broad recognition: by the University of Pretoria (Academic Achievers Award, 2017; Exceptional Young Researcher's Award, 2018), the NRF (Y1 rating), the Royal Society of South Africa (Meiring Naudé medal, 2019), the Albert-Ludwigs University of Freiburg in Germany through a prestigious fellowship in 2015, and the South African Young Academy of Science (SAYAS, 2019), where he currently serves as an Executive Committee member. The US National Academies of Sciences, Engineering, and Medicine recognised him in 2021 as an expert panellist in Quantum Biology, and in the same year he joined the Editorial Board of the Journal of Physical Chemistry Letters. He recently had the privilege to talk about his research on SAfm.

ABSTRACT

Biophysics: an introduction to its science and applications

The 21st century has been called the "century of biology" since the biggest innovations are predicted at the intersection between biology and technology. Physics plays a key role in establishing this intersection. In fact, during the past couple of decades, biophysics has contributed to substantial advances in solving important and fundamental questions in biology and it is indispensable for confronting mankind's health challenges. Biophysics underpins large sections of the global bio-economy. A strong and diverse biophysics research and commercial sector is therefore vital for the success of the African economy.

Biophysics bridges the complexity of life with the elegant physical laws of nature. It weds the complex beauty of biology with the rigour of physics.

This presentation will serve as a broad introduction to biophysics with a particular emphasis on molecular biophysics. I will include a few examples of quantum biology that illustrate how we may draw inspiration from the biological world for our own quantum technologies. This will be followed by an introduction to selected methods for manipulating and controlling the properties of individual biomolecules. I will conclude with examples from my own laboratory, showing how the photon emission signatures of individual light-harvesting complexes can reveal new biological functions.

Dr Lee-Anne McKinnell

Managing Director at SANSA Hermanus

Dr Lee-Anne McKinnell is currently the Managing Director responsible for the Space Science Programme and Hermanus Facility of the South African National Space Agency (SANSA). She holds a PhD in Space Physics from Rhodes University, and a MBA from the Business School Netherlands. In her current role Dr McKinnell represents South Africa on a number of international committees and working groups ensuring Africa's interests are maintained in the field of space science and related technology. She is a champion for space weather applications and is leading the SANSA project to develop 24/7 operational space weather capability for Africa.

As a current member of the SANSA Executive team, Dr McKinnell contributes towards the leadership team of SANSA utilizing her expertise as a Space Scientist combined with her facility and programme management experience to ensure sustainability of Space Science and the Hermanus facility within SANSA and South Africa.

ABSTRACT

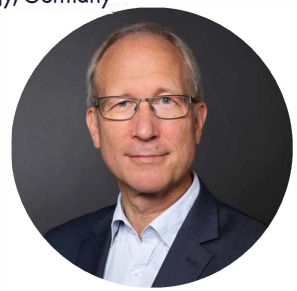
The past, present and future of the Space Agency in Hermanus

In 2021 the South African National Space Agency (SANSA) celebrated 80 years of Magnetic Observations in Hermanus as well as 10 years as part of the national Space Agency. The SANSA Hermanus campus has grown significantly over the past few years in both infrastructure and expertise. However, it should always be remembered that the foundation upon which the success of today has been built comes from the operations of the facility on magnetic principles. And these principles are embedded in a knowledge of Physics. Today SANSA Hermanus is a leading Space Physics institute that utilizes the research to operations value chain to provide products and services in Magnetic Technology and Space Weather.

The last 3 years have been especially significant for the facility as SANSA has implemented the growth strategy to be the leading space weather information provider in Africa. This presentation will explore how the past 81 years has laid the foundation for the Space Agency to become a leading institute on the international stage. The growth strategy that includes the new Space Weather Centre will be shared and how humble beginnings has led to international scientific recognition.

Prof Matthias Wuttig

RWTH Aachen University of Technology, Germany



Prof. Matthias Wuttig currently holds the Chair of Physics of Novel Materials at RWTH Aachen University in Germany. After his PhD he spent time in Marseille, Tsukuba, Berkeley, Murray Hill (Bell Labs) and the Research Center Jülich, before he moved to RWTH Aachen University in 1997. There he was speaker of the Strategy Council advising the University Rectorate, Dean of the Faculty of Mathematics, Informatics and Natural Sciences and has been the speaker of the Collaborative Research Center Nanoswitches since 2011.

In the last ten years, he has also spent time at IBM's Almaden Research Center (San Jose), Lawrence Berkeley Laboratory, Stanford University, CINaM (Marseilles) as well as the Shanghai Institute of Microsystem and Information Technology (Chinese Academy of Sciences). Developing novel materials is the goal of Matthias Wuttig's work.

In doing so, he relies on an unconventional approach, the development of 'treasure maps' to identify promising materials. This has enabled the identification of fundamental relationships between relevant material properties and the underlying chemical bonding mechanism. He is particularly interested in the design of materials for photonic applications, data storage and energy conversion.
He has received various scientific awards and funding for his work, such as an Einstein Professorship of CSC and an ERC Advanced Grant. He is an elected fellow of the Materials Research Society and has published more than 400 papers (with about 25.000 citations (Web of Science)).

ABSTRACT

Functional Materials by Design: Developing Treasure Maps with Quantum Chemistry

Scientists and practitioners have long dreamt of designing materials with novel properties. Yet, a hundred years after quantum mechanics lay the foundations for a systematic description of the properties of solids, it is still not possible to predict the best material in applications such as photovoltaics, superconductivity or thermoelectric energy conversion. This is a sign of the complexity of the problem, which is often exacerbated by the need to optimize conflicting material properties. Hence, one can ponder if design routes for materials can be devised.
In recent years, the focus of our work has been on designing advanced functional materials with attractive opto-electronic properties, including phase change materials, thermoelectrics, photonic switches and materials for photovoltaics.
To reach this goal, one can try to establish close links between material properties and chemical bonding.

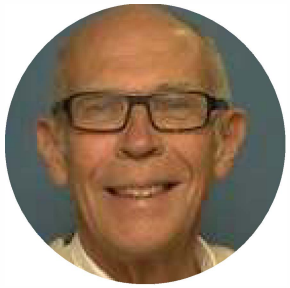
However, until recently it was quite difficult to adequately quantify chemical bonds. Some developments in the last decades, such as the quantum theory of atoms in molecules have provided the necessary tools to describe bonds in solids quantitatively. Using these tools, it has been possible to devise a map which separates different bonding mechanisms. This map can now be employed to correlate chemical bonding with material properties. Machine learning and property classification demonstrate the potential of this approach. These insights are subsequently employed to design phase change as well as thermoelectric materials. Yet, the discoveries presented here also force us to revisit the concept of chemical bonds and bring back a history of vivid scientific disputes about 'the nature of the chemical bond'.

Dr Sune Svanberg

Department of Physics, Lund University, Sweden

Sune Svanberg obtained his PhD from University of Gothenburg in 1972, and is since 1980 professor of physics at Lund University, Lund, Sweden. During 30 years, he was head of the Atomic Physics Division, and during 20 years director of the Lund Laser Centre. From 2011 to 2021 he was also a distinguished professor at South China Normal University, Guangzhou on a part-time appointment. He holds 9 honorary doctor/professor appointments, is a member of 6 scientific academies, a fellow of 5 learned societies, and received numerous national and international awards, including 5 gold medals.

He served on many boards and committees, including a 10-year membership of the Nobel Committee for Physics of the Royal Swedish Academy of Sciences.



Based on a long career in basic atomic spectroscopy and high-power laser/matter interactions, his current research interests focus on laser spectroscopic applications to the environmental, ecological and biomedical fields. He has for many years been involved in capacity building in applied laser spectroscopy in Africa.

ABSTRACT

Laser Spectroscopy Applied in Environmental, Ecological, Agricultural and Medical Research

Laser spectroscopy is a flourishing research area, which had major impact in science during recent years. In applied laser spectroscopy, the fields of combustion diagnostics, atmospheric remote sensing, agriculture and ecology, as well as biomedicine are prominent. An overview of certain applications of laser spectroscopy is given, with emphasis on the environmental, agricultural/ecological, and biomedical areas, as based on the experience of the author within these fields. Optical probing of the atmosphere using active remote sensing techniques of the laser-radar type will be discussed. Atmospheric objects of quite varying sizes can be studied.Mercury is the only pollutant in atomic form in the atmosphere, while other pollutants are either molecular or in particle form. Light detection and ranging (Lidar) techniques provide three-dimensional mapping of such constituents. Recently, the techniques have been extended to the ecological field. Monitoring of flying insects and birds is of considerable interest, and several projects have been pursued in collaboration with biologists.

Fluorescence lidar allows remote monitoring of vegetation and historical building facades. In agricultural applications, e.g., the fertilization levels of crops can be assessed. Drone-based techniques are now also augmenting the possibilities of fluorescence mapping of the environment.

Fluorescence spectroscopy has important applications in tissue characterization, using similar methods as for environmental monitoring, but now on a smaller scale. Tumours can be eradicated using photodynamic therapy. Free gases related to the human body are found, e.g., in the lungs, the middle ear, and the sinus cavities. The gas in scattering media absorption spectroscopy (GASMAS) technique has proved useful in the monitoring of lung function in neonatal children, and shows promising potential in the characterization of otitis and sinusitis.

The importance of cross-disciplinary work in solving important societal problems is emphasised.

Dr Marie Clémentine Nibamureke

Department of Zoology, University of Johannesburg

Dr Uwineza Marie Clémentine Nibamureke holds a PhD degree in “Aquatic Health” from the University of Johannesburg, South Africa. Her research interest is studying the potential effects of different chemicals compounds in surface water on aquatic organisms and human health. Today, Marie Clémentine is a Postdoctoral Fellow at the Department of Zoology, University of Johannesburg. Her current project is investigating the effects of human pharmaceutical compounds detected in African aquatic environments on fish health. Different biomarkers are used to investigate the health of fish exposed to pollutants in water from the molecular to the organism level. The project is also studying innovated techniques of removing antiretrovirals from waste water. Marie Clémentine is passionate about community engagement initiatives; she herself has started a community engagement project with mission is to raise awareness of communities on the safe disposal of expired and unwanted medicines.

Marie Clémentine is also an active member of scientific organizations which raises awareness to girls’ education in STEM fields such as the Rwandan Association for Women in Science and Engineering (RAWISE) and the Organization for Women in Science for the Developing World (OWSD). She is also a co-convener of the community engagement initiative of the African Strategy for Fundamental and Applied Physics (ASFAP). Marie Clémentine is deeply committed to the role of women in STEM fields, and as an aquatic scientist herself, she hopes to contribute to improving the health of aquatic ecosystems in Africa and the whole world.

ABSTRACT

strategic directions for sustainable development in Physics education and research in Africa

In 2015, countries adopted the UN 2030 Sustainable Development Goals as a universal call to end poverty. Poverty is considered as one of the greatest challenges to sustainable development in Africa as approximately 80% of people in extreme poverty are located in Sub-Saharan Africa. The lack of proper education, jobs, infrastructures, and clean water are among the mains factors contributing to perpetuating poverty in Africa.

Africa, with the youngest and fast growing population, with more than 60% of the world’s arable lands and 30% of the world’s minerals should not be lagging behind other continents in development. One of the ways to unlock Africa’s potentials is education by addressing the existing gaps in needed skills in science and technology. Community awareness programs about environmental problems and cultural bias on girls’ education are also needed to achieve sustainable development in Africa. An important key step in education is improving the teaching and learning of physics in Africa.

Physics as the basis of all applied sciences can help in breaking the cycle of perpetual poverty in Africa by building sustainable renewable energy systems and finding solutions to social and environmental problems including water pollution and climate change. However, this cannot be achieved without the collaboration and communication between all stakeholders namely local communities, the scientific community, policymakers and international partners.

This talk will focus on the activities and plans of the African Strategy for Fundamental and Applied Physics (ASFAP), an initiative launched by African Physicists living and working in different countries around the world in November 2020 with a vision to unlock Africa development through improved Physics education and research capabilities. Amongst ASFAP objectives are encouraging and strengthening physics education in schools (secondary and tertiary), young scientists capacity building, innovating scientific research and collaboration between countries, engaging the community through outreach programs, influencing directions of science strategies taken by policymakers and creating a proper cultural environment and conditions in which science in Africa can prosper.

Dr Danas Ridikas

Physics Section, Department of Nuclear Sciences and Applications,
International Atomic Energy Agency, Vienna, Austria

Danas Ridikas holds a position at the International Atomic Energy Agency (IAEA) as a Section Head of Physics Section at the Department of Nuclear Sciences and Applications. The Physics Section is responsible for planning and implementing activities in the areas of (i) effective utilization of research reactors and accelerator-based neutron sources, (ii) fostering relevant research and development and applications using particle accelerators and nuclear instrumentation, and (iii) controlled fusion research and technology. The IAEA Physics Section also operates the Nuclear Science and Instrumentation Laboratory (NSIL), located at the Agency's Laboratories in Seibersdorf, which assists IAEA Member States to improve the effective utilization of nuclear spectrometry, compact neutron generators and related instrumentation by providing technical advice, training, QA/QC services, and other assistance on request.

Danas Ridikas has a background of a nuclear physicist, with PhD in experimental nuclear physics in France and MSc in theoretical nuclear physics in Norway. He also holds a BSc degree in physics awarded in Lithuania and MSc degree in Environmental Sciences and Policy, accredited by the University of Manchester. In 2012 Danas Ridikas has been awarded a doctor habilitation degree in fundamental sciences. Before coming to the IAEA, Danas Ridikas has worked for almost 10 years at the French Atomic Energy Commission (CEA) as a senior scientist and, later, as a laboratory head in Nuclear Physics Division.

ABSTRACT

IAEA activities in support of nuclear physics research and applications

Facilitation of development and promotion of nuclear applications for peaceful purposes and related capacity building are among the IAEA missions where Physics Section contributes most [1]. The relevant activities fall under the IAEA's program on nuclear science and cover three main thematic areas: research and applications with particle accelerators and neutrons sources (incl. research reactors), nuclear instrumentation and capacity building, and controlled fusion research and technology (incl. cooperation with ITER). As a result, the Section helps IAEA's Member to advance their capabilities and progress in materials research, energy, environment, food, agriculture, health care, cultural heritage, forensics, and some other fields with a direct socioeconomic impact. The Section also operates the Nuclear Science and Instrumentation Laboratory (NSIL) at Seibersdorf [2], located approximately 40 km south of Vienna.

The NSIL provides expertise, training and support in the effective utilization of nuclear instrumentation and analytical techniques in a broad range of applications, with a focus on mobile radiation monitoring, X-ray spectrometry, accelerator technologies, and compact neutron generators. This presentation will illustrate through a number of selected examples how the IAEA supports nuclear physics research and diverse applications in order to address key development priorities in many areas of societal importance and economic growth of the developing countries. In addition, some future plans on enhancing capabilities of the Nuclear Science and Instrumentation Laboratory as part of Physics Section will be highlighted, in particular by establishment of the neutron science facility and considerations for a compact ion beam accelerator.

[1]https://www.iaea.org/about/organizationalstructure/department-of-nuclear-sciences-and-applications/division-of-physical-and-chemical-sciences/physics-section
[2] https://www.iaea.org/publications/search/type/nuclear-science-and-instrumentation-newsletter

Prof Wikus van Niekerk

Dean of Engineering at Stellenbosch University

Prof Wikus van Niekerk is the Dean of Engineering at Stellenbosch University. He holds a PhD from the University of California at Berkeley and an Executive MBA from the Graduate School of Business at the University of Cape Town.

He completed his PhD on the active control of transient noise transmission in 1994. After holding the Sasol Chair in Vehicle Engineering at the University of Pretoria he moved to Stellenbosch University in January 2000. At Stellenbosch he has been Head of the Mechanics Division, Chair of the Department of Mechanical Engineering and Director of the Institute for Thermodynamics and Mechanics. He was the founding Director of the Centre for Renewable and Sustainable Energy Studies and played a leading role to establish research, education and training programmes in renewable energy and influence funding and policy priorities on the national level. He has a keen interest in solar and ocean energy. As Dean of the Faculty of Engineering he is responsible for six ECSA accredited engineering programmes with 3 000 undergraduate and 1 000 postgraduate students. Prof van Niekerk is a registered professional engineer with the Engineering Council of South African and has been practising as a consultant to industry for 25 years.

He is regularly consulted by industry on a variety of areas including renewable energy systems and technology; solar, wind and ocean energy; and energy policy and research strategy. He has published more than 35 articles in refereed international journals and presented many papers at international conferences.

Prof Van Niekerk is an honorary fellow of the South African Institution of Mechanical Engineering and a fellow of the South African Academy of Engineering and the Southern African Acoustics Institute. He is a member of the ASME and SESSA, and a Board Member of the South African Academy of Engineering and the Fraunhofer Chile Research Center for Solar Energy Technologies. He is also a Senior Advisor of the Fraunhofer Gesellschaft in Africa.

In 2014 Prof Van Niekerk received the SANEA Energy Award.

ABSTRACT

Scenarios for Powering the South African Electricity Grid to Supply the Electricity Demand in Future

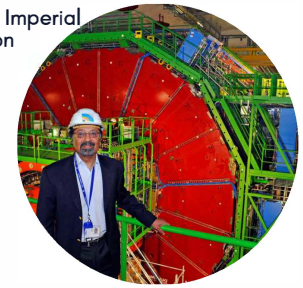
South Africa is grappling with a number of very serious challenges to supply the country with sufficient electricity to service the requirements of all sectors of the economy as well as the demand from all our citizens.Some of these are driven by global concerns, such as the carbon emissions from coal-fired power stations causing climate change, and others specific to the South African landscape, such as the collapse of the skills base of the staff of our national utility.

In this talk we will review the current state of the electricity supply system in South Africa, the possible demand going forward and how we will be able to service this demand considering all the options available.We will focus on possible scenarios that may play out given our current context and constraints; discuss the benefits and risks of the various supply options; and theorise on the what may the best pathway in the short and medium term.

Prof Sir Tejinder Singh Virdee

Higgs Boson Special Lecture

Professor of Physics at Imperial College, London



Tejinder Virdee is Professor of Physics at Imperial College, London. Over the last 30 years Tejinder has concentrated on the physics and experimentation at CERN's Large Hadron Collider. He is one of the two founding fathers of the Compact Muon Solenoid Collaboration (CMS) at the LHC and has played a major role in all phases of the experiment, from conception and design, through construction to the extraction of science. He was involved in almost all the key scientific and technical choices made for the experiment. He pioneered some of the techniques used in the discovery of the Higgs boson announced by the CMS experiment in July 2012, along with the sister experiment ATLAS.
Tejinder was the Spokesperson (Leader) of the CMS Collaboration for three years, from 2007, a period that included the start of collision data taking, and was its Deputy Spokesperson from 1993 to 2006.
Tejinder's current work involves studies of the newly found Higgs boson, search for physics beyond the standard model of particle physics and the design of the upgrades of the CMS detector for very high luminosity LHC running that is due to start in mid-2020's.

Amongst the prizes he has won is the 2009 UK Institute of Physics (IOP) Chadwick Medal and prize, the 2013 European Physical Society-HEPP prize, the 2013 Fundamental Physics Prize, the 2015 IOP Glazebrook Medal and Prize, the 2017 American Physical Society Panofsky Prize, and the 2020 Blaise Pascal Medal of the European Academy of Sciences.
Tejinder was elected to the Fellowship of the Royal Society in 2012 and was made Knight Bachelor in the 2014 Queen's Birthday Honours List.
Tejinder is passionate about promoting the benefits of science and its importance in society. He funds diverse and impactful educational and scientific activities in schools and universities in Africa, India and the UK, and projects in sub-Saharan African countries, through the Virdee Grants, in collaboration with the UK Institute of Physics.
Wikipedia: https://en.wikipedia.org/wiki/Tejinder_Virdee

ABSTRACT

The discovery of the Higgs boson

At the Large Hadron Collider (LHC) at CERN, Geneva we can probe our Universe moments after the Big Bang to tackle the questions about its origin, evolution and composition. These include: What is the origin of mass? What constitutes dark matter? How many dimensions of space and time do we live in? Why is the universe composed of matter and not antimatter? The answers have the potential of altering our perception of how Nature operates at the fundamental level.

The discovery in July 2012 of the Higgs boson at the Large Hadron Collider (LHC), one of the most important of this new century, completes the particle content of the standard model (SM) of particle physics, a theory that describes our visible universe in exquisite detail.

his talk will describe the long journey to the discovery of the Higgs boson, briefly recalling the physics aims, outlining some of the technological and engineering challenges faced during construction, and the making of the discovery itself.

The talk also will discuss the prospects for the high-luminosity operation of the LHC, especially those related to the examination of the properties of the Higgs boson with larger data samples.

Prof Shobhana Narasimhan

Women in Physics in South Africa (WiPiSA)

Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, India and
IAS, Technical University, Munich, Germany

Shobhana Narasimhan grew up on the campus of a scientific institute in Bombay (now called Mumbai). She obtained her BSc from St. Xavier's College, Bombay, and her MSc from IIT Bombay. She obtained her PhD in physics from Harvard University. After holding postdoctoral positions at Brookhaven National Laboratory, USA, and the Fritz Haber Institut, Berlin, Germany, she returned to India and joined the faculty of the Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, where she is currently heads the Computational Nanoscience group, and is a Professor in the Theoretical Sciences Unit.
She has always has a strong interest in promoting women in science: as a student at Harvard, she helped to found the group 'Women in the Mathematical and Physical Sciences', and while she was a postdoc at Brookhaven she made the suggestion to the American Physical Society that resulted in the setting up of the "WIPHYS" bulletin board.

She was a member of the IUPAP Working Group for Women in Physics. She has been a member of several national committees set up by the Government of India to help women in science, including the National Task Force on Women in Science and the Standing Committee on Women in Science. She is currently chair of the Indian Academy of Science's Panel on Women in Science. She is also currently an Anna Boyksen Fellow at the IAS, Technical University of Munich; this fellowship is intended for scientists with an interest in gender issues.
She is an International Honorary Member of the American Academy of Arts and Sciences, and a Fellow of the National Academy of Sciences, India, and the Indian Academy of Sciences.

ABSTRACT

Women in STEM: a perspective from the Global South

Almost everywhere in the world, women constitute a minority in the STEM workforce. A frequently misconception is that the number of women in STEM is particularly low in the Global South. In fact, on plotting the percentage of women in the STEM workforce of a nation versus its per capita income PPP, one obtains an inverted U: as a country becomes richer, the percentage of women in STEM rises sharply, then falls slowly.
Economically richer and poorer countries also tend to show differ patterns of retention in STEM ; in economically developed countries, the main problem seems to be in attracting girls to studying science, whereas in developing countries, one sees a big dropout among women studying science after the tertiary level.

Of course, women in STEM in developing countries have to deal with a lack of infrastructure and resources, and also frequently face societal challenges and biases, both within and outside their countries.
One effort to address the problems faced by women physicists in the developing world is the Career Development Workshops for Women in Physics that have been held since 2013 at the ICTP in Trieste, Italy, and also at the new ICTP-EAIFR in Kigali, Rwanda. I will briefly describe the structure of these workshops, and some of their success stories.

SUSTAINABLE RESEARCH: BRIDGING THE GAP BETWEEN ACADEMIA AND INDUSTRY

1 JULY 2022

CHAIR: IGLE GLEDHILL, WITS SCHOOL OF MECHANICAL, INDUSTRIAL & AERONAUTICAL ENGINEERING

Time	Topic	Presenter
9:00 - 9:10	Welcome	Dr Priscilla Mensah
9:10 - 9:55	Drivers for industry engagement and research commercialisation	Francesco Petruccione, UKZN School of Chemistry and Physics - Quantum Research Group
9:55 - 10:40	Research to impact: Trends in knowledge exchange and commercialisation	Jaci Barnett, Oxford University Innovation
10:40 - 11:00	Tea Break	
11:00 - 11:45	Legal limitations and funding opportunities	Tinus Vorster, NWU Research Support Department
11:45 - 12:30	Panel Q & A	
12:30 - 13:30	Lunch Break	
13:30 - 16:30	How to create a business plan	Margret Cullen, NMU Business School

BIOPHYSICS IN CONFRONTING HEALTH CHALLENGES

1 JULY 2022

CHAIR: TREVOR SEWELL (UCT)

Time	Topic	Presenter
9:00 - 9:05	Welcome and Introduction	Trevor Sewell (UCT)
9:05 - 9:50	Plant health: resolving molecular photoprotection mechanisms using single-molecule spectroscopy	Tjaart Kruger (UP)
9:50 - 10:35	Breaking the diffraction limit: Brief take on superresolution imaging techniques	Gurthwin Bosman (SU)
10:35 - 11:00	Tea/Coffee break	
11:00 - 11:45	Using genomic sequence data to understand the evolution of viruses like SARS-CoV-2	Darren Martin (UCT)
11:45 - 12:30	The role of biophysics in driving vaccine development in the 21st century	Martin Friede (WHO)
12:30 - 13:30	Lunch	
13:30 - 14:15	Molecular dynamics for the interpretation of Cryo-EM and X-ray crystallography	Tristan Croll (Cambridge Institute for Medical Research)
14:15 - 15:00	Cryo-EM reveals dynamic mechanisms at the heart of an ace blood-pressure regulating enzyme	Lizelle Lubbe (UCT)
15:00 - 16:00	Advances in cryo-electron microscopy automation: Better, faster, cheaper, smarter	Bridget Carragher (New York Structural Biology Center)


1 NO POVERTY
3 GOOD HEALTH AND WELL-BEING
6 CLEAN WATER AND SANITATION
4 QUALITY EDUCATION
7 AFFORDABLE AND CLEAN ENERGY
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
17 PARTNERSHIPS FOR THE GOALS
5 GENDER EQUALITY
SUSTAINABLE DEVELOPMENT GOALS
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
8 DECENT WORK AND ECONOMIC GROWTH
13 CLIMATE ACTION
2 ZERO HUNGER
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
11 SUSTAINABLE CITIES AND COMMUNITIES
14 LIFE BELOW WATER
10 REDUCED INEQUALITIES

Timetable

General Timetable

	1 JULY 2022					4 JULY 2022	5 JULY 2022	6 JULY 2022	7 JULY 2022	8 JULY 2022
09:00 - 09:15										
09:30 - 10:15						Opening function				
10:30 - 11:15			SAIP council meeting	Winter school on "Sustainable Research: Bridging the Gap between Academia and Industry"	Winter school on "Biophysics in Confronting Health Challenges"	Plenary 1: Prof. VAN NIEKERK, Wikus Chair: Ferrer, Phil	Plenary 2: Dr KRÜGER, Tjaart Chair: Ferrer, Phil	Plenary 4: Dr MCKINNELL, Lee-Ann Chair: Katamzi-Joseph, Zama	The SAIP: Past, Present and Future (Prof GLEDHILL, Igle; Prof CHITAMBO, Makaiko) Chair: Naidoo, Deena	Plenary 6: Prof WUTTIG, Matthias Chair: Erasmus, Rudolph
11:30 - 12:00						Oral presentations	Oral presentations & Industry Day	Poster session	Oral presentations	Oral presentations
12:00 - 12:15										
12:15 - 13:00								WiPiSA: Prof Shobhana Narasimhan Chair: Modiba, Rosinah		
13:00 - 14:00	LUNCH BREAK					LUNCH BREAK	LUNCH BREAK	WiPiSA LUNCH	LUNCH BREAK	LUNCH BREAK
14:00 - 14:45						10th Anniversary of Discovery of Higgs Boson: Prof Sir Tejinder Singh Virdee Chair: Mellado, Bruce	Plenary 3: Dr SVANBERG, Sune Chair: Neethling, Pieter		Plenary 5: Dr RIDIKAS, Danas Chair: Maleka, Peana	Plenary 7: Dr NIBAMUREKE, Marie Clémentine U. Chair: Ramaila, Sam
15:00 - 16:30			SAIP council meeting	Winter school on "Sustainable Research: Bridging the Gap between Academia and Industry"	Winter school on "Biophysics in Confronting Health Challenges"	Oral presentations	Oral presentations & Industry Day	Poster session (judging)	Oral presentations	Annual General Meeting (AGM)
17:00 - 18:30							Council meeting with HODs	Division meetings	Council meeting with division chairs	Closing ceremony and prizegiving

Nuclear, Particle & Radiation Physics

	4 JULY 2022	5 JULY 2022	6 JULY 2022	7 JULY 2022	8 JULY 2022
09:30 - 10:15	Opening function				
10:30 - 11:15	Plenary 1	Plenary 2	Plenary 4	SAIP Day	Plenary 6
	Session Chair: Manny Mathuthu	**Session Chair: Edwarde Nkadimeng**		**Session Chair: Mukesh Kumar**	
11:30 - 11:45	7 In-situ Determination of Radioactivity Levels and Radiological Hazards in and around the Gold Mine Tailings of the West Rand Area, South Africa. ***MOSHUPAYA,* Paballa** *(National Nuclear Regulator)*	63 Time stability of the response of gap/crack scintillators of the Tile Calorimeter of the ATLAS detector to isolated muons. **RAPHEEHA, Phuti Ntsoko** (University of the Witwatersrand)	Poster Session	52 Studying the Production of a Singlet Scalar at Future e+ e- Colliders with Deep Neural Networks. **MULAUDZI, Anza-Tshilidzi** (University of the Witwatersrand)	
11:45 - 12:00	336 Assessment of the radiological and heavy metal water quality of Vaal River, South Africa. **BOITSHEKWANE, Kgantsi** (University of North West)	126 Search for resonant production of strongly-coupled dark matter in proton-proton collisions **VAN DER SCHYF, Hannah** (University of Witwatersrand)		89 Compatibility of the CMS dilepton spectra with the Neutral Scalar with Mass around 151 GeV. **BHATTACHARYA, Srimoy** (University of the Witwatersrand)	
12:00 - 12:15	247 Characterization of UF4 waste using gamma spectroscopy. **DESIREE, Tsholofelo Mokgele** (North-West University)	66 Application of semi-supervision learning for the search of new resonances decaying to Zγ with topological features. **CHOMA, Nalamotse Joshua** (University of the Witwatersrand)		68 Explaining new type of multi-lepton excesses at the LHC with singletscalar extended 2 HDM model. **SWAIN, Abhaya Kumar** (University of the Witwatersrand)	
12:15 - 12:30	279 Nuclear forensic analysis of natural uranium mined from northern Nigeria. ***USMAN, Lyabo (****University of the Witwatersrand)*	59 Evaluation and Optimisation of a Generative-Classification Hybrid Variational Autoencoder in the Search for Resonances at the LHC. ***STEVENSON, Finn*** (University of the Witwatersrand)	Plenary (WiPiSA):	71 Comparing 2HDM + S and 2HDM + S + N models to explain multi-lepton excesses at the LHC. **BHATTACHARYA, Srimoy** (University of the Witwatersrand)	
12:30 - 12:45	322 Simulation of neutron and electron material damage in CuO, MgO, and Al2O3. ***MAHAFA, Tshepo (****University of Witwatersrand)*	199 Search for new spin-1 or spin-0 boson using ATLAS detector data. **MAPEKULA, Xola** (University of Johannesburg)		223 A frequentist study of the false signals generated in the training of semi-supervised neural network classifiers using a WGAN as a data generator. **LIEBERMAN, Benjamin** (University of Witwatersrand)	
12:45 - 13:00	69 Role of nucleon-nucleon and three-body interactions on the structure of 22C halo system. **VILAKAZI, Happy** (University of South Africa)	53 Growing evidence of new bosons at the LHC. **MELLADO, Bruce** (University of the Witwatersrand)			
13:00 - 14:00	***LUNCH BREAK***	***LUNCH BREAK***	***LUNCH BREAK***	***LUNCH BREAK***	***LUNCH BREAK***

Nuclear, Particle & Radiation Physics

	4 JULY 2022	5 JULY 2022	6 JULY 2022	7 JULY 2022	8 JULY 2022
13:00 - 14:00	LUNCH BREAK	LUNCH BREAK	LUNCH BREAK	LUNCH BREAK	LUNCH BREAK
14:00 - 14:45	Special Lecture: Higgs Boson	Plenary 3		Plenary 5	Plenary 7
	Session Chair: Thomas Dietel/Zinhle Buthelezi	Session Chair: Armand Bahini		Session Chair: James Keaveney	
15:00 - 15:15	13 Production of muons from heavy-quark hadron decays in pp collisions at √s = 13 TeV with the ALICE detector. **SHABA, Tebogo** (iThemba LABS)			143 Measurement of the leptonic charge asymmetry in \ttw production using the trilepton final state in proton-proton collisions at centre-of-mass energy of 13 TeV using the ATLAS experiment. **GARVEY, Cameron**	
15:15 - 15:30	16 Correlation of heavy-flavour production and charged-particle multiplicity in pp collisions at √s = 5.02 TeV measured in ALICE **MDHLULI, Joyful** (University of the Witwatersrand)	274 Dipole polarizability effect on the quadrupole moment of the first 2+ state in 12C. **NGWETSHENI, Cebo** (University of the Western Cape)		156 A search for tWZ production with the ATLAS detector using the three and four lepton final states in proton-proton collisions at √s = 13 TeV. **VELTMAN, Alexander** (University of Cape Town)	
15:30 - 15:45	14 Design and development of the ALICE Common Readout Unit user-logic firmware for the Muon Identifier readout chain. **THYS-DINGOU, Dieuveil Orcel** (Cape Peninsula University of Technology)	303 Determination of matrix elements in 62Ni to test surface vibrations in nuclei. **LESCH, Brenden**	Poster session *(judging)*	219 Higgs decay to dark vector bosons via an additional scalar. **CONNELL, Matthew** (University of Johannesburg)	Annual General Meeting (AGM)
15:45 - 16:00	49 Burn-in testing of the ATLAS Tile-calorimeter Phase-II low-voltage power supply transformer-coupled buck converters **MCKENZIE, Ryan** (University Of the Witwatersrand)			299 Optimization of Scintillation Properties of Plastic Scintillator for PET/CT Using GEANT4 Simulations. **AKAKPO, Elijah Hornam** (University of the Western Cape)	
16:00 - 16:15	48 Search for dark sector showering in ATLAS using semi-visible jets. **SINHA, Sukanya** (The University of Witwatersrand)	51 The isoscalar giant monopole resonance in the Ca isotope chain. **NEVELING, Retief** (iThemba LABS)			
16:15 - 16:30	285 CFD humidity and temperature modelling in the ATLAS ITK Strip. **MAFA TAKISA, Pedro** (University of South Africa)	212 Investigating the impact of neutrons on Cadmium Zinc Telluride Compton Camera system. **DE KLERK, Josiah** (University of Cape Town)			

Photonics

	4 JULY 2022	5 JULY 2022	6 JULY 2022	7 JULY 2022	8 JULY 2022
09:30 - 10:15	Opening function				
10:30 - 11:15	Plenary 1	Plenary 2	Plenary 4	SAIP Day	Plenary 6
	Chair: Pieter Neethling	**Chair: Andrew Forbes**		**Chair: Mitchell Cox**	
11:30 - 11:45	21 Synergistic Cytotoxic Effects of Photodynamic Therapy and Cannabidiol Treatment on Cervical Cancer Cells. ***RAZLOG*, Radmila** (University of Johannesburg)	330 Realizing topological relativistic dynamics with slow-light polaritons. **JORDAAN, Bertus** (NMISA)	Poster Session	81 Orbital and spin angular momentum interaction in second harmonic generation. **WAGNER, Tavares Buono,** (University of the Witwatersrand)	
11:45 - 12:00	61 Recombinant Antibody-Conjugated Silver Nanoparticles for Improved Drug Delivery in Photodynamic Therapy for Metastatic Melanoma. **MALINDI, Zaria** (University of Johannesburg)	100 Links and Twists within the Stokes Field. **ORNELAS, Pedro** (University of the Witwatersrand)		235 Simulating a deformable mirror with a spatial light modulator. **MOHAPI, Lehloa** (University of the Witwatersrand)	
12:00 - 12:15	58 Antiproliferative and Cytotoxicity Effects of Aluminium (III) Phthalocyanine Chloride Tetra Sulphonic Acid Mediated Photodynamic Therapy on Oesophageal Cancer. **DIDAMSON**, **Onyisi Christiana** (University of Johannesburg)	101 Teleporting into high dimensions. **SEPHTON, Bereneice**. (University of the Witwatersrand)		150 A New Angle on the Tilted Lens. **PETERS, Cade Ribeiro** (University of the Witwatersrand)	
12:15 - 12:30	44 PBM at 660 nm reduces stress induced apoptosis in diabetic wounded fibroblast cells in vitro. **JERE**, **Sandy** (University of Johannesburg)	43 Effect of nanoparticle geometry on photon statistics. **UGWUOKE, Luke** (Stellenbosch University)		145 Flatptop beam shaping for use in optical fiber. **PHALA, Ashley** (University of Witwatersrand)	
12:30 - 12:45	96 Photobiomodulation at 830 nm modulates proliferation and migration of wounded fibroblast cells. ***LEYANE, Thobekile*** *(University of Johannesburg)*	178 Quantum Photonic Entanglement. **SMITH, André** (Stellenbosch University)	Plenary (WiPiSA)	140 Broadband Beam Shaping Using Digital Micromirror Devices. **PERUMAL, Leerin Michaela** (University of the Witwatersrand)	
12:45 - 13:00	179 Photobiomodulation at 830 nm influences diabetic wound healing in vitro through modulation of inflammatory cytokines. **MGWENYA, Tintswalo** (University of Johannesburg)				
13:00 - 14:00	***LUNCH BREAK***	***LUNCH BREAK***	***LUNCH BREAK***	***LUNCH BREAK***	***LUNCH BREAK***
14:00 - 14:45	Special Lecture: Higgs Boson	Plenary 3		Plenary 5	Plenary 7
	Chair: Gurthwin Bosman	**Chair: Christine Steenkamp**			
15:00 - 15:15	60 Comparison of modelling and measurements of resonance laser ionisation of zinc isotopes **STEENKAMP, Christine** (University of Stellenbosch)	8 Theoretical Modeling of Infrared Thermography. **NOLTING, Volkmar** (Vaal University of Technology)			
15:15 - 15:30	146 Wavelength calibration of a monochromator system. **RABE, Irma** (NMISA Photometry & Radiometry scientist)	26 Simulation of Coherent Supercontinuum Generation in Silicon Germanium waveguide. **MUNSAKA, Proficiency** (National University of Science and Technology)			
15:30 - 15:45	94 Investigating the morphology of an optically trapped particle using Mie scattering **ERASMUS, Anneke** (Stellenbosch University)	29 Interferometric orbital angular momentum mode detection in turbulence with deep learning. **COX, Mitchell** (University of the Witwatersrand)			
15:45 - 16:00	82 Fourier Ptychographic Microscopy for high-resolution, large field of view imaging **FOUCHE, Eugene** (Stellenbosch University)	39 Investigating Two-Mode Mode Diversity with Laguerre-Gaussian and Hermite-Gaussian Modes. **DROZDOV, Alice**			
16:00 - 16:15	137 Resolution enhancement in quantum ghost imaging by machine intelligence **MOODLEY, Chané Simone** (University of the Witwatersrand)	124 Communicating through turbulence using classical-entanglement. **SINGH, Keshaan** (University of the Witwatersrand)			
16:15 - 16:30			Poster session *(judging)*		Annual General Meeting (AGM)

Condensed Matter & Materials

	4 JULY 2022	5 JULY 2022	6 JULY 2022	7 JULY 2022	8 JULY 2022
09:30 - 10:15	Opening function				
10:30 - 11:15	Plenary 1 **Chair:Rudolph Erasmus**	Plenary 2 **Chair: Daniel Wamwangi**	Plenary 4	SAIP Day **Chair: Bharati Bamana**	Plenary 6 **Chair: Thulani Jili**
11:30 - 11:45	287 Lattice expansion studies of the crystal structure transformation in intermediate valent Ce_2Rh_2Ga **XHAKAZA, Sindisiwe**	34 Characterization of defects in Ar+ implanted ZnO semiconductor using positron annihilation technique. **KHULU, Musawenkosi** (University of Zululand)	Poster Session	168 Structural and magnetic properties of $Co_xNi_{1-x}Cr_2O_4$ (x = 0.75, 0.80, 0.85) nanoparticles. **JACOB, Mariam** (University of Johannesburg)	55 Non-Specialist Lecture: Neutron scattering prospects at the new Multi-Purpose Reactor **KESHAW, Jeetesh** (Department of Mineral Resources and Energy)
11:45 - 12:00	311 Property and structural characterisation of Fe and Ni bonded NbC cermets for improved tribological applications. **PETERS, Gerrard** (University of the Witwatersrand)	177 Magnetocaloric effect in Dy based chromium oxides. **SIBANDA, Eugene**		183 Structural and magnetic properties of $Co_{(1-x)}Cu_xCr_2O_4$ nanoparticles. **NAGARAJ, Shobana** (University of Johannesburg)	
12:00 - 12:15	117 Thermal stability of diketopyrrolopyrrole-based terpolymers with tunable broad band absorption for polymer solar cells. **NCHINDA, Leonato Tambua** (University of Pretoria)	185 Effect of solvents on the extraction and absorption study of natural dye from Bidens pilosa for dye sensitized solar cells. **RANDELA, Ronel Ronella** (University of Venda)		196 Synthesis, Structural, and Magnetic Properties of $CoCr_2O_4/Cu_2O$ nanocomposites. **NKOSI, Thabang Johannes** (University of Johannesburg)	181 Thermal conductivity of Chalcogenides Alloys: Energy and information storage applications **WAMWANGI, Daniel** (University of the Witwatersrand)
12:15 - 12:30	106 Synthesis and modification of Boron Nitride nanotubes using ion implantation. **LISEMA, Lehlohonolo** (University of Witwatersrand)	277 Synthesis of copper nanowires for application as flexible transparent conducting electrodes. **HOY, Nicholas** (UNISA)	Plenary (WiPiSA)	46 Transition metal carbonate precursors as cathode materials for li-ion batteries: computational and experimental study. **MORUKULADI, Mogahabo**	79 Media Structured for Nonlinear Optics **WAGNER, Tavares Buono** (University of the Witwatersrand)
12:30 - 12:45	118 Highly methane responsive nanosensor layer based on mesoporous nanostructured belts-like Indium Oxide. **KGOMO, Mosima** (CSIR)	190 Preparation and characterization of porous ZnFe2O4 hollow fibers with enhanced sensing response and selective detection of acetone **NEMUFULWI, Murendeni** (University of free state)		259 Investigating sodium incorporated Li2MnO3 nanostructured cathodes for lithium-ion batteries. **MOGASHOA, Tshidi** (UL)	317 TEM Observation of room temperature stability and phase transformation of SHI induced tetragonal tracks i monoclinic zirconia. **LEE, Michael** (Nelson Mandela University)
12:45 - 13:00	278 Electrochemical Synthesis and Characterization of PANI/Graphene-foam Composite Films. **CHILUKUSHA, Daniel** (Tshwane University of Technology)	165 Impact of rapid thermal annealing on the properties of different Ag layer thicknesses Ag/ ITO bilayer films. **OLLOTU, Emmanuel Rasiel** (Mkwawa University College of Education)		302 Simulations synthesis of Na0.23TiO2 nanosphere at varied temperatures: Beyond li-ion batteries. **RIKHOTSO, Blessing** (University of Limpopo)	337 Machine Learning Structure-Property Model for Carbon Steels. **WESTRAADT, Johan** (Nelson Mandela University)
13:00 - 14:00	***LUNCH BREAK***	***LUNCH BREAK***	***LUNCH BREAK***	***LUNCH BREAK***	***LUNCH BREAK***
14:00 - 14:45	Special lecture: Higgs Boson **Chair: Cliffton Masedi**	Plenary 3 **Chair: Ramogohlo Diale**	Poster session *(judging)*	Plenary 5 **Chair: Rudolph Erasmus**	Plenary 7
15:00 - 15:15	123 Phase Stability of Li2Mn1-xTMxO3 (TM= Ni, Co, Cr and Ru) Cathode Material Using Cluster Expansion and Monte Carlo Simulations **MPHAHLELE, Mamonamane** (University of Limpopo)	9 First-principles study on interaction of O2 with (100) surfaces of sperrylite and platarsite minerals **NEMUTUDI, Bradley** (University of Limpopo)		130 Structural and optical properties of TiO2 photoelectrodes fabricated for photoelectrochemical water splitting. **SULIALI, Nyasha** (Nelson Mandela University)	Annual General Meeting (AGM)
15:15 - 15:30	174 Development of machine learning models for predicting energies of sodium-ion battery materials. **MONARENG, Keletso**	306 Study of inorganic lead halide perovskites properties using density functional theory for photovoltaic and optoelectronic devices. **MALEKA, Prettier Morongoa**		198 Structural and Magnetic Study of $NdCrTiO_5$ Nanoparticles. **BAMANA, Bharati.** (University of Johannesburg)	
15:30 - 15:45	220 The phase stability, mechanical and electronic properties of CsCl-type intermetallic: TiTM (TM = Ni, Ru and Pd), a first-principles approach. **NGOBE, Bongani** (WITS and MINTEK)	213 Ground state phase stability simulation of Fe-X-Al alloys (X= Pd and Ag). **MKHONTO, Chrestinah**		206 First-principle studies of cubic Ti2AlV and tetragonal TiAl2V structural stability. **MODIBA, Rosinah** (CSIR)	
15:45 - 16:00	262 Effect of Mn addition on the ductility of FeCo soft magnetic alloy. **LEDWABA, Tebogo** (University of Limpopo)	275 Ab-initio study of hydrofluoric acid and ethylene carbonate adsorption on the Nb-doped on the LiMn2O4 surfaces. **RAMOGAYANA, Brian** (University of Limpopo)		229 Magnetic Phase Transitions in Ce^{3+} Substituted $CoCr_2O_4$ Nanoparticles. **MOHANTY, Pankaj** (University of Johannesburg)	
16:00 - 16:15	171 Ab initio and Cluster Expansion study on Magnesium Spinel (MgX2Z4: where X=Sc, Y and In; Z=S and Se) **TIBANE, Khumbulani** (UL)	238 Machine Learned Buckingham Interatomic Potentials for Co-doped Li-Mn-O spinel. **HLUNGWANI, Donald** (University of limpopo)		231 Impact of Cr substitution on magnetic properties of cobalt-doped ZnO nanoparticles. **SHANKARAPPA Lokesha Handalagere** (University of Johannesburg)	
16:15 - 16:30	252 The effects carbon and boron on the T-MnAl alloy properties employing the first principle approach. SEBE, Itumeleng (Sefako Makgatho Health Science University)	250 Evaluating the small Ti7 cluster in α-TiCl3 medium. **MAZIBUKO, Andile** (University of Limpopo)		135 Phase stability prediction of mixed Li2S1-xSex system. **MASEDI, Cliffton** (University of Limpopo)	

Astrophysics

4 JULY 2022

09:30 - 10:15 — Opening function

10:30 - 11:15 — Plenary 1

Chair: Brian van Soelen

11:30 - 11:45
- 38 — Probing 2HDM+S with MeerKAT Galaxy Cluster Legacy Survey. **LAVIS, Natasha** (University of the Witwatersrand)

11:45 - 12:00
- 142 — MeerKAT's view on galaxy clusters: Diffuse radio emission in MeerKAT Galaxy Cluster Legacy Survey (MGCLS). **KOLOKYTHAS, Konstantinos** (North-West University)

12:00 - 12:15
- 80 — Studying gas flows in the SUNBIRD starburst galaxies and LIRGs. **JANSE VAN RENSBURG, Petro** (UCT/SAAO)

12:15 - 12:30
- 99 — Spatially resolved stellar kinematics of the CLoGS brightest group early-type galaxies **STEVENS, Clinton** (North-West University)

12:30 - 12:45
- 290 — Stellar populations of green valley galaxies **MAHORO, Antoine** (South African Astronomical Observatory)

12:45 - 13:00
- 102 — A study of the baryon cycle in groups at different stages of assembly. **SANKAR, Sriram** (South African Astronomical Observatory (SAAO))

13:00 - 14:00 — *LUNCH BREAK*

14:00 - 14:45 — Special lecture: Higgs Boson

Chair: Geoff Beck

15:00 - 15:15

15:15 - 15:30
- 127 — Simulating the radio emissions of dark matter for new high-resolution observations with MeerKAT. **BECK, Geoff** (University of Witwatersrand)

15:30 - 15:45
- 78 — Primordial Black Holes and the SZ effect. **TARRANT, Justine** (WITS)

15:45 - 16:00
- 153 — Constraining the properties of Dark Matter using multi-messenger observations of dwarf galaxies. **NOORBHAI, Raees** (Wits School of Physics)

16:00 - 16:15
- 193 — Physics of the Early Universe. **NETSHIHENI, Shonisani Ednah** (University of Venda)

16:15 - 16:30
- 36 — Cosmological perturbations of interacting dark fluid models. **MBEWE, Bonang George** (North West University)

5 JULY 2022

10:30 - 11:15 — Plenary 2

Chair: Konstantinos Kolokythas

11:30 - 11:45
- 98 — Spectral and temporal analysis of 16 short Gamma-Ray Bursts detected by the Fermi Space Telescope with know redshift. **MAHESO, Dimakatso Jeannett** (University of Johannesburg)

11:45 - 12:00
- 116 — Tracing water masers at their smallest scale with VLBI. **VORSTER, Jakobus** (Centre for Space Research)

12:00 - 12:15
- 30 — Seeing the inside of stars with sound. **MEKONNEN Mengistie, Getachew** (University of Zululand)

12:15 - 12:30
- 56 — Parametric Spectral and Light Curve Modelling of Gamma-ray Millisecond Pulsars. **HAMED, Hend** (North-West University)

12:30 - 12:45
- 170 — Constraining the multipolar magnetic field of millisecond pulsar PSR J0030+0451 via X-ray light curve fitting. **KUNDU, Anu** (Centre for Space Research, North-West University)

12:45 - 13:00
- 40 — Modelling the multi-wavelength Non-thermal Emission of AR Sco. **VENTER, Christo** (North-west University)

13:00 - 14:00 — *LUNCH BREAK*

14:00 - 14:45 — Plenary 3

Chair: Zama Katamzi-Joseph

15:00 - 15:15
- 180 — Neutron monitors as space weather instruments. **STRAUSS, Du Toit** (Centre for Space Research, North-West University)

15:15 - 15:30
- 320 — The South African Astronomical Observatory **MCBRIDE, Vanessa** (Office of Astronomy for Development)

15:30 - 15:45
- 266 — The development of Radio Astronomy in South Africa **GOEDHART, Sharmila** (SARAO)

6 JULY 2022

10:30 - 11:15 — Plenary 2

Poster Session

Plenary (WiPiSA)

LUNCH BREAK

Poster session *(judging)*

7 JULY 2022

10:30 - 11:15 — SAIP Day

Chair: Christo Venter

11:30 - 11:45
- 268 — African Astronomical Society (AfAS): the voice of astronomy in Africa. **TAKALANA, Charles** (African Astronomical Society)

11:45 - 12:00
- 77 — Taking the Nooitgedacht telescope to the next level. **HUG, Rigardt** (North-West University)

12:00 - 12:15
- 84 — From setting up a new telescope to optimizing astrometric solutions. **LETSOALO, Jane Mankhubu**

12:15 - 12:30
- 74 — A Closer Look at Potential Exoplanets Targets from the Nooitgedacht Observatory **VORSTER, Henriëtte** (North-West University)

LUNCH BREAK

14:00 - 14:45 — Plenary 5

Chair: Vanessa McBride

15:00 - 15:15
- 205 — Preparing to welcome the global astronomy community to Africa in 2024. **MCBRIDE, Vanessa** (Office of Astronomy for Development)

15:15 - 15:30
- 210 — Spatio-Spectral Modelling of the Pulsar Wind Nebula Kes 75. **VENTER, Christo** (North-west University)

15:30 - 15:45
- 293 — Particle Acceleration at Reflected Shocks in Supernovae Remnants **LE ROUX, Jacobus Frederik** (North West University)

15:45 - 16:00
- 182 — SALT observations of gamma-ray binaries **VAN SOELEN, Brian** (University of the Free State)

8 JULY 2022

10:30 - 11:15 — Plenary 6

Chair: Brian van Soelen

11:30 - 11:45
- 32 — Stochastic differential equations as a powerful numerical tool. **STRAUSS, Du Toit** (Centre for Space Research, North-West University)

11:45 - 12:00
- 316 — An artificial Neural Network to quickly classify transients in the era of LSST. **MARAIS, Johannes Petrus** (UFS)

12:00 - 12:15
- 222 — Modelling compact stars: numerical solutions to the structure equations using Python. **MAZWI, Luyanda** (University of Johannesburg)

LUNCH BREAK

14:00 - 14:45 — Plenary 7

Annual General Meeting (AGM)

Space Science

	4 JULY 2022	5 JULY 2022	6 JULY 2022	7 JULY 2022	8 JULY 2022
09:30 - 10:15	Opening function				
10:30 - 11:15	Plenary 1 **Chair: Rendani Nndanganeni**	Plenary 2 **Chair: Du Toit Strauss**	Plenary 4	SAIP Day	Plenary 6 **Chair: Brian van Soelen**
11:30 - 11:45	5 Supersolitons that propagate obliquely to the magnetic field in a plasma with adiabatic ions, Boltzmann distributed cool electrons and Cairns or Kappa-distributed hot electrons. ***SINGH, Shivani*** *(UNISA)*	192 Effects of solar storms on the radiation exposure to aircraft passengers and crew. **NNDANGANENI, Rendani Rejoyce** (South African Nation Space Agency)	Poster Session		32 Stochastic differential equations as a powerful numerical tool **STRAUSS, Du Toit** (Centre for Space Research, North-West University
11:45 - 12:00	276 The effects of ion beams on slow and fast ion-acoustic solitons in plasmas with two-temperature electrons. M**AXENGANA**, M. (South African National Space Agency (SANSA) Space Science)	221 Development of the HARM model for aviation dosimetry .**MOSOTHO, Moshe Godfrey** (North-West University)			
12:00 - 12:15	228 The Vacuum Arc Ion Thruster for Space Science Applications. **STANSELL, Paul** (University of the Witwatersrand)	301 Assessment of the Cosmic-ray Soil Moisture Observing System for different agroclimatic zones. **MOLOTO, Katlego** (North-West University)			316 An artificial Neural Network to quickly classify transients in the era of LSST. **MARAIS, Johannes Petrus** (UFS)
12:15 - 12:30	163 Enhanced Vacuum Arc Thruster with Pulsed Magnetic Fields. **RENCKEN, Tristan**		Plenary (WiPiSA)		222 Modelling compact stars: numerical solutions to the structure equations using Python. **MAZWI, Luyanda** (University of Johannesburg)
12:30 - 12:45	93 Constraining the Cross-field Diffusion of Jovian Electrons. **VAN DEN BERG, Jabus** (Centre for Space Research, North-West University)				
12:45 - 13:00	167 Simulating Solar Energetic Particle Transport As Observed By Solar Orbiter. **STEVENS**, **Jaclyn** (North West University)				
13:00 - 14:00	***LUNCH BREAK***	***LUNCH BREAK***	***LUNCH BREAK***	***LUNCH BREAK***	
14:00 - 14:45	Special lecture: Higgs Boson **Chair: Katlego Moloto**	Plenary 3 **Chair: Zama Katamzi-Joseph**		Plenary 5	Plenary 7
15:00 - 15:15	27 SuperDARN RADAR Groundscatter Statistics Over Antarctica. **SOSIBO, Phakamile** (University of KwaZulu-Natal)	180 Neutron monitors as space weather instruments. **STRAUSS, Du Toit** (Centre for Space Research, North-West University)	Poster session *(judging)*		Annual General Meeting (AGM)
15:15 - 15:30	189 The investigation of the skynoise parameter of the Sanae SuperDARN radar. **DLAMINI, Mbali**				
15:30 - 15:45	194 Determining the response of southern hemisphere SuperDARN convection maps to the southward turning of the Interplanetary Magnetic Field. **MCHITHAKALI, Aviwe**	320 The South African Astronomical Observatory **MCBRIDE, Vanessa** (Office of Astronomy for Development)			
15:45 - 16:00	271 A behavior of EIA during geomagnetic storms. **BULALA, Avuyile** (iThemaba LABS)				
16:00 - 16:15		266 The development of Radio Astronomy in South Africa **GOEDHART, Sharmila** (SARAO)			
16:15 - 16:30					

Physics for Development, Education & Outreach

(Tuesday – Industry Day)

	4 JULY 2022	5 JULY 2022	6 JULY 2022	7 JULY 2022	8 JULY 2022
09:30 - 10:15	Opening function				
10:30 - 11:15	Plenary 1 **Chair: Alan Cornell**	Plenary 2 **Chair: Deena Naidoo**	Plenary 4	SAIP Day **Chair: Alan Cornell**	Plenary 6 **Chair: Deena Naidoo**
11:30 - 11:45		**INDUSTRY DAY** 362 Industry Connection Roadmap. **MATTHEWS, Alan**	Poster Session		281 Teach electronics to applied physics students. Prototyping, design and research on a printed circuit board. **MARIOLA, Marco** (University Of Kwazulu Natal)
11:45 - 12:00	22 Leveraging design thinking and systems thinking approach in Physics education research. **NSHIMWE, Ngwende Rethabile** (Botswana International University of Science and Technology)			23 *Leveraging quantum machine learning in finance.* ***TSHIDI, MOTSHIDISI*** *(Botswana International University of Science and technology)*	296 The effects of expert problem solving on first-year mainstream physics students' performance and results. **HERBERT, Mark** (University of the Western Cape)
12:00 - 12:15	113 Challenges pre-service students have while practicing to answer questions using context-content alignment problem-solving strategy. **MOLEFE, Paul** (University of Johannesburg)	358 Optical fabrication technology; where are we? and where are we going? **KARA, Ravin**		19 Correlations between matric marks and mechanics misconceptions. **CORNELL, Alan** (University of Johannesburg)	353 Using a Kibble balance to explain physics principles in education. **MNDEBELE, Landile Floyd** (National Metrology Institute of South Africa)
12:15 - 12:30	138 A modal approach to teaching and understanding paraxial light propagation. **MOODLEY, Chané Simone** (University of the Witwatersrand)	364 Quantum technology for industry. **NDAGANO Bienvenu**	Plenary (WiPiSA)	11 Exploring the impact of teacher education programme on the development of pre-service science teachers' TPACK. **NDUMANYA, Emmanuela** (University of Johannesburg)	
12:30 - 12:45	249 Students' understanding of physical components of electrical circuits. **KHWANDA, Mphiriseni** (University of Johannesburg)	361 Physics in action: a personal journey from the Space Shuttle to aeronautics, explosions, rational drug design and ocean waves. **GLEDHILL, Irvy (Igle)**		136 Assessment of energy supply and use in households of Mudavula village in Collins Chabane Municipality in Limpopo province. **MBUYISA, Busisiwe** (University of Venda)	
12:45 - 13:00	297 Flippin Amazing? **WARD, Kebra** (Massachusetts College of Liberal Arts)			209 The impact of simulation experiments on the understanding of the concepts of acceleration and energy. **EWUOLA, Oluwatoyin** (University of Johannesburg)	
13:00 - 14:00	***LUNCH BREAK***	***LUNCH BREAK***	***LUNCH BREAK***	***LUNCH BREAK***	***LUNCH BREAK***
14:00 - 14:45	Special lecture: Higgs Boson **Chair: Paul Molefe**	Plenary 3 **Chair: Simon Connell**	Poster session *(judging)*	Plenary 5 **Chair: Itumeleng Phage**	Plenary 7
15:00 - 15:15	308 High School learners' difficulties with kinematics graphs. **PHAGE, Itumeleng**	**INDUSTRY DAY** 360 PVinsight: Determining photovoltaic module quality and degradation rates. **CROZIER MCCLELAND, Jacqui** (Nelson Mandela University/PVinsight)		10 The inclusion of nature of science in grade 12 high-stakes physics assessments in South Africa. **RAMNARAIN, Umesh** (University of Johannesburg)	Annual General Meeting (AGM)
15:15 - 15:30	211 Astronomy for development: past, present & future. **MCBRIDE, Vanessa** (Office of Astronomy for Development)			25 Online teaching in the digital age. **LETARTE, Bruno** (North-West University)	
15:30 - 15:45	300 Creating Support for Tutoring Physical Sciences and Mathematics: A Collaboration Between Metro South Education District and the Department of Physics and Astronomy. **AUDU, Bako Nyikun** (University of the Western Cape)	359 Case Studies of deploying AI-enabled and IoT-based Solutions for Industrial Applications. **ADAMS, Dominique E**		233 Water Quality Assessment Using Graph Convolutional Neural Networks. **SENEKANE, Makhamisa** (University of Lesotho)	
15:45 - 16:00	298 Teacher's perceptions of Modeling Instruction for the South African classroom. **HERBERT, Mark** *(University of the Western Cape)*			258 The effects of monitored peer teaching and learning on the understanding of basic Physics concepts. **SONDEZI, Buyi** (University of Johannesburg)	
16:00 - 16:15	62 Language in learning. How far can we teach Physics in isiZulu? **FISH, Derek** (University of Zululand)	363 Nuclear Technologies in Medicine. **ZEEVAART, Jan**			
16:15 - 16:30					

Applied Physics

	4 JULY 2022	5 JULY 2022	6 JULY 2022	7 JULY 2022	8 JULY 2022
09:30 - 10:15	Opening function				
10:30 - 11:15	Plenary 1	Plenary 2	Plenary 4	SAIP Day	Plenary 6
	Chair: Phil Ferrer	**Chair: Ernest van Dyk**		**Chair: Thulani Hlatshwayo**	
11:30 - 11:45	35 High order stabilized finite elements for gas dynamics. **KHULU, Musawenkosi** (University of Zululand)	232 Forecasting Short-term Power Consumption Using Deep Learning and Boosting Machine Learning Techniques. **SENEKANE, Makhamisa** (National University of Lesotho)	Poster Session	50 A Nonlinear Logistic Regression Model for the Measurement of Drug Potency in Photodynamic Therapy. **CHIZENGA, Elvin** (Laser Research Centre, University of Johannesburg)	
11:45 - 12:00	105 Unmasking phase with ghost imaging. **SEPHTON, Bereneice** (University of the Witwatersrand)	256 Density functional theory study of Nax (TiyZnzMnw)O2 as a cathode material. **RANWAHA, Tshifhiwa Steven** (University of Venda)		226 Developing an Infectiousness model for droplet transmission. **RALIJAONA, Mbolahasina** (University of Johannesburg)	
12:00 - 12:15	108 An Internet Of Things (IoT) pilot project as a primer for the future development of IoT technology for particle physics detector data acquisition systems. **MCKENZIE, Ryan** (University Of the Witwatersrand)	132 Computational Fluid Dynamics in the ATLAS Detector. **CONNELL, Matthew** (University of Johannesburg)		28 Blending and thermal stability studies of a composite biopolymeric material for the removal of toxic pollutants in pharmaceutial effluents. **SIMELANE, Nontobeko Precious**	
12:15 - 12:30	115 Threading a Laser Through the Eye of a Needle: Multimode Fibre Coupling in Turbulence. **IGA, Fortune** (University of the Witwatersrand)	282 Optimised mathematical library for Atmel microcontrollers. **MARIOLA, Marco** (University Of Kwazulu Natal)		269 Physics-Informed Neural Networks **MATTHEWS, Alan** (UKZN)	
12:30 - 12:45	122 The Vacuum Arc Ion Thruster. **STANSELL, Paul** (University of the Witwatersrand)	295 Serendipitous p- to n-type response switching in β-Ga2O3 needles: A potential application to selective CO and CH4 gas sensors. **GATSI, Nyepudzai Charsline** (University of the Witwatersrand)	Plenary (WiPiSA)	154 Analysis of bulk materials using fast neutron transmission analysis. **MHLONGO, Sizwe** (University of Cape Town)	
12:45 - 13:00	128 Fast, cheap, variable sensitivity wavefront sensor for applications in communication to microscopy and beyond **SINGH, Keshaan** (University of the Witwatersrand)	340 Direct-couple PVWPS sizing using borehole hydraulic parameters. **MASEVHE, Livhuwani** (UNIVEN)		155 Validation of the Monte Carlo Detector Effects model for the UCT POLARIS Compton camera. **SMUTS, Frank** (University of Cape Town)	
13:00 - 14:00	*LUNCH BREAK*	*LUNCH BREAK*	*LUNCH BREAK*	*LUNCH BREAK*	*LUNCH BREAK*
14:00 - 14:45	Special lecture: Higgs Boson	Plenary 3		Plenary 5	Plenary 8
	Chair: Freddie Vorster	**Chair: Trevor Derry**		**Chair: Trevor Derry**	
15:00 - 15:15	343 Non Specialist Lecture: Synchrotron-enabled macromolecular crystallography in Brazil: From plant biomass hydrolysis to biomedical applications. **POLIKARPOV , Igor**	125 Comparison between the empirical, machine and deep learning techniques to predict global solar irradiance for Mutale area in Limpopo Province, South Africa. **MURIDA, Thalukanyo Whitney** (University of Venda)		64 ATLAS Tile Calorimeter Phase-II upgrade low-voltage power supply production and testing. **NKADIMENG, Edward** *(University of the Witwatersrand)*	
15:15 - 15:30		141 Construction of the Solar trough Cavity receiver. **FERRER, Phil** (WITS)		173 MicroPEPT: A step towards hybrid PEPT detectors. **VAN DER MERWE, Robert** (University of Cape Town)	
15:30 - 15:45	139 Reconstructing a quantum ghost image without a camera. **MOODLEY, Chané Simone** (University of the Witwatersrand)	291 Development of a luminescence imaging system for the characterization of PV cells. **ROODT, Roelof** (Nelson Mandela University)	Poster session *(judging)*	260 Developing a Nuclear Orientation Thermometer for the UCT Dilution Refrigerator. **NTOLOSI, Yanga** (NMISA & University of Pretoria)	Annual General Meeting (AGM)
15:45 - 16:00	144 Simulation Modelling the Conductivity of Metal Oxide Gas Sensors from the First Principles. **NHLOZI, Blessing Mvana** (University of Zululand)	292 Analysis of degradation of Perovskite PV devices using injection dependent Photoluminescence imaging. **DIX-PEEK, Ross** (Nelson Mandela University)		267 Measurement of fast neutron removal cross sections for the elemental analysis of concrete. **SEGALE, Nalesi** (University of Cape Town)	
16:00 - 16:15	148 Tailoring Noise Invariant Light for Robust Optical Communication. **PETERS, Cade Ribeiro** (University of the Witwatersrand)	305 Outdoor current-voltage testing of bifacial photovoltaic modules to determine bifaciality coefficients and gain. **NDZONDA, Siyabonga** (Nelson Mandela University)		263 Positron Emission Particle Tracking (PEPT): Data analysis techniques for tracking multiphase flows. **SITOBOLI, Rorisang** (University of the Witwatersrand)	
16:15 - 16:30	149 Modal Description of Optical Elements. **ORNELAS, Pedro** (University of the Witwatersrand)				

Theoretical & Computational Physics

	4 JULY 2022	5 JULY 2022	6 JULY 2022	7 JULY 2022	8 JULY 2022
09:30 - 10:15	Opening function				
10:30 - 11:15	Plenary 1	Plenary 2	Plenary 4	SAIP Day	Plenary 6
	Chair: Thomas Konrad	Chair: Alan Cornell			
11:30 - 11:45	17 5D MSSM at Two loop. **CORNELL, Alan** (University of Johannesburg)	31 Matters of the Rh=ct universe. **ABEBE, Amare** (North-West University)	Poster Session		
11:45 - 12:00	15 Black holes and nilmanifolds: quasinormal modes as fingerprints of extra dimensions **CHRYSOSTOMOU, Anna** (University of Johannesburg)	325 Is gravity quantised? **MAHARAJ, Shamik** (University of KwaZulu-Natal)			
12:00 - 12:15	166 Rapidity Distributions of Pb+Pb and Au+Au from the microscopic Ultra-relativistic Quantum Molecular Dynamics (UrQMD 3.3) model. **NEMAKHAVHANI, Thendo Emmanuel** (University of Johannesburg)	175 Quantum spectrum of tachyonic black holes in a brane-anti-brane system. **BEESHAM, Aroonkumar** (University of Zululand)			
12:15 - 12:30	242 First principle' study of the properties of the Titanium based alloys (Ti doped with Mo, Mg, Zr, Ta and Si) for biomedical applications **MABEBA, Kobe**	111 The Physics of Core-Collapse Supernovae **NZUZA, Wandile** (University of Witwatersrand)			
12:30 - 12:45	54 The QCD Equation of State in Small Systems **HOROWITZ, William** (University of Cape Town)		Plenary (WiPiSA)		
12:45 - 13:00	76 An Introduction to Lattice QCD: The Metropolis Algorithm and the Anharmonic Oscillator. **NGWENYA, Blessed Arthur** (University of Cape Town)	289 Anomaly Detection on the high throughput network of the ATLAS TDAQ system. **PHIRI, Mitchell** (University of Johannesburg)			
13:00 - 14:00	*LUNCH BREAK*	*LUNCH BREAK*	*LUNCH BREAK*	*LUNCH BREAK*	*LUNCH BREAK*
14:00 - 14:45	Plenary 2	Plenary 3	Plenary 5	Plenary 7	
	Chair: Alan Cornell	Chair: Azwinndini Muronga			
15:00 - 15:15	225 Statistical thermal models for particle reproduction in heavy ion collisions. **SITHOLE, Kudzai** (University of the Western Cape)	329 Control of quantum systems by quantum systems **KONRAD, Thomas** (UKZN)			
15:15 - 15:30	253 Quantum key distribution protocol implemented with biphotons. **SEKGA, Comfort** (Botswana International University of Science and Technology)	328 Wigner functionals in Quantum optics **DURGAPERSADH, Akshay**			
15:30 - 15:45	324 Quantum-optical description of sum-frequency generation in terms of spatial light modes. **PERMAUL, Tanita** (University of KwaZulu-Natal)	335 A generalised approach to measurement-based feedback Control of a Quantum System in a Harmonic Potential. **ROUILLARD, Amy** (University of KwaZulu-Natal)			
15:45 - 16:00	86 Measurement-Based Quantum Network Coding on a Noisy Superconducting Processor. **RALL, Hjalmar** (Stellenbosch University)	200 A new Bell inequality for measuring entanglement in relativistic frames. **HARTMAN, Jonathan** (University of Johannesburg)			
16:00 - 16:15	333 A verification scheme for universal quantum computers. **SEGIREDDY, Anirudh Reddy** (UKZN)	120 Cavity QED based open quantum walks. **ZUNGU, Ayanda** (North-West University)			
16:15 - 16:30	87 Using linear spectroscopy to accurately determine the Hamiltonian of a light-harvesting complex. **NÖTHLING, Towan** (University of Pretoria, NITheCS)	342 Higher order relativistic dissipative fluid dynamics for heavy ion collisions and astrophysics. **MURONGA, Azwinndini** (Nelson Mandela University)			

Poster session
(judging)

Annual General Meeting (AGM)

This track is sponsored by NITheCS National Institute for Theoretical and Computational Sciences

Track A - Physics of Condensed Matter and Materials

ID	Title	Author	Affiliation
12	Synthesis, Electron Spin Resonance and Photoluminescence properties of Sm3+ ion doped Zn-Mn nanoferrites synthesized by glycol-thermal method	Amos Nhlapo	Sefako Makgatho Health Sciences University
65	Atomistic simulation studies of binary M9S8 (M=Ir, Rh) and ternary (RuPd)9S8 Pentlandite-like systems	Kgwajana Barnard Molala	University of Limpopo
70	Facile Zn and Ni co-doped hematite nanorods for efficient photocatalytic water oxidation	Joan Talibawo	University of Rwanda/University of Pretoria
73	Computational Study on Surface Reconstruction of Co9S8	Nontobeko Zavala	-
85	Alpha Iron Oxide (α-Fe2O3) Nanoparticles doped with Ruthenium for Gas Sensing Properties.	Ndlangamandla, Cebo	University of Zululand
90	Structural stability of some gold (Au) and silver (Ag) nanoparticles	Malesela Walter Makgoba	University of Limpopo
109	Computational Modelling Study on the Stability Li1.2Mn0.8O2 Cathode Material	Vusani Mikosi	-
112	Multi-scale modelling of p2 and o2 type materials for utilization as core-shell materials	Precious Makhubela	-
114	Computational Study bulk and Surface RuO2 as a catalyst in Li-air Batteries	Mmeshi Hiine	-
129	Reactive Molecular Dynamics Simulations of the Atomic Oxygen impact on Poly(2,5)-benzimidazole	Ernst Ellis	North-West University
160	The effect of ferromagnetic elements (Fe, Ni) on the magnetic properties of MnPt alloy	Ramogohlo Diale	UL and MINTEK
164	Preparation of erbium activated orthovanadate-phosphate by chemical bath deposition	Mosidi Mokoena	University of the Free-State
169	Electronic, elastic, and transport properties of copper sulphide	Moshibudi Ramoshaba	University of Limpopo
172	Machine learning models for predicting the density of sodium-ion battery materials	Keletso Monareng	University of Limpopo
176	Structural, stability and vacancy properties of both defect free and defected 2D h-BNNSs.	Magopa Tshepho Mcdonald Kekana	University of Limpopo
184	Hall Coefficient of (Cr100-xAlx)95Mo5 Alloy System	B Muchono	University of Eswatini
187	Investigation of Structural and Dynamical Properties of Sperrylite (PtAs2) Mineral Based on Molecular Dynamics Simulations	Thapelo Ntobeng	University of Limpopo
195	First principle studies of structural, elastic, electronic and optical properties of chalcogenide LiAlS2 under pressure	Boitemogelo Phale	University of Limpopo
202	{Electrodeposition of CdTe Thin Film Effect of Deposition Temperature from acetate precursor for Solar Energy Application }	Ahmed Ahmed Yimamu	-
203	Effects of size and Cr substitution on the structural and magnetic properties of α–CoV2O6	Murei Mulibana	University of Johannesburg
215	Correlations of Ferroic Orders in Multiferroic TbMnO3 and TbMn2O5Thin Films	Geoffrey Mwendwa	University of the Witwatersrand

218	The synthesis and characterization of metallic@semiconductor nanocomposite materials as active ingredients for solar and thermal energy harvesting applications	Tshepho Trevor Makgale	saip and nitherp
230	Topic: Computational analyses of graphene quantum dots as anode material for lithium-ion batteries.	Thokozane Mlotshwa	saip and nitherp
234	Structure, optical and magnetic properties of combustion synthesized Ni-Cr doped ZnO	Lokesha Handalagere Shankarappa	University of Johannesburg
246	Synthesis and Characterization of Graphene Oxide Nanocomposite for Application in Hybrid Supercapacitors	Maano Tryphinah Nemukongwe	University of Venda
251	Layered organic-inorganic perovskite films in solar cells	Sandile Thubane	University of Pretoria
255	Carbon Ion implanted ZnO Nanorods-Structural and Optical analysis	Kebadiretse Lefatshe	Botswana International University of Science and technology
257	Li adsorption on a self-healed graphane for the next generation ion batteries.	Edwin Mapasha	University of Pretoria
261	Modelling Weather Patterns and Solar PV systems for the Sizing of Standalone PV Battery Charging System	Happy Ndlovu	University of Zululand
264	Electronic, Magnetic and Mechanical Properties Of Nd2Fe14B Permanent Magnets: Ab Initio Study	Mphamela Enos Baloyi	University of Limpopo
265	Photoluminescence characteristics of bulk hydrogenated anatase TiO2	Assane Talla	Nelson Mandela University
286	Deposition and characterisation of a Zinc Oxide thin film on p-type Silicon prepared by thermal spray pyrolysis.	Zahlia Stacey	-
309	Effects of NaOH and lime in the separation of chalcopyrite and pyrite minerals using allyl-N-diethyl dithiocarbamate as collectors: DFT and experimental studies	Peace Mkhonto	University of Limpopo
310	Kinetic Analysis of Thermoluminescence of α-Al2O3:C Annealed at 1200 ^{o}C	Fiindje Elago	Rhodes University
315	Assessment of the experimental band gap of alxga1-xn epilayers	JAA Engelbrecht	Nelson Mandela University
321	Structural and photoluminescent properties of Y2O3, Y2O3-AG: Eu3+ (where AG = PO42-, SO42-, BO33-) nanophosphors for white-LED applications	Mathe T.G.	University of Johannesburg
327	Mechanical properties of Ti 50–xHfxPt50, (0 < x < 50) for HTSMAs applications	Mordecai Mashamaite	University of Limpopo
332	Synthesis and evaluation of CZTS/CZTSSe nano-powders for optoelectronic applications	Akin Olaleru	University of Venda

Track B - Nuclear, Particle and Radiation Physics

ID	Title	Author	Affiliation
41	Comparative study of the isoscalar giant monopole resonance in ^{58}Ni and analysis of its fine structure	Armand Bahini	University of the Witwatersrand
83	Study of systematic uncertainties and spurious signals of resonant $H\rightarrow Z\gamma$ production at ATLAS Experiment	Gaogalalwe Mokgatitswane	University of the Witwatersrand
93	A study of top quark pair production in association with a high energy photon at the LHC.	Thuso Mathaha	University of the Witwatersrand
119	Kernel Density Estimation based simulations of Monte-Carlo events at LHC	Nidhi Tripathi	University of the Witwatersrand
186	Characterisation of a new LSO block detector for Positron Emission Particle Tracking	Alice McKnight	University of Cape Town
201	Geant4 Analysis of Secondary Neutrons in Proton Therapy	Alice Roux	-
207	Tilted Precession Bands in 133Ce and 131Ba	Ignasio Wakudyanaye	University of the Western Cape
217	Survey of radiation levels at ithemba labs using a mobile radiation detection unit equipped with a LaBr3:Ce detector	Ferdie van Niekerk	-
270	Nuclear Structure of Neutron-Rich 128In Using Beta-decay Spectroscopy	Nikita Bernier	-
283	Coulomb Excitation of 66Ge	Kenzo Abrahams	University of the Western Cape
304	Optimization of Digital Parameters and Offline Sorting Code for Experiments at IDS/CERN	Remember Ayanda Madonsela	University of the Western Cape

Track C - Photonics

ID	Title	Presenters	Affiliation
67	In Vitro antiproliferative effects of berberine in phthalocyanine-mediated photodynamic therapy on MCF-7 Breast Cancer Cells with Overexpressed P-Glycoprotein	Alexander Chota	University of Johannesburg
97	Photodynamic Efficacy of a Chlorophyll based Photosensitizer Pheophorbide a against Resistant Breast Cancer Cells	Paromita Sarbadhikary	Laser Research Centre
103	Photobioinhibitory Effect of Laser on Resistant MCF-7 Cancer Cell Line	Nosipho Fakudze	University of Johannesburg
104	Exploring the photodynamic potency of BMOV against breast cancer and breast cancer stem cells following laser irradiation at 405 nm	Bhawna Uprety	Laser Research Centre
134	Simulation of a malaria nanoplasmonic biosensor based on extraordinary optical transmission.	A.S. Kiyumbi	Stellenbosch University
151	The Most Robust Modes Through Atmospheric Turbulence	Cade Ribeiro Peters	University of the Witwatersrand
152	Threading a laser through the eye of a needle: Multimode Fibre Coupling in Turbulence	Fortune Iga	University of the Witwatersrand
191	Design and construction of a counter propagating optical trap for aerosol droplets.	Anneke Erasmus	Stellenbosch University
237	Binarised phase masks	Lehloa Mohapi	University of the Witwatersrand

Track D1 - Astrophysics

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95	H I Size–Mass: MIGHTEE-HI vs TNG50	Omphile Rabyang	North West University

Track D2 - Space Science

ID	Title	Presenters	Affiliation
167	Simulating Solar Energetic Particle Transport As Observed By Solar Orbiter	Jaclyn Stevens	North West University
228	The Vacuum Arc Ion Thruster for Space Science Applications	Paul Stansell	University of the Witwatersrand

Track E - Physics for Development, Education and Outreach

ID	Title	Presenters	Affiliation
294	Returning to the first-year mainstream physics classroom at the University of the Western Cape after the COVID-19 pandemic	Mark Herbert	University of the Western Cape

Track F - Applied Physics

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18	Development of a MELCOR Model for the Koeberg pressurised water reactor	Nontobeko Khumalo	National Nuclear Regulator
42	Sol-gel derived and electrospun mesoporous TiO2 nanoparticles: Effects of calcining temperature on the structure, morphology and surface area	Dieketseng Tsotetsi	-
75	Implementation of the LED Integrator panel for the Prometeo system in the ATLAS Tile Calorimeter	Onesimo Mtintsilana	University of the Witwatersrand
88	AI in Medical Assay	Temweka Chirwa	Perinatal HIV Research Unit
91	Upgrade of ATLAS Tile Calorimeter TTC system for Phase-II test-beam campaigns	Humphry Tlou	University of the Witwatersrand
107	Multi-channel, turbulence resistant Quantum Key Distribution	Pedro Ornelas	University of the Witwatersrand
131	Using Machine Learning to Model and Predict the Effects of Atmospheric Turbulence on Lasers	Steven Makoni	University of the Witwatersrand
147	The investigation between covariability of energy fluxes and CO2 flux exchanges at Skukuza Kruger National Park by Eddy Covariance technique.	Lufuno Takalani Sophie Mulaudzi	University of Venda
157	Setting up an environment to monitor and analyse ATLAS Tile Calorimeter detector control system temperatures	Lungisani Phakathi	University of Zululand
158	A modified Zinc Oxide (ZnO) gas sensor approach to detect oxidizing gases	Lungisani Sipho Phakathi	University of Zululand

197	ATLAS SoC TDAQ and ATCA OPCUA server implementation on the TileCoM for the ATLAS TileCal Phase-II upgrade	Mpho Gift Doctor Gololo	University of the Witwatersrand
208	First principle calculation of electronic and optical properties of graphene and mono doped graphene with Ti, Zn, and Ru.	Lutendo Phuthu Lutendo Mathomu	University of Venda
227	Hyper-parameter optimization in the search for new resonances using weak supervised learning	Edward Nkadimeng	University of the Witwatersrand
239	Effect of annealing temperature and time on α-hematite thin films prepared via dip coating method for photoelectrochemical water splitting applications	Nombuso Msiza	University of Pretoria
273	Effects of changing operational voltage on Thermal and Current-Voltage measurements of poly-crystalline Photovoltaic module and individual cells	Monphias Vumbugwa	Nelson Mandela University
284	Electrochemical Impedance Spectroscopy. Case of study and software implementation.	Senzo Hlongwane	University of Kwazulu-Natal
307	Resistive Switching Memory Device Fabricated Using Raw Organic Cow Milk as the Active layer	Zolile Wiseman Dlamini	Central University of Technology
313	Traceability for future radiopharmaceuticals	Milton van Rooy	NMISA
318	Microwave synthesis of a novel transition metal doped MOFs derived Ni@Mn Yolk-shell for high energy density supercapacitor electrodes	Guy Leba Kabongo	Université Pédagogique Nationale
326	Communication distance and security improvement in satellite based quantum key distribution via photon polarization pseudo-random bases encoding	Alain Giresse Tene	-

Track G - Theoretical and Computational Physics

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20	Computational modelling studies on adsorption of triazine and xanthate collectors on cooperite (101) surfaces.	Thato Manyama	University of Limpopo
72	First Principles Study of Vanadium decorated Graphene; effect on hydrogen storage and H2S sensing.	El Hadji Oumar Gueye	University of Pretoria
121	Finite System Size Correction in ϕ^4 Theory NLO scattering	Jean Du Plessis	Stellenbosch University
161	Vibrational and thermodynamic properties of monazite-type LnPO4 (Ln=La, Ce): A first Principles study	Lebogang Motsomone	University of Limpopo
216	Modelling the infectiousness of viruses when exposed to ultra-violet germicidal system: A computational fluid dynamics approach	Emmanuel Igumbor	University of Johannesburg
241	Enhancement of Li and graphane interaction through extended H vacancy pathways for Li-ion batteries: Ab initio study.	Refilwe Mapasha	-
248	structural and electronic properties of TiNOs (N = 1-15) clusters:A density functional theory study	Ramalebana Moeti	-
288	First Principles Study of Nitrogen Dopant-Vacancy Complexes in Graphane	Hezekia Mapingire	University of Pretoria
319	First principle study on the magnetic properties and electronic structure of Ce and Dy substituted on Nd2Fe14B permanent magnet.	Lesego Miya	Sefako Makgatho Health Sciences University
323	First-principle study of TiAl (100), (110) and (111) surfaces	Renny Rambevha	Sefako Makgatho Health Sciences University
331	Constructing converging control channels from unsharp measurements	Siphesihle Majozi	University of Kwazulu-Natal
334	Introduction to Ito Calculus and it's Applications	Yastheer Hurriraj Bauchoo	University of Kwazulu-Natal

Book of Abstracts

Space Science / 5

Supersolitons that propagate obliquely to the magnetic field in a plasma with adiabatic ions, Boltzmann distributed cool electrons and Cairns or Kappa-distributed hot electrons

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Arbitrary amplitude nonlinear ion-acoustic waves are investigated in a three-component magnetised plasma consisting of inertial adiabatic ions and two-temperature electrons. The existence of nonlinear solitary wave structures is determined using the Sagdeev pseudopotential formalism, under the assumption of quasineutrality. The direction of wave propagation is oblique to the ambient magnetic field. The cool electrons are assumed to be Boltzmann distributed, however, the distribution of the hot electrons is varied in order to study the influence of superthermal kappa and non-thermal Cairns distributions on the supersolitons. A supersoliton has a distinct deformed appearance in potential and in the electric field in contrast to a regular soliton. The regions in parameter space that support the existence of supersoliton structures are identified, by varying the physical parameters such as obliqueness, the Mach number, cool ion temperature, and superthermal and non-thermal effects of the hot electrons. Whilst the main thrust of our study is to identify parameter combinations which support the existence of supersolitons, we will also investigate the conditions which are needed for which the positive potential supersolitons can coexist with negative potential solitons. An interesting aspect relating to coexisting solitons such as the polarity switching of solitons having similar characteristics as Korteweg-de Vries solitons which cannot propagate at the acoustic speed will also be investigated.

Student award:

No

Level for award:

N/A

Nuclear, Particle and Radiation Physics / 7

In-situ Determination of Radioactivity Levels and Radiological Hazards in and around the Gold Mine Tailings of the West Rand Area, South Africa

Authors: Paballo Moshupya[1]; Tamiru Abiye[2]; Ian Korir[1]

[1] *National Nuclear Regulator*

[2] *University of the Witwatersrand*

Corresponding Author: pmoshupya@nnr.co.za

Mining and processing of naturally occurring radioactive materials could result in elevated levels of natural radionuclides in the environment. The aim of this study was to evaluate the radioactivity levels on a large scale in the West Rand District in South Africa, which is dominated by abandoned gold mine tailings and the consequential radiological exposures to members of the public. The activity concentrations of U-238, Th-232 and K-40 in mine tailings, soil and rocks were assessed using the BGO Super-Spec (RS-230) gamma spectrometer. The measured activity concentrations for U-238, Th-232 and K-40 in the studied mine tailings were found to range from 209.95 to 2578.68 Bq/kg, 19.49 to 108.00 Bq/kg and 31.30 to 626.00 Bq/kg, respectively. In surface soils, the overall average activity concentrations were found to be 59.15 Bq/kg, 34.91 and 245.64 Bq/kg for U-238,Th-232 and K-40, respectively. For the rock samples analyzed, the mean activity concentrations were 32.97 Bq/kg, 32.26 Bq/kg and 351.52 Bg/kg for U-238, Th-232 and K-40, respectively. High radioactivity levels were found in mine tailings, with U-238 contributing significantly to the overall activity concentration. The external gamma radiation received from surface soil in the area is generally low, with an average of 0.07 mSv/y. The highest annual effective doses were estimated from the tailings dams and the levels varied between 0.14 mSv/y and 1.09 mSv/y, with an average of 0.51 mSv/y. In certain locations the recommended dose constraint of 0.25 mSv/y from a single source to the average member of the public within the exposed population was exceeded indicating the need for further monitoring and regulatory control measures specific to these areas to ensure protection of resident members of the public.

Student award:

No

Level for award:

No

Photonics / 8

Theoretical Modeling of Infrared Thermography

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Thermography is a non-destructive evaluation tool to measure the amount of infrared energy emitted by an object. This energy depends on temperature and wavelength and is described by Planck's law. From the solution of the wave equation the k-dependent photon energies and their density of states are calculated. The equation of state and a statistical description of the photon gas are presented. From the heat released during condensation and the heat capacity as a function of temperature T the dependence of the phase transition on the dimension d of the system is discussed. It is shown that only the one and two dimensional gas show a 2nd order phase transition while in the 3d case a 1st order phase transition is observed. Applications to real systems in nature are presented.

Student award:

N/A

Level for award:

N/A

Physics of Condensed Matter and Materials / 9

First-principles study on interaction of O2 with (100) surfaces of sperrylite and platarsite minerals

Authors: Bradley Nemutudi[1]; peace prince mkhonto[1]; Phuti Ngoepe[1]

[1] *University of Limpopo*

Corresponding Author: bradleynemu@gmail.com

Platinum group minerals (PGMs) are usually exposed to oxidation due to weathering and aging and there is lack of understanding in their interaction with oxygen. We have employed the density functional theory (DFT) to investigate the oxidation mechanism of sperrylite (PtAs2) and platarsite (PtAsS) (100) surface. The computed surface energies and morphologies for sperrylite and platarsite models, depicted the (100) plane as the preferred cleavage. We have adsorbed the oxygen molecule at different adsorption sites to attain the most exothermic site and preferred bonding mode. The oxidation mechanisms of the (100) surfaces of sperrylite and platarsite favoured the mono atomic oxygen bonding, which resulted from the dissociation of the O2 molecule on the surfaces. The adsorption energies was more exothermic for PtAs2 (100) surface oxidation (−217.19 kJ.mol−1), compared to platarsite (−181.86 kJ.mol−1), suggesting that sperrylite highly oxidises than the platarsite

mineral. These findings have demonstrated the oxidation behaviour of the sperrylite and platarsite platinum group minerals that is applicable to their weathering, and consequently how the oxidation may affect their floatability.

Student award:

Yes

Level for award:

PhD

Physics for Development, Education and Outreach / **10**

The inclusion of nature of science in grade 12 high-stakes physics assessments in South Africa

Author: Umesh Ramnarain[1]

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This research explores the representation of Nature of Science (NOS) is three national high-stakes grades 12 physics examinations. This study has particular significance due to curriculum reform that deliberately attempted to transform the previous curriculum that depicted to the learner and teacher a view of science which was not compatible with the nature of science. Science curricula worldwide have given more emphasis to NOS and this goal was also set by curriculum developers in post-Apartheid South Africa. It is therefore of interest to know whether this curriculum intent translates into the assessment of learners in high stakes physics examinations. A recent characterization of NOS is called the Family Resemblance Approach (FRA). This study adopted FRA as conceptual framework in guiding the analysis of grade 12 physics items for the representation of NOS. FRA offers 11 categories that consolidate the epistemic, cognitive and social aspects of science in a holistic, flexible and descriptive way. The findings of this study suggest that greater attention needs to be given to the representation of NOS in both the cognitive-epistemic and social-institutional systems. A particular concern is the weak representation of NOS in the socio-institutional dimension where it was found that physics items only to a small extent address the categories of professional activities, scientific ethos, social certification and dissemination, social values of science, social organizations and interactions, political power struggles, and financial systems. An implication of this is that learners are not tested on higher-order skills such as critical thinking that would inform their decision-making on socio-scientific issues related to physics. This is therefore a call for deliberation amongst stakeholders on the tasks that set in physics examinations.

Student award:

No

Level for award:

N/A

Physics for Development, Education and Outreach / **11**

Exploring the impact of teacher education programme on the development of pre-service science teachers' TPACK

Authors: Sam Ramaila[1]; Emmanuela Ndumanya[1]

[1] *University of Johannesburg*

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Technology integration is central to the improvement of teaching and learning especially in science education. The extent to which technology integration is harnessed in teacher training programmes informs pedagogical practices adopted by pre-service teachers when integrating technology in science teaching and learning. While pre-service teachers often have sufficient knowledge and skills, they find it increasingly challenging to harness technology integration to foster effective science teaching and learning in diverse contexts. This study explores the impact of teacher education programme on the development of pre-service science teachers' technological pedagogical content knowledge (TPACK) by adopting a generic qualitative design located within the interpretivist paradigm. The empirical investigation involved six conveniently selected pre-service science teachers enrolled for a Bachelor of Education degree at a South African university. Qualitative data was collected through analysis of lesson plans, evaluation of micro lesson presentations, and semi-structured interviews. The study is underpinned by TPACK framework as a theoretical lens. Key findings demonstrated that the training programme provided meaningful opportunities for pre-service science teachers to use various technologies as learning tools. These opportunities enable pre-service science teachers to acquire knowledge and skills required for coherent integration of technology to foster effective science teaching and learning in diverse contexts. It is recommended that sustainable professional development opportunities ought to be provided to implore science teachers to fully embrace digital transformation as a key imperative associated with the advent of the Fourth Industrial Revolution. Theoretical implications for technology-enhanced teaching and learning are discussed.

Student award:

No

Level for award:

N/A

Poster Session / **12**

Synthesis, Electron Spin Resonance and Photoluminescence properties of Sm3+ ion doped Zn-Mn nanoferrites synthesized by glycol-thermal method

Author: Amos Nhlapo[1]

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Nano-crystalline Zn0.5Mn0.5SmxFe2-xO4 ($0 \leq x \leq 0.05$) with average crystallite sizes varying between 12 and 17 nm were synthesized by the glycol-thermal process. XRD analysis confirmed a single-phase cubic spinel structure in all the compounds. Substituting a smaller Fe3+ ion with a larger rare-earth Sm3+ ion has affected the distribution of metal ions on tetrahedral (A) and octahedral (B) sites. A scanning electron microscope has been used to study the morphology of nanoparticles and it revealed spherical shaped nanoparticles. EDX confirmed the phase purity and the elemental composition. Crystallite sizes affect ESR signal intensity and the line width. The g-values fluctuated ranging from 2.31 to 2.51 due to fluctuating crystallite sizes. The broad visible emission band is observed at 318 nm and 380 nm in the entire PL spectroscopy results for all compositions with an excitation wavelength of 340 nm. The emission intensity was found to be dependent on Sm3+ ion concentration and crystallite sizes of the compounds and the spin number.

Student award:

No

Level for award:

N/A

Nuclear, Particle and Radiation Physics / 13

Production of muons from heavy-quark hadron decays in pp collisions at √s = 13 TeV with the ALICE detector

Author: Tebogo Shaba[1]

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Heavy quarks (charm and beauty) are produced at an early stage of the collision via hard parton scatterings. In ALICE, heavy quarks are measured in the central barrel (|η|<0.9) which is optimized for the reconstruction ofη|η|<0.9) which is optimized for the reconstruction of<0.9) which is optimized for the reconstruction of) which is optimized for the reconstruction of hadrons, electrons, photons and jets via the hadronic and electronic decay channels, and at forward pseudo rapidity (−4<η<−2.5) with the muon) with the muon spectrometer which is responsible for the reconstruction of muon decay products of heavy quarks, quarkonia and electroweak bosons via the single muon decay channel. The inclusive single muon cross sections from heavy- quark hadron decays, produced at forward rapidity, are measured using muon triggered events from proton-proton (pp)collisions at √s = 13 TeV. The pT and pseudorapidity (η) differential cross sections are presented and compared to perturbative quantum chromodynamics (pQCD) based Fixed Order plus Next-to-Leading Logarithms (FONLL) calculations. These measurements provide a testing ground for pQCD calculations.

Student award:

Yes

Level for award:

PhD

Nuclear, Particle and Radiation Physics / 14

Design and development of the ALICE Common Readout Unit user-logic firmware for the Muon Identifier readout chain

Author: Dieuveil Orcel Thys-dingou[1]

Co-authors: Atanda Raji [1]; Zinhle Buthelezi [2]; Siegfried Förtsch [2]

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A Large Ion Collider Experiment (ALICE) at the Large Hadron Collider (LHC) at CERN is undergoing a major upgrade during which some of its subdetectors are replaced with new ones, while others are equipped with new electronics to handle the expected higher collision rates in the next running period (Run 3), which is foreseen to start in 2022. As part of the upgrade, certain sub-detectors such as the Muon Trigger (MTR), renamed to Muon Identifier (MID), can now operate in a continuous, trigger-less readout mode, in addition to the previous triggered readout mode. The previous MTR readout chain could only operate in triggered mode and needed to be replaced. Due to the increased quantity of data, typical methodologies are impossible to employ without massive efforts to expand the processing capacity. Since the new ALICE computing system cannot keep up with the increased data flow of the MID, a new processing algorithm has to be established. This research provides a new approach to processing the MID readout data based on a customized user-logic firmware.

Student award:

Yes

Level for award:

MEng

Theoretical and Computational Physics / 15

Black holes and nilmanifolds: quasinormal modes as fingerprints of extra dimensions

Authors: Alan Cornell[1]; Aldo Deandrea[2]; Anna Chrysostomou[1]; Etienne Ligout[3]

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Quasinormal modes (QNMs), the damped oscillations in spacetime that emanate from a perturbed body as it returns to an equilibrium state, have served for several decades as a theoretical means of studying *n*-dimensional black hole spacetimes. These black hole QNMs can in turn be exploited to explore beyond the Standard Model (BSM) scenarios and quantum gravity conjectures. With the establishment of the LIGO-Virgo-KAGRA network of gravitational-wave (GW) detectors, there now exists the possibility of comparing computed QNMs against GW data from compact binary coalescences. Encouraged by this development, we investigate whether QNMs can be used in the search for signatures of extra dimensions. To address a gap in the BSM literature, we focus here on higher dimensions characterised by negative Ricci curvature. As a first step, we consider a product space comprised of a 4D Schwarzschild black hole spacetime and a 3D nilmanifold (twisted torus); we model the black hole perturbations as a scalar test field. We find that the extra-dimensional geometry can be stylised in the QNM effective potential as a squared mass-like term. We then compute the corresponding QNM spectrum using three different numerical methods and determine constraints for the extra dimensions for a toy BSM model.

Student award:

Yes

Level for award:

PhD

Nuclear, Particle and Radiation Physics / 16

Correlation of heavy-flavour production and charged-particle multiplicity in pp collisions at $\sqrt{s} = 5.02$ TeV measured in ALICE

Author: Joyful Mdhluli[1]

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Measurements of heavy-flavour (charm and beauty quark) production in proton-proton (pp) collisions as a function of the charged-particle multiplicity are important in order to gain more insight on which processes are involved in the collision at a partonic level. These measurements also provide information on the interplay between hard and soft mechanisms during particle production. We report on heavy-quark production as a function of the charged-particle multiplicity using data collected in pp collisions with the ALICE detector during the LHC Run 2 at $\sqrt{s} = 5.02$ TeV. This study is essential for reference measurements for p-Pb and Pb-Pb systems. The measurement will also probe the role of multi-parton interactions (MPIs) in the production of heavy quarks and investigate whether collective effects play a role in particle production as already observed in other collision systems (p-Pb and Pb-Pb) at different center-of-mass energies. In addition, the study will be used to test QCD-based theoretical models.

Student award:

Yes

Level for award:

PhD

Theoretical and Computational Physics / 17

5D MSSM at Two loop

Author: Alan Cornell[1]

Co-authors: Mohammed Omer Khojali [2]; Aldo Deandrea [3]; Ammar Abdalgabar [4]; Howeida Mohamed

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The evolution equations of all supersymmetric and soft-terms are derived for the two-loop renormalisation group equations (RGEs) in a five-dimensional MSSM compactified on a S_1/Z_2 to yield the standard four space-time dimensions. Different possibilities can be discussed, however, we shall consider the limiting case of superfields where the Standard Model matter fields are restricted to the brane. We will compare our two-loop results to the results found at one-loop level. In this model the power law running in five dimensions and a compactification scale in the 10 – 10^3 TeV range has significant effects on the running. We also show that gluino mass may drive a large enough A_t to reproduce the measured Higgs mass of 125 GeV and have a light stop superpartner below ~1 TeV, as preferred by the fine tuning argument for the Higgs mass.

Student award:

No

Level for award:

N/A

Poster Session / 18

Development of a MELCOR Model for the Koeberg pressurised water reactor

Authors: Nontobeko Khumalo[1]; Bonginkosi Mnisi[1]; Ian Korir[1]

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The nuclear industry and its regulators have always prioritized safety and reliability in the operation of nuclear power plants. Thus the emphasis on the development, validation, and application of reliable predictive modeling capabilities for both normal and accident conditions. The Centre for Nuclear Safety and Security (CNSS) at the National Nuclear Regulatory (NNR) provides an important function in the nuclear regulatory process in South Africa. The responsibilities of the CNSS include independent research in the safety analysis and the analyses of the consequences of design basis and severe accidents at the Koeberg Nuclear Power Station (KPNS) The objective of the present work is to develop the MELCOR computer model for the KPNS. MELCOR is a fully integrated, engineering-level computer code that models the progression of severe accidents in light water reactor nuclear power plants. This code system is developed by Sandia National Laboratories (SNL) for the US NRC. MELCOR as with other reactor analysis codes, e.g. TRACE, RELAP etc. relies on nodalization schemes on various packages to capture/model the geometry of the core. These packages include the Control Volume Hydrodynamics (CVH), Core (COR), Heat Structure (HS) and Flow Paths (FL) packages. The nodalisation is done consistent with MELCOR Best Practices as Applied in the State-of-the-Art Reactor Consequence Analyses (SOARCA) Process. This is a long term-term development research project aimed at ensuring that the NNR has the capacity and capability to perform SOARCA consistent the US NRC prescribed process. The present work focuses on developing a model for the Reactor Pressurized Vessel (RPV) and the reactor core. Input data used for developing the model are mainly obtained from the original drawings and system descriptions from the Koeberg Safety Analysis Report (KSAR). This input deck will be improved continually by adding more sub-systems that are not included in this input deck, and the severe accident analysis of the KNPS will, thereafter, be performed.

Student award:

No

Level for award:

N/A

Physics for Development, Education and Outreach / 19

Correlations between matric marks and mechanics misconceptions

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The Force Concept Inventory (FCI) is a well-established physics education assessment tool used to evaluate students' comprehension of elementary mechanics principles. While it can be used to analyse the effectiveness of instruction if deployed as a pre- and post-test, we utilise the FCI here as pre-test only, to extract insights into first-year students' (mis)conceptions of Newtonian mechanics as they enter university. In this preliminary study, we tested 337 students enrolled at the University of Johannesburg in 2022, across five introductory physics courses, and correlated their responses with their matric marks and other global details. All subsequent data analysis anonymised the data, where we focussed on their responses to six "polarising" questions on the FCI test, for which the presence of a correct and a mostly correct answer allows for a clear demonstration of persistent misconceptions.

Student award:

No

Level for award:

N/A

Poster Session / 20

Computational Modelling Studies on Adsorption of Triazine and Xanthate Collectors on Cooperite (101) Surfaces

Author: Thato Manyama[1]

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

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Cooperite has been found to have a natural floatability and therefore there are few reports on its interaction with reagents such as collectors. In this study we employed the density functional theory with dispersion correction (DFT-D) to investigate the interaction of sodium 2,6-dithio-4-butylamino-1,3,5-triazine (SDTBAT) and sodium normal butyl xanthate (SNBX) collectors with PtS (101) surface

within the CASTEP code. The surface energy computed for (101) surface was found to be 1.14 J/m2. In the adsorptions, we initially tested different adsorption sites, to identify the most preferred active and exothermic site on the surface. We observed that the adsorption of SDTBAT preferred to adsorb on the 3-coordinated Pt atoms through Pt–S, Pt–N, Pt–S bridging mode. The SNBX was found to also adsorb on the 3-coordinated Pt atoms and formed a Pt–S1, Pt–S2 bridging. The SDTBAT collector was found to give the most exothermic adsorption energy of −610.1 kJ/mol compared to the SNBX which gave −378.8 kJ/mol. This indicated that SDTBAT has stronger adsorption strength than that of SNBX which suggested that SDTBAT has the potential to replace the xanthate as the collector due to its high selectivity and flotation power. Therefore this study has paved a way for design and adsorption of the triazine collectors on hard to float mineral such as sperrylite to improve their floatability. Keywords: DFT; PtS (101) Surface; Triazine collectors; Xanthate; Adsorption energies.

Student award:

Yes

Level for award:

MSc

Photonics / **21**

Synergistic Cytotoxic Effects of Photodynamic Therapy and Cannabidiol Treatment on Cervical Cancer Cells

Authors: Radmila Razlog[1]; Cherie Ann Kruger[2]

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Introduction: Cervical cancer (CC) is the fourth most diagnosed cancer in women worldwide. Conventional treatments include surgery, chemo- and radio- therapy, however these are often invasive and cause severe side effects. Additionally, approximately 70% of late-stage CC patients experience metastasis due to treatment resistance and limitations. There is thus a dire need to investigate alternative therapeutic combination therapies. Photodynamic therapy (PDT) is an alternative CC treatment modality that has been clinically proven to treat primary CC. Since PDT is a non-invasive localized treatment, with fewer side effects and less resistance to dose repeats, it is considered more advantageous. However, more research is required to refine its delivery and dosing, as well as improve its ability to activate specific immune responses to eradicate secondary CC spread. Cannabidiol (CBD) plant isolates post treatment, have been shown to exert in vitro CC anticancer effects and hinder secondary CC metastatic spread by causing apoptosis and inducing specific immune responses, which obstruct tumor invasion and angiogenesis. Methodology: The focus of this study was to investigate the synergistic cytotoxic PDT effect of a sulphonated zinc phthalocyanine PS (ZnPcS4) when combined with CBD in order to prevent the primary and secondary survival of CC cells. The individual (to determine the minimum inhibitory concentration - MIC) and combinative effects of PDT and CBD treatments were assessed by exposing in vitro HeLa CC cultured cells to varying doses of ZnPcS4 PS and CBD and irradiating the cells using a 673 nm diode laser. The effects were measured using the Trypan blue viability and Lactate Dehydrogenase (LDH) membrane integrity cytotoxicity assay, as well as inverted microscopy to assess cellular damage. Results: Individual PDT and CBD treated cellular responses showed dose dependent morphological damages, with decreased cellular viability and increased cellular cytotoxicity. The MIC for ZnPcS4 PS and CBD was found to be 0.125 µM and 0.5 µM respectfully. Combinative treatments at these MIC concentrations reported a significant 80% induction of cytotoxicity, with a notable 76% in cell death and morphological images revealed substantial cell death, suggestive of non-recovery. Conclusion: The findings from this study suggest that the synergistic combinative ZnPcS4 PS PDT treatment of in vitro cultured HeLa CC cells with CBD, can successfully induce primary cellular destruction, as well as limit secondary CC metastatic spread and so warrants further confirmatory investigation within in vivo models.

Student award:

No

Level for award:

N/A

Physics for Development, Education and Outreach / **22**

Leveraging Design Thinking and Systems Thinking Approach in Physics Education Research

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Design thinking and systems thinking approaches have become critical to creativity and innovation to address the engineering and technology challenges of the 21st century. We build on existing research on design thinking and systems thinking and discuss how physics education research practitioners can leverage these methodologies to improve student learning and experience. Most importantly, we investigate how these approaches could influence the behavior of students and instructors to develop higher-order thinking skills to understand and address complex problems in physics education research leading to improved learner performance, experience, and course design at higher education institutions.

Student award:

Yes

Level for award:

MSc

Physics for Development, Education and Outreach / **23**

Leveraging Quantum Machine Learning in Finance

Authors: MOTSHIDISI TSHIDI[1]; MHLAMBULULI MAFU[2]

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Quantum computers are expected to outperform the computational capabilities of classical computers during this decade and achieve a disruptive impact on numerous industry sectors, particularly finance. Quantum machine learning is an emerging field that will develop quantum algorithms to perform advanced machine learning tasks. Quantum machine learning is at the intersection between quantum computing and artificial intelligence and is set to revolutionize what the future looks like. Therefore, it is essential to understand the basic theory of machine learning and examine how it fits into quantum machine learning. We demonstrate how quantum machine learning can be leveraged to assist financial services organizations to solve problems and create opportunities by improving essential processes, for example, fraud detection and prevention, credit decision and underwriting.

Student award:

Yes

Level for award:

MSc

Physics for Development, Education and Outreach / 25

Online teaching in the digital age

Author: Bruno Letarte[1]

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Since 2020, many of us had to adapt to online teaching. From adapting to the circumstances the best we could in 2020 to a modern system digitally monitoring all possible aspects of each student in 2022. I will present the method I use to teach a large class ~500 first year students since 2020, how it was developed and evolved to what it is currently in 2022. This covers class attendance and participation, interaction with class content, and post-evaluation engagements. The picture it paints is very troubling, no matter what angle one uses to probe the situation, there is usually no more than 25-30% of the students who are active, leading to very weak throughput and many repeaters the following year. This class is a service module for students not majoring in physics, so their lack of interest for physics is pronounced. As you will discover with this presentation, much more than a test mark that can be extracted from each student!

Student award:

No

Level for award:

N/A

Photonics / 26

Simulation of Coherent Supercontinuum Generation in Silicon Germanium waveguide

Author: Proficiency Munsaka[1]

Co-authors: Peter Baricholo [1]; Gurthwin Bosman [2]; Erich Rohwer [2]

[1] *National University of Science and Technology*

[2] *Stellenbosch University*

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We report the simulation of ultrafast pulse evolution along the silicon germanium waveguide. Pulse evolutions of 205 fs duration and 2.35 kW peak power at 4.15 µm propagating along a 7 cm long silicon germanium on silicon air-clad waveguide were simulated by solving the generalised nonlinear Schrödinger equation using the fourth order Runge Kutta in the interaction picture method. Coherent supercontinuum covering more than one octave from 2.61 – 8.16 µm (relating to a bandwidth of 5.54 µm) at -30 dB is achieved. The simulated spectra fully spans the 4 – 8 µm spectral region comprising of molecular fingerprints for most hazardous and greenhouse gases making it attractive for gas absorption spectroscopy applications.

Student award:

Yes

Level for award:

MSc

Space Science / 27

SuperDARN RADAR Groundscatter Statistics Over Antarctica

Author: Phakamile Sosibo[1]

Co-authors: Michael Kosch [2]; Judy Stephenson [3]

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The South African advanced Super Dual Auroral Radar Network (SuperDARN) radar has been in operation for over the decade now and is located at South African National Antarctica Expedition (SANAE) station in Antarctica. SANAE radar scans the polar ionosphere over much of Antarctica, mainly to observe and study ionospheric plasma convection. SuperDARN is designed such that it can estimate the horizontal vector of ionospheric plasma drift at ~250 km altitude based on the Doppler frequency shift of the ionospheric backscatter returns. In addition, due to ionospheric refraction, the SuperDARN also receive ground scatter echoes approximately 1500 - 2000 km downrange. This allows the study of distant over the horizon ground level features such as mountains and ocean surface. The SuperDARN radar scans all 16 beams every 2 minutes and 75 range gates out to 3500 km. We determine the statistics on how often ground scatter is observed for all beams and range gates over a period of six years (2010-2015). A ray tracing tool is used to obtain the location of ground scatter in order to determine its likely origin.

Student award:

Yes

Level for award:

MSc

Applied Physics / 28

Blending and Thermal Stability Studies of a Composite Biopolymeric Material for the Removal of Toxic Pollutants in Pharmaceutical Effluents

Author: Nontobeko Precious Simelane[None]

Co-authors: J.K.O Asante ; P.P Ndibewu ; L.L Sibali

Corresponding Author: nontosimelane80@gmail.com

Pharmaceutical industries produce a wide range of pollutants in the form of effluents that have a negative impact on environmental health, resulting in not only a significant economic loss but also a violation of the human right to clean and safe water. These wastes contain significant levels of volatile organic chemicals (VOC) (e.g., benzene, toluene, and ethylbenzene). A kind of biopolymer composite materials with variety of reinforcements and fillers are fabricated, via Spark Plasma Sintering (SPS), characterized (using FT-IR, SEM, N2-BET, and XRD), and made to remove VOC in pharmaceutical effluents. Besides, the thermal stability of the biocomposite was investigated. A GC-FID instrument was used for VOCs quantification after the batch adsorption experiments. The results showed that for all of the tested VOCs, benzene, toluene, and ethylbenzene, the synthesized biopolymer composite material demonstrated good removal capacity in excess of 95%, indicating that this material is a promising adsorbent for the removal of volatile organic compounds.

Student award:

Yes

Level for award:

MSc

Photonics / 29

Interferometric orbital angular momentum mode detection in turbulence with deep learning

Author: Mitchell Cox[1]

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Orbital angular momentum (OAM) modes are topical due to their versatility, and they have been used in several applications including free-space optical communication systems. The classification of OAM modes is a common requirement, and there are several methods available for this. One such method makes use of deep learning, specifically convolutional neural networks, which distinguishes between modes using their intensities. However, OAM mode intensities are very similar if they have the same radius or if they have opposite topological charges, and as such, intensity-only approaches cannot be used exclusively for individual modes. Since the phase of each OAM mode is unique, deep learning can be used in conjugation with interferometry to distinguish between different modes. We demonstrate a very high classification accuracy of a range of OAM modes in turbulence using a shear interferometer, which crucially removes the requirement of a reference beam. For comparison, we show only marginally higher accuracy with a more conventional Mach–Zehnder interferometer, making the technique a promising candidate towards real-time, low-cost modal decomposition in turbulence.

Student award:

No

Level for award:

N/A

Astrophysics / 30

Seeing the Inside of Stars with Sound

Author: Getachew Mekonnen Mengistie[1]

Co-authors: Thebe Medupe [2]; Thulani Jili [1]

[1] *University of Zululand*

[2] *North-West University*

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In this talk, we introduce photometric mode identification formula for pulsating stars. By considering radiative transfer equations, appropriate physical conditions and mathematical formulations, we derive a formula that describes the effect of pulsations in the light output of pulsating stars. For this formulation, we took into consideration the interaction of light with the different layers of the atmosphere of the star. For non-radially pulsating stars, the calculation we did show the dependence of the variation in the observed luminosity on the surface area, surface normal and variation in temperature. We used the theories and principles introduced by Watson (1987, 1988), Medupe (2009) and studied photometric mode identification to introduce an alternative way of deriving theoretical photometric mode identification formula. We also demonstrate the effect of pulsation in the light output of a pulsating star. As a result, the calculation we did show the dependence of the variation in the observed luminosity on the surface area, surface normal and variation in temperature caused by nonradial pulsation. Key words: Mode identification; Photometry; Pulsating Stars; Radial and Nonradial Pulsation; Radiative transfer equations; Flux perturbations

Student award:

No

Level for award:

N/A

Theoretical and Computational Physics / 31

Matters of the Rh=ct universe

Author: Amare Abebe[1]

[1] *North-West University*

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Decades of astronomical observations have shown that the standard model of cosmology based on General Relativity - the closest we have to a standard theory of gravitation - does not adequately describe our universe without the ad hoc introduction of dark matter and dark energy to late-time cosmology and inflation to early-universe cosmology. This certainly has created dilemmas in cosmology, and the wider astronomy community and several alternative models of cosmology and gravitation are being considered at the moment. Here I will give a brief overview of the cosmological dynamics of the Rh=ct universe in the framework of non-standard forms of matter and gravitation.

Student award:

N/A

Level for award:

N/A

Astrophysics & Space Science / 32

Stochastic differential equations as a powerful numerical tool

Author: Du Toit Strauss[1]

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

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Often, for different astro- and space physics applications, a Fokker-Planck type diffusion-convection equation must be solved to obtain the particle distribution function. The complexity of the problem generally requires a numerical solution in multiple dimensions. In this talk we discuss the use of stochastic differential equations (SDEs) to numerically integrate the 5D (three spatial dimensions, energy, and time) Parker transport equation for cosmic rays propagating through the turbulent interplanetary medium. We introduce this numerical approach and focus on the so-called time-backward approach which is much more efficient for certain test-particle applications. Selected results are presented where we emphasise the ability of the SDE approach to provide additional insight into the physics of particle transport.

Student award:

N/A

Level for award:

N/A

Physics of Condensed Matter and Materials / 34

Characterization of defects in Ar+ implanted ZnO semiconductor using positron annihilation technique

Author: Musawenkosi Khulu[1]

Co-authors: Thulani Jili [1]; Morgan Madhuku [2]; Cebo Ndlangamandla [1]

[1] *University of Zululand*

[2] *iThemba LABS*

Corresponding Author: musakhulu.mk@gmail.com

Defects investigations were carried out in wurzite ZnO of space group P6_3mc, which were generated by 150 keV Ar+ ions during the implantation with fluencies from 10^4 to 10^16 cm-2. RBS technique was used to determine which elements are in the sample after implantation and X-ray diffraction was utilized to determine the presence of phase change or structural damage or both that might have occured during the implantation process. Local density approximation (LDA) and generalized gradient approximation (GGA) models were employed to theoretically determine the corresponding S-parameters., Thereafter, Doppler broadening of the annihilation centroids were obtained and S-parameters ranging from 0.35975 to 0.38995 at different fluences were then determined. Theoretical values agree with the experimental values. The theoretical positron lifetimes calculation through GGA suggests the formation of Zn+ vacancies.

Student award:

Yes

Level for award:

MSc

Applied Physics / 35

High order stabilized finite elements for gas dynamics

Author: Musawenkosi Khulu[1]

Co-author: Sibisiso Mabuza [2]

[1] *University of Zululand*

[2] *Clemson University*

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We considering the Euler equations in one dimension. The system is discretized in space using an arbitrarily high order Bernstein finite element scheme. In time, the equations are discretized using a high order implicit or explicit Runge-Kutta time stepper. To deal with shocks and spurious oscillations in the numerical solution, stabilization, in the form of algebraic flux correction is introduced to the method. The flux corrected transport method here consists of a low order local extremum diminishing part and a constrained antidiffusive part. The low order part is based on a either a scalar Rusanov diffusion operator computed from the maximum propagation speed or a coupled Roe diffusion operator. Mass conservative mass lumping is also performed on the time derivative term of the system. The antidiffusive part is the difference between the low order part and the original Galerkin discretization of the equations. This is scaled element-wise such that in the vicinity of steep fronts the low order stable solution is returned and in smooth regions the original Galerkin scheme is realized. Challenging shock problems such as the Sod test tube problem and Woodward Colella are considered. A linear waves tests is used to demonstrate the numerical convergence of the method.

Student award:

Yes

Level for award:

MSc

Astrophysics / 36

Cosmological perturbations of interacting dark fluid models

Author: BONANG GEORGE MBEWE[1]

[1] *NORTH WEST UNIVERSITY*

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Astronomical data show that the observed universe is dominated by the dark sector, which is comprising of dark matter and dark energy. Since most of the existing work in the literature is limited to the study of background cosmological dynamics, the project studies late time cosmology where the universe is filled with dark fluids, namely dark matter and dark energy interacting with each other. The equations that govern the evolution of cosmological pertubations of viscous dark fluids will be derived and analysed to see if the theory explains the structure formation of the universe. In the above-mentioned case different models will be investigated namely little rip, pseudo rip and bounce cosmology models.

Student award:

Yes

Level for award:

MSc

Astrophysics / 38

Probing 2HDM+S with MeerKAT Galaxy Cluster Legacy Survey

Authors: Natasha Lavis[1]; Geoff Beck[2]

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[2] *University of Witwatersrand*

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Dark matter is believed to constitute the majority of the matter content of the universe, but virtually nothing is known about its nature. Physical properties of a candidate particle can be probed via indirect detection by observing the decay and/or annihilation products. While this has previously been done primarily through gamma-ray studies, the increased sensitivity of new radio interferometers means that searches via the radio bandwidth are the new frontrunners. MeerKAT's high sensitivity, ranging from 3 μJy beam^{-1} for an 8 arcsecond beam to 10 μJy beam^{-1} for an 15 arcsecond beam, make it a prime candidate for radio dark matter searches. Using MeerKAT Galaxy Cluster Legacy Survey (MGCLS) data to obtain diffuse synchrotron emission within galaxy clusters, we are able to probe the properties of a dark matter model. In this work we consider both generic WIMP annihilation channels as well as the 2HDM+S model. The latter was developed to explain various anomalies observed in Large Hadron Collider (LHC) data from runs 1 and 2. The use of public MeerKAT data allows us to present the first WIMP dark matter constraints produced using this instrument.

Student award:

Yes

Level for award:

MSc

Photonics / **39**

Investigating Two-Mode Mode Diversity with Laguerre-Gaussian and Hermite-Gaussian Modes

Author: Alice Drozdov[None]

Co-author: Mitchell Cox [1]

[1] *University of the Witwatersrand*

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One of the main effects of turbulence on higher order modes used within Free Space Optical systems is crosstalk between neighbouring modes, which in turn causes Mode Dependent Loss (MDL) and generally reduces the capacity of communication systems using multiplexing. Nevertheless, crosstalk could also be used for "energy conservation" within a system. This so-called mode diversity could help reduce MDL and improve the resilience of a system in turbulence. Rudimentary mode diversity using Orbital Angular Momentum modes has indeed been shown to minimise MDL. Could the use of other higher order mode sets also lead to improved mode diversity systems? In this presentation the use of Laguerre-Gaussian (LG) and Hermite-Gaussian (HG) modes are investigated in two-mode mode diversity systems. Modes with both unnormalized and normalised second moment radii are investigated and the combinations of modes which provide the highest received power are found by examining the modal decompositions of modes within both mode diversity systems and systems involving single modes. It is shown that for both LG and HG modes with unnormalized radii the maximum power is received for a given mode when a Gaussian beam is sent with the mode, however, for modes with normalised radii the maximum power is received when adjacent modes are sent.

Student award:

Yes

Level for award:

MSc

Astrophysics / **40**

Modelling the multi-wavelength Non-thermal Emission of AR Sco

Author: Louis Du Plessis[1]

Co-authors: Christo Venter [2]; Zorawar Wadiasingh [3]; Alice Harding [4]

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AR Sco is a binary system that contains both a white and red dwarf. The spin rate of the white dwarf has been observed to slow down with time, analogous to rotation-powered radio pulsars; it has thus been dubbed a "white dwarf pulsar". We previously fit the traditional radio pulsar rotating vector model to linearly polarized optical data from this source, constraining the system geometry and white dwarf mass. Next, using a much more extensive dataset from the South African Astronomical Observatory (SAAO) HIPPO Polarimeter on their 1.9-m telescope, we also explored the application of the same geometric model to the orbitally phase-resolved optical polarimetric data. These are thought to be the result of non-thermal synchrotron radiation. We constrained the magnetic inclination angle and the observer angle at different orbital phases. Now, we have constructed a much more sophisticated emission model, solving the particle dynamics from first principles, including a generalized radiation reaction force, and implementing similar techniques to what were used in a pulsar emission code developed by A.K. Harding and collaborators to produce sky maps, light curves and spectra. We present the first results of single-particle spectra and light curves, as well as studying the difference of using generalized dynamical equations vs. a super-relativistic approximation only. Finally, we obtain a magnetic mirror scenario, similar to that of Takata et al. (2017), and show the importance of not being constrained by assumptions of super-relativistic particles and small pitch angles.

Student award:

Yes

Level for award:

PhD

Poster Session / **41**

Comparative study of the isoscalar giant monopole resonance in ^{58}Ni and analysis of its fine structure

Author: Armand Bahini[1]

Co-authors: Iyabo Usman [2]; John Carter [3]; Peter von Neumann-Cosel [4]; Retief Neveling [5]; N. N. Arsenyev [6]; Philip Adsley [7]; Nolan Botha [3]; J Brummer [8]; Lindsay Donaldson [9]; SANDILE JONGILE [10]; Charmane Khumalo [5]; Mouftahou Latif [11]; Kevin Li [12]; Phumzile Mabika [13]; Pheladi Molema [14]; Chané Simone Moodley [3]; Sunday Olorunfunmi [15]; Paul Papka [16]; Luna Pellegri [17]; Bernadette Rebeiro [13]; ELIAS SIDERAS-HADDAD [3]; Frederick David Smit [5]; Smarajit Triambak [13]; JJ van Zyl [18]

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[12] *Stellenbosch University, iThemba Labs*

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Background: Inelastic α-particles scattering at energies of a few hundred MeV and very-forward scattering angles including 0° has been established as a best tool for the study of the isoscalar giant monopole (IS0) strength distributions in nuclei across the periodic table. The present study describes a systematic investigation of the fine structure of the IS0 resonance in ^{58}Ni.

Objective: This work aims to extract the IS0 strength distributions and analysis of their fine structure in the energy region of the isoscalar giant monopole resonance (ISGMR).

Methods: The ISGMR was excited in ^{58}Ni using α-particle inelastic scattering measurements acquired with an $E_\alpha = 196$ MeV beam at scattering angles $\theta_{\text{Lab}} = 0^\circ$ and 4°. The K600 magnetic

spectrometer at iThemba LABS was used to detect and momentum analyse the inelastically scattered α particles. An experimental energy resolution of $\approx$ 70 keV (FWHM) was obtained, revealing fine structure in the excitation-energy region of the ISGMR. The IS0 strength distributions in the nuclei studied were obtained with the Difference-of-Spectrum (DoS) technique. Further, the extraction of characteristic energy scales from the fine structure observed in the IS0 strength distributions was performed using the technique of Continuous Wavelet Transform (CWT). The theoretical comparison is based on the phonon-phonon coupling (PPC) model where the calculation of the single spectrum and the parameters of the residual interaction are done with the Skyrme forces f^{-}.

Results: IS0 strength distributions for ^{58}Ni are extracted and compared to previously published results from experiments performed at 240 MeV incident energy at the Texas A&M University (TAMU) and from experiments performed at 386 MeV incident energy at the Research Center for Nuclear Physics (RCNP). With some exceptions, a reasonable agreement is obtained. Wavelet-analysis techniques are used to extract characteristic energy scales of the fine structure of the ISGMR from the experimental data. Comparisons with the PPC predictions provide insight into the damping mechanisms of the ISGMR.

Conclusions: Fine structure in the energy region of the ISGMR is observed and may arise from coupling to collective phonons and the non-harmonicity owing to interactions among phonons.

Student award:

No

Level for award:

N/A

Poster Session / **42**

Sol-gel derived and electrospun mesoporous TiO2 nanoparticles: Effects of calcining temperature on the structure, morphology and surface area

Authors: Dieketseng Tsotetsi[None]; Pontsho Mbule[None]; Mokhotjwa Dhlamini[None]

Corresponding Author: dieketsengklara96@gmail.com

We synthesized and electrospun mesoporous titanium dioxide (mp-TiO2) particles followed by calcination at 350 oC, 450 oC and 550 oC for 4 hours. Structure, morphology, porosity and optical properties were subsequently analyzed. X-ray diffraction (XRD) analysis revealed anatase and rutile phases of mp-TiO2, observed at calcining temperature of 450 oC and 550 oC, whereas as-prepared and mp-TiO2 calcined at 350 oC showed an amorphous-like structure. Mesoporous spherical particles were observed for as-prepared sample, however, upon calcination an interconnected network of porous particles were observed. Nitrogen adsorption – desorption isotherms showed increased pore size with an increase of calcining temperature and was found to be 17.78 nm at 550 oC. Relatively higher surface area shown by Brunnauer–Emmet–Teller (BET) was increased with a decrease of particle size for a sample calcined at 450 oC and was 31.39 m2/g which suggests more surface active sites for the adsorption of molecules for improved photon absorption in perovskite solar cells. The bandgap estimation was found to be ~3.08 eV for mp-TiO2, then upon combination with methyl ammonium lead iodide (MAPbI3), a perovskite material, approximately 2.99 eV, 2.87 and 2.99 eV bandgap values were obtained for as-prepared mp-TiO2, calcined samples at 450 oC and 550 oC, respectively. This indicate lower electron-hole recombination rates and these results correspond to Photoluminescence (PL) analysis where we observed that there is an improved charge transfer between mp-TiO2 and MAPbI3.

Student award:

yes

Level for award:

PhD

Photonics / **43**

Effect of nanoparticle geometry on photon statistics

Authors: Luke Ugwuoke[1]; Luke Ugwuoke[2]

Co-author: Mark Tame [1]

[1] *Department of Physics, Stellenbosch University*

[2] *Stellenbosch University*

Corresponding Authors: wal.chinedu@gmail.com, u18198432@up.ac.za

A non-perturbative quantum plasmonics study of the geometry-dependent light scattering by a metamolecule weakly-driven by a plane-polarized electric field is presented. The metamolecule consists of a CdSe semiconductor quantum dot coupled to a gold nanoparticle. We show that at the Fano-dip, the delay time where scattered photons are anti-bunched diminishes as the nanoparticle geometry is tuned from prolate to oblate to spheric at constant particle volume. This is due to the geometry-dependent localized surface plasmon resonance and quantum dot-nanoparticle coupling.

Student award:

No

Level for award:

N/A

Photonics / **44**

PBM at 660 nm reduces stress induced apoptosis in diabetic wounded fibroblast cells in vitro

Author: Sandy Jere[1]

Co-author: Nicolette Houreld [1]

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Uncontrolled diabetes mellitus (DM) increases reactive oxygen species (ROS) and oxidative stress. Oxidative stress provoke apoptosis, a programmed cell death which typically sustains the developmental mechanism for normal body homeostasis. Oxidative damage affects the expression of pro-apoptotic proteins and anti-apoptotic proteins including caspases and B cell lymphoma 2 (Bcl-2). Uncontrolled apoptosis is one of the major causes for the development of chronic diabetic wounds. Photobiomodulation (PBM) requires exposing wounds to lasers or light emitting diodes (LED) to induce healing. However, its protective mechanisms and ideal protocol on cellular apoptosis remain unclear. In this investigation, WS1 skin fibroblast cells were split in to diabetic (D) and diabetic wounded (DW) cell models, and were subjected to a continuous wave diode laser at a wavelength of 660 nm and a fluence of 5 J/cm^2. Non-irradiated (0 J/cm^2) were used as control. After irradiation, cells were incubated for 48 h, and were evaluated for viability, activity of caspase 3 and apoptosis. PBM at 660 nm significantly increased cellular viability, and reduced the activity of caspases 3 in both irradiated D and DW cells. This study suggests that PBM at 660 nm and 5 J/cm2 increases cell viability and reduces apoptosis.

Student award:

No

Level for award:

NA

Plenary 4 - Astrophysics and Space Science / 45

The past, present and future of the Space Agency in Hermanus

Author: Dr. Lee-Anne McKinnell[1]

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In 2021 the South African National Space Agency (SANSA) celebrated 80 years of Magnetic Observations in Hermanus as well as 10 years as part of the national Space Agency. The SANSA Hermanus campus has grown significantly over the past few years in both infrastructure and expertise. However, it should always be remembered that the foundation upon which the success of today has been built comes from the operations of the facility on magnetic principles. And these principles are embedded in a knowledge of Physics. Today SANSA Hermanus is a leading Space Physics institute that utilizes the research to operations value chain to provide products and services in Magnetic Technology and Space Weather. The last 3 years have been especially significant for the facility as SANSA has implemented the growth strategy to be the leading space weather information provider in Africa. This presentation will explore how the past 81 years has laid the foundation for the Space Agency to become a leading institute on the international stage. The growth strategy that includes the new Space Weather Centre will be shared and how humble beginnings has led to international scientific recognition.

Student award:

No

Level for award:

N/A

Physics of Condensed Matter and Materials / 46

Transition Metal Carbonate Precursors as Cathode Materials for Li-ion Batteries: Computational and Experimental Study

Author: Mogahabo Morukuladi[1]

Co-authors: Cliffton Masedi ; Noko Ngoepe ; Phuti Ngoepe

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The development of next generation cathode materials for lithium-ion batteries (LIBs) is critical to enable full implementation of energy storage into a grid and transportation sectors. The most common cathodes in today's LIBs are transition metal oxides with compositions LiNiaMnbCocO2 (referred to as NMCs). As a demand for new and improved technology continues to grow, critical factors such as cost and safety begin to play a significant role in lithium-ion batteries. Therefore, lithium and manganese-rich compounds are highly commended as sustainable candidates for the next generation of cathode materials due to their inherent safety, low cost and high reversible capacities of >250mAh/g. The electrochemical performances of these compounds depends mainly on the physical properties of the precursor materials. Precursors for NMC cathodes are generally synthesized via co-precipitation method. The two most common methods to synthesize precursors are carbonate co-precipitation and hydroxide co-precipitation. However, for this study carbonate co-precipitation method will be used to synthesize precursors because it is capable of keeping the valence state of 2+ for Mn-rich stable throughout the process. Cluster expansion methods were employed to determine the phase stability of Ni1-xMnxCO3 structures using the Universal Cluster Expansion (UNCLE) code. From the generated phase stability we further chose the stable structures and performed their preliminary first-principles density functional theory (DFT) calculations to investigate the structural, electronic and mechanical properties for transition metal carbonate using Vienna ab-initio simulation package (VASP) code. We further synthesized the Mn-rich transition metal carbonate precursors using the carbonate co-precipitation method whereby the tap density, morphology and particle growth for Mn-rich transition metal carbonates were calculated. Keywords: Binary diagrams, electronic stability, mechanical stability, vibrational stability, morphology and particle growth.

Student award:

Yes

Level for award:

PhD

Nuclear, Particle and Radiation Physics / 48

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

Author: Sukanya Sinha[1]

Co-author: Deepak Kar [2]

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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 mostly an unexplored domain within ATLAS. In this talk, I will discuss the public results of the first t-channel ATLAS search for semi-visible jets, that focussed on overcoming 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.

Student award:

Yes

Level for award:

PhD

Nuclear, Particle and Radiation Physics / 49

Burn-in testing of the ATLAS Tile-calorimeter Phase-II low-voltage power supply transformer-coupled buck converters

Author: Ryan Mckenzie[1]

Co-authors: Roger van Rensburg [2]; Edward Nkadimeng [2]

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The start of the operation of the High Luminosity LHC (HL-LHC) is planned for the year 2029. The associated increase in luminosity provides an opportunity for further scientific discoveries as well as many technical challenges. The HL-LHC environment has necessitated the Phase-II upgrade of the ATLAS hadronic Tile-Calorimeter. The upgrade will take place during the long shutdown from December 2025 up until the beginning of 2029. It will encompass the replacement of both on- and off-detector electronics. The on-detector readout electronics of the Tilecal are powered by Low-Voltage Power Supplies (LVPS) which contain transformer-coupled buck converters known

as Bricks. These Bricks function to step-down bulk power received from off-detector to the power required by the local circuitry. A Brick failure will result in the front-end electronics to which it supplies power being offline for a commensurate time. Therefore, the reliability of the LVPS Bricks is of the utmost importance. To ensure the reliable operation of the Bricks once on-detector a quality control procedure will be implemented which includes Burn-in testing. Burn-in testing is a form of accelerated aging of electronic components which functions to improve the reliability of the Bricks once on-detector. The Burn-in procedure results in components that would fail prematurely within TileCal failing within the Burn-in station, thereby allowing for their replacement. The development of the Burn-in station as well as the Burn-in procedure that it employs will be explored with the presentation culminating in the Burn-in results of the latest LVPS prototypes produced.

Student award:

Yes

Level for award:

PhD

Applied Physics / **50**

A Nonlinear Logistic Regression Model for the Measurement of Drug Potency in Photodynamic Therapy

Authors: Elvin Chizenga[1]; Heidi Abrahamse[None]

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Medical physics has revolutionized how cancer is diagnosed and treated. From imaging to therapy, the principles of physics have shown the inseparable relationship with biological systems. One such example is Photodynamic Therapy (PDT), a therapeutic modality that uses light to kill cancer by means of a photochemical reaction that is initiated when a photosensitizer (PS) molecule absorbs a photon of light to become phototoxic. Like all other therapies, the potency of PDT has to be determined before confirming its usage. Many PSs are available, some are being investigated and yet more will emerge in future. To measure the therapeutic potency of these PSs in PDT therefore, a good model and technique for the accurate measurement of potency is indispensable. Unlike most therapies, where a single drug causes effect, in PDT there are two input variables to produce a response, the PS and the light. A design for accurate estimation of PDT potency was therefore developed in this present investigation, using regression analysis of the proliferation of cells treated with PDT. A cancer cell line, SiHa cells, was cultured and treated with serially diluted PS concentrations for treatment at two different laser fluences. Using nonlinear regression, the dose response curve was fitted and the half growth inhibition (GI50) value was calculated using an adjusted Four Parameter Logistic (4PL) Model. This work has since provided guiding principles for the accurate estimation of PDT potency for early stage PDT investigations, and includes theoretical considerations for the accurate estimation of the GI50 value.

Student award:

Yes

Level for award:

PhD

Nuclear, Particle and Radiation Physics / **51**

The isoscalar giant monopole resonance in the Ca isotope chain

Authors: Retief Neveling[1]; Sunday Olorunfunmi[2]; John Carter[3]; Peter Neumann-Cosel[4]; Iyabo Usman[5]; Philip Adsley[6]; Armand Bahini[7]; LPL Baloyi[8]; J Brummer[9]; Lindsay Donaldson[10]; Harshna Jivan[3]; N.Y. Kheswa[1]; Kevin Li[11]; Daniel Marin-Lambarri[12]; Pheladi Molema[13]; Chané Simone Moodley[3]; George O Neill[12]; Paul Papka[14]; Luna Pellegri[15]; Vicente Pesudo[12]; ELIAS SIDERAS-HADDAD[3]; F.D. Smit[1]; Deoin Steyn[1]

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Interest in the evolution of the isoscalar giant monopole resonance (ISGMR) within the calcium isotope chain follows from a 2017 study which suggests that the monopole resonance energy, and thus the incompressibility of the nucleus KA, increase with mass. In 2020 a different group reported a weak decreasing trend of the energy moments, resulting in a generally accepted negative value for Kτ, which is the asymmetry term in the nuclear incompressibility.

We provide an independent measurement of the ISGMR in the Ca isotope chain to gain a better understanding of the origin of the different systematic trends. Inelastic scattering of 196 MeV α particles from a range of calcium targets 40,42,44,48Ca, observed at small scattering angles, including 0°, were momentum analyzed in the K600 magnetic spectrometer at iThemba LABS, South Africa. Monopole strengths spanning an excitation-energy range 9.5 - 25.5 MeV were obtained using the difference-of-spectra (DoS) technique, adjusted to correct for the variation of the angular shape of the sum of the L>0 multipoles as a function of excitation energy, and compared with previous results that employed multipole-decomposition analysis (MDA) techniques.

It was found that the structure of the E0 strength distributions of 40,42,44Ca agrees well with the results from the previous measurement that supports a weak decreasing trend of the energy moments, while no two datasets agree in the case of 48Ca. Despite the variation in the structural character of the E0 strength distribution from the different studies we find, within the excitation-energy range that covers the resonance peak, fair agreement between moment ratios of specific isotopes from different studies. And while it is difficult to identify from the moment ratio calculation in this excitation energy range a clear systematic trend as a function of mass, it appears as if different mass trends previously observed for the nuclear incompressibility are caused by contributions to the measured strength distribution outside of the region defined by the peak of the resonance, and in particular for high excitation energies. While procedures exist to identify and subtract instrumental background, more work is required to characterize and subtract continuum background contributions at high excitation energies, to ensure that the measured strength distributions from this work as well as earlier studies only represent ISGMR.

Student award:

No

Level for award:

N/A

Nuclear, Particle and Radiation Physics / 52

Studying the Production of a Singlet Scalar at Future e+ e- Colliders with Deep Neural Networks

Author: Anza-Tshilidzi Mulaudzi[1]

Co-authors: Bruce Mellado [1]; Mukesh Kumar [1]; Abhaya Kumar Swain [1]; XIFENG RUAN [2]

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Motivated by the multi-lepton anomalies, a search for narrow resonances with S ⟶ γγ, Zγ in association with light jets, b-jets, or missing transverse energy was reported in arXiv:2109.02650. The global significance of the excess at 151.5 GeV is 4σ, where the combination with the multi-lepton anomalies gives a significance much larger than 5σ. In this paper, the final states that are considered are the l+ ν j j γ, l- ν j j γ and j j j j γ and we use machine learning tools to determine the final state with the most significance. A classification model is developed in order to distinguish between the signal and background processes through the use of a Deep Neutral Network (DNN) which is constructed using a dataset that consists of the energy, the pseudo-rapidity, and azimuthal angle for each of the particles in each final state. The parameters of the DNN are tuned using a hyperparameter optimisation algorithm so that the convergence of the receiver operating characteristic (ROC) curve is achieved.

Student award:

Yes

Level for award:

MSc

Nuclear, Particle and Radiation Physics / 53

Growing evidence of new bosons at the LHC

Author: Bruce Mellado[1]

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Particle Physics today displays a growing number of anomalies that cannot be explained by the Standard Model. Some of these anomalies are related to New Physics via quantum corrections. Other anomalies may be connected with the decay of new particles. This is the case the multi-lepton (electrons and muons) anomalies at the LHC. 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. The internal consistency of these anomalies and their interpretation in the framework of a simplified model are presented, where the inconsistency of the data with the SM is more than 8 sigma. This points towards the existence of a new scalar S with a mass in the range 130-170 GeV produced from the decay of a heavier new scalar H. Motivated by this, a search for narrow resonances with S->gamma gamma, Zgamma in association with light jets, b-jets or missing transverse energy is performed. Using a simplified model, the maximum global significance of about 4 sigma is achieved for mS=151.5 GeV. Combined with the multi-lepton anomalies the significance far surpasses 5 sigma. The potential connection of these excesses with other anomalies will be discussed as well.

Student award:

No

Level for award:

N/A

Theoretical and Computational Physics / 54

The QCD Equation of State in Small Systems

Author: William Horowitz[1]

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Multiparticle correlations measurements in even the smallest collision systems are consistent with predictions from viscous relativistic hydrodynamics calculations. However, these hydrodynamics calculations use a continuum extrapolated—i.e. infinite volume—equation of state. For the modest temperature probed in these small collisions, the controlling dimensionless product of the temperature and system size T*L ~ 400 MeV * 2 fm / 197 MeV fm ~ 4 is not particularly large. One should therefore investigate the small system size corrections to the equilibrium QCD equation of state used in modern viscous hydrodynamics simulations.

We present first results on just such finite system size corrections to the equation of state, trace anomaly, and speed of sound for two model systems: 1) free, massless scalar theory and 2) quenched QCD with periodic boundary conditions (PBC). We further present work-in-progress results for quenched QCD with Dirichlet boundary conditions. We show that free, massless scalar fields, which are maximally sensitive to the finite size box, deviate enormously from their infinite volume conformal limit. Quenched QCD with PBC show corrections of ~20% for the trace anomaly near the phase transition. These corrections are more modest, but will have a meaningful, quantitative impact on the extracted bulk and shear viscosities in these small systems.

This presentation is based on Mogliacci et al., Phys.Rev.D 102 (2020) 11, 116017 [arXiv:1807.07871] Kitazawa et al., Phys.Rev.D 99 (2019) 9, 094507 [arXiv:1904.00241] Horowitz and Rothkopf, in progress

Student award:

No

Level for award:

N/A

Physics of Condensed Matter and Materials / 55

Non-Specialist Lecture: Neutron scattering prospects at the new Multi-Purpose Reactor

Authors: Jeetesh Keshaw[1]; Andrew Venter[2]

[1] *Department of Mineral Resources and Energy*

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Corresponding Author: jkeshaw@gmail.com

The SAFARI-1 Research Reactor is a flagship nuclear facility with exemplary operational, maintenance and management records. Notwithstanding its commissioning stemming from 1965, that classifies it as one of the oldest large research reactors in the world, it occupies high international stature as a prominent producer of medical radioisotopes in conjunction with Necsa business units. To sustain these capabilities and expertise, a project for its replacement with a Multi-Purpose Reactor has high prominence and momentum. This brings with it the prospect of expanded utilisation into fields of scientific and industrial research, primarily through various neutron scattering techniques. Research reactors with dedicated neutron scattering centres feature thermal and cold neutron beams that facilitate research of matter at the atomic level with applications transgressing many scientific and engineering disciplines in material science, physics, chemistry and biology. This report presents the development of the Multi-Purpose Reactor project, featuring neutron scattering facilities as a prominent entity to bring modern world-class large-scale research in-

frastructure to the benefit of academic and industrial research communities through an active User Access program. Intensive stakeholder engagement is inherent to the process to determine priorities with the instrument suite selection.

Student award:

No

Level for award:

N/A

Astrophysics / **56**

Parametric Spectral and Light Curve Modelling of Gamma-ray Millisecond Pulsars

Authors: Hend Hamed[1]; Christo Venter[2]; Isabelle Grenier[3]; Alice Harding[4]; Anu Kundu[5]; Zorawar Wadiasingh [6]; Constantinos Kalapotharakos[7]

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Millisecond pulsars (MSPs) are a class of pulsar with fast spin periods (<30 ms) and relatively low surface magnetic fields (~10^9 G). The *Fermi* Large Area Telescope (LAT) has detected gamma rays from more than 275 pulsars over the past 14 years, with over 125 being MSPs. Capitalising on this substantial growth in the population of detected gamma-ray MSPs that now includes bright pulsars with high-quality spectra and light curves, we aim to uncover new and confirm tentative trends among key quantities by using the latest data from the Third *Fermi* Pulsar Catalog (3PC). Specifically, we will perform phase-resolved spectroscopy for more than 25 bright MSPs. As a first step, we will conduct parametric fitting of GeV spectra and light curves in order to isolate morphological features (such as main peaks, inter-peak bridge emission, and local maxima) and then define relevant phases relating to these features for follow-up spectral analysis. This will allow us to probe the spectra relating to the distinct light curve features, informing subsequent modelling of the MSP emission processes and possible new trends.

Student award:

No

Level for award:

N/A

Photonics / **58**

Antiproliferative and Cytotoxicity Effects of Aluminium (III) Phthalocyanine Chloride Tetra Sulphonic Acid Mediated Photodynamic Therapy on Oesophageal Cancer

Authors: Onyisi Christiana Didamson[1]; Rahul Chandran[2]; Heidi Abrahamse[3]

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Oesophageal cancer is an aggressive and lethal malignancy accounting for the eighth leading cause of cancer and sixth cause of cancer-related death globally. Conventional treatments for oesophageal cancer are characterised by suboptimal efficiency resulting in treatment resistance and relapse. Photodynamic therapy (PDT), a non-invasive modality, has emerged as a potential alternative cancer therapy. Report has shown that aluminium (III) Phthalocyanine Chloride Tetra sulfonic Acid (AlPcS4Cl) is a promising photosensitiser in PDT owing to its photochemical and photophysical features. This study examined the antiproliferative and cytotoxic impacts of AlPcS4Cl-mediated PDT in an oesophageal cancer cell line (HKESC-1). The HKESC-1 cells were grown and maintained in a culture medium incubated at 37° C, with 5% CO2 and 85% humidity. The cells were treated with increasing dose concentrations of AlPcS4Cl and irradiated at a fluence of 5 J/cm2 using a diode laser at 673.2nm wavelength. The cellular activities following 24-hours post-PDT were evaluated using microscopy and biochemical tests to determine the response of HKESC-1 cells to treatments. Results from treated cells displayed a dose-dependent response as shown by the significant morphologic changes, increased cytotoxic damage, and reduced cell viability and proliferation. Fluorescent microscopy revealed that AlPcS4Cl was internalised in the mitochondria and lysosomes, suggesting the possible cell death pathways. The study showed that AlPcS4Cl mediate PDT is an efficient treatment modality for oesophageal cancer. Further research on the mechanism of cell death pathways in oesophageal cancer could enhance and translate the potential application of AlPcS4Cl mediated PDT of cancer in clinical settings.

Student award:

Yes

Level for award:

PhD

Nuclear, Particle and Radiation Physics / **59**

Evaluation and Optimisation of a Generative-Classification Hybrid Variational Autoencoder in the Search for Resonances at the LHC

Author: Finn Stevenson[1]

Co-authors: Benjamin Lieberman [1]; Xifeng Ruan [1]; Abhaya Swain [1]; Salah-Eddine Dahbi [1]; Bruce Mellado [1]

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The Standard Model (SM) of particle physics was completed by the discovery of the Higgs boson in 2012 by the ATLAS and CMS collaborations. However, the SM is not able to explain a number of phenomena and anomalies in the data. These discrepancies to the SM motivate the search for new bosons. In this paper, searches for new bosons are completed by looking for Zgamma resonances in $Z\gamma$ ($pp \rightarrow H \rightarrow Z\gamma$) fast simulation events. This research makes use of a Variational Autoencoder (VAE), in the search for new bosons. The functionality of a VAE to be trained as both a generative model and a classification model makes the architecture an attractive option for aiding the search. The VAE is used as a generative model to increase the amount of $Z\gamma$ fast simulation Monte Carlo data whilst simultaneously being used to classify samples containing injected signal events that differ from the Monte Carlo events on which the model was trained. This presentation concentrates on the final evaluation and optimisation of the VAE for both generative and classification purposes.

Student award:

Yes

Level for award:

MSc

Photonics / 60

Comparison of modelling and measurements of resonance laser ionisation of zinc isotopes

Author: Christine Steenkamp[1]

Co-authors: Andre de Bruyn [2]; Anton du Plessis [3]; Erich Rohwer [1]

[1] *University of Stellenbosch*

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Pure isotopes of zinc find application in the production of radiopharmaceuticals for medical diagnostic scans (68-Zn and 67-Zn). Enrichment processes relying on mass differences do not produce products of sufficient purity for medical applications, therefore resonance laser ionisation is a potential final step in the purification process. An experimental setup for resonance laser ionisation of zinc vapour, followed by time of flight mass spectrometry was used to investigate a promising ionisation scheme, using both the singlet and triplet energy levels of Zn. It was complemented by the development of a numerical model. The rate equations of Zn are solved in every segment of the sample along the laser beam path, to yield the changes in population of atomic energy levels and the light absorption per segment. Comparison of experimental and model results are presented, as well as extrapolations of model results to long and dense media and high laser power.

Student award:

No

Level for award:

N/A

Photonics / 61

Recombinant Antibody-Conjugated Silver Nanoparticles for Improved Drug Delivery in Photodynamic Therapy for Metastatic Melanoma

Author: Zaria Malindi[1]

Co-authors: Stefan Barth [2]; Heidi Abrahamse [3]

[1] *University of Johannesburg*

[2] *Medical Biotechnology and Immunotherapy Research Unit, University of Cape Town*

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

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Melanoma is the most dangerous skin cancer and is inherently chemoresistant; thus, alternative theranostic strategies are needed for its management. Immunotherapy involves the use of antibody technology to target cancer-associated-antigens; photodynamic therapy (PDT) involves the irradiation of a photosensitiser to generate cytotoxic levels of singlet oxygen and reactive oxidative species; and nanomedicine involves the use of nanomaterial drug delivery systems for enhanced drug biodistribution and uptake. We aim to establish a chemical conjugation model allowing for directional attachment of SNAP-tag-based recombinant antibodies (rAbs) to nanobioconjugates composed of the photosensitiser zinc phthalocyanine tetra-sulphonic acid attached to silver nanoparticles for the photoimmunotheranostic management of melanoma. The initial aim was to express and purify rAbs comprising the anti-CSPG4 mAb9.2.27 single-chain variable fragment (scFv) and the SNAP-tag enzyme and to validate the selective binding of the protein to CSPG4-positive melanoma cells. To accomplish this, HEK293T cells transfected with plasmids containing the mAb9.2.27 scFv and SNAP-tag DNA sequences, co-expressing the green fluorescent protein reporter gene, were used as a transient mammalian vector expression system. Cell culture supernatant containing secreted protein was purified using his6-tag for affinity capture. The protein was then characterised using SDS-PAGE and Western blot, demonstrating retention of functional protein of interest during purification. The rAb was then validated using fluorescent markers to confirm selective binding to target cells. These preliminary results indicate the feasibility of this rAb as a targeting ligand for antibody-mediated nano-PDT against melanoma.

Student award:

Yes

Level for award:

PhD

Physics for Development, Education and Outreach / 62

Language in learning: How far can we teach Physics in isiZulu?

Author: Derek Fish[1]

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The language of learning has long been an important and controversial topic, especially in South Africa with 11 official languages but matric science available in only two of them. The author considered this issue in the refinement of a science show presented at Unizulu Science Centre. The show uses music and musical instruments to introduce students to topics around sound and waves. In previous presentations at SAIP conference, the author has reported on an extensive study of this show (conducted towards a masters degree) which measured what students learnt from the show and which revealed difficulties for students coming from rural schools when contrasted with those from urban and township schools.

As an extension to this study (conducted towards a doctoral degree) the show was presented to the weaker rural group in isiZulu, while the survey instruments used were kept in English. Significant gains in student confidence and learning were measured, compared with that previously achieved by similar rural groups. The author will also report on how these language issues have affected the offline digital video project currently being developed.

While performed in the context of science shows in science centres, this study nevertheless has relevance to all educational interventions in physics. Whatever the challenges, it may be argued that mother-tongue instruction is preferable wherever possible for maximising student understanding and engagement. The implications of these findings for presenting further Physics courses in isiZulu will be outlined for discussion by delegates.

Student award:

No

Level for award:

N/A

Nuclear, Particle and Radiation Physics / 63

Time stability of the response of gap/crack scintillators of the Tile Calorimeter of the ATLAS detector to isolated muons

Author: Phuti Ntsoko Rapheeha[1]

Co-author: Bruce Mellado [2]

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The Tile Calorimeter of the ATLAS experiment at the Large Hadron Collider is a hadronic sampling calorimeter that is designed for the reconstruction of hadrons, jets, tau-particles and missing transverse energy. In this study, the response of the gap/crack scintillators of Tile calorimeter is measured using isolated muons from $W \rightarrow \mu\nu$ events. The response of the scintillating cells is quantified by measuring the amount of energy deposited per unit length in both data and Monte Carlo simulation to evaluate the stability of the response over time to quantify how well the calibration compensates for time-dependent effects of the calorimeter.

Student award:

Yes

Level for award:

PhD

Applied Physics / 64

ATLAS Tile Calorimeter Phase-II upgrade low-voltage power supply production and testing

Author: Edward Nkadimeng[1]

Co-authors: Ryan Mckenzie [2]; Bruce Mellado [3]

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The Large Hadron Collider (LHC) has planned a series of upgrades leading to a High Luminosity LHC (HL-LHC), which would produce five times the nominal instantaneous luminosity of the LHC. The ATLAS Phase II upgrade in 2029, will accommodate the detector and data acquisition system for the HL-LHC. The Tile Calorimeter on- and off-detector electronics will be completely replaced. This is expected to improve the precision of the calorimeter signals used by the trigger system. The ATLAS Low Voltage Power Supply (LVPS) Project is a research and development project that aims to design and manufacture a set of replacement low voltage power supply transformer-coupled buck converter (bricks) to replace an existing design used for the LHC Run-2 period. The latest TileCal bricks are DC-DC converters that take 200V input from the DC power sources and output 10V to the front-end circuits with individual brick control, and radiation hardness. A total of 256 Low Voltage boxes will be put on the detector, with 8 low voltage bricks mounted in each box. Results of the electrical tests of the latest brick prototype will be presented.

Student award:

Yes

Level for award:

PhD

Poster Session / 65

Atomistic simulation studies of binary M9S8 (M=Ir, Rh) and ternary (RuPd)9S8 Pentlandite-like systems

Author: Kgwajana Barnard Molala[1]

Co-authors: M.A Mehlape [1]; P.P Mkhonto [1]; P.E Ngoepe [1]

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Pentlandite (Pn) is an iron nickel sulphite with chemical formula of (Fe,Ni)9S8 and is contained mainly in Merensky Reef (~30%) of Bushveld complex. Pn systems are known to host precious metals in solid solutions or as intergrowths. However, the concentration of the precious metals hosted in the pentlandite structure and the effect of temperature and pressure on Pn-PGEs has not been established. Therefore, the formation of the PGEs in the Pentlandite structure must be explored and could establish new forms of Pentlandite. Pentlandite structures have been studied mostly experimentally but computational studies have been scares. Chauke et al. conducted study on stability of Cobalt pentlandite (Co9S8) and Iron Nickel Pentlandite ((Fe,Ni)9S8) using first principle density functional theory. Moreover, Mehlape investigated various forms of cobalt Pentlandite mineral, (Co9S8) at different temperatures, using classical atomistic simulation methods and found that the melting temperature of Co9S8 was 1300K. In this study, we derived atomic potentials for binary M9S8 (M=Ir, Rh) and ternary Ru5Pd4S8 and Ru5Pd4S8 Pentlandite-like systems, which produced the elastic constants that are in good agreement with ab-inito density functional theory (DFT) results and further conducted the classical atomistic simulation on binary M9S8 (M=Ir, Rh) and ternary Ru5Pd4S8 and Ru5Pd4S8 and found that the melting temperature for binary M9S8 (M=Ir, Rh) and ternary (RuPd)9S8 Pn-like systems 1800K and 1500K respectively.

Student award:

Yes

Level for award:

PhD

Nuclear, Particle and Radiation Physics / 66

Application of semi-supervision learning for the search of new resonances decaying to $Z\gamma$ with topological features

Author: Nalamotse Joshua Choma[1]

Co-authors: Salah-eddine Dahbi [1]; Gaogalalwe Mokgatitswane [1]; Xifeng Ruan [1]; Bruce Mellado [1]

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Deep neural networks have the ability to learn from highly complex data and discover non-linear feature combinations. This makes them a suitable tool to explore the high volumes of data in HEP. This study explores the ability of semi-supervised learning in conjunction with deep neural networks to extract signal from the background in the $Z\gamma$ final state using the Monte Carlo simulated signal samples for 139 fb^{-1} of integrated luminosity for Run 2, collected at the LHC. The approach is adopted with the sole intention of calculating the limit on the production of Higgs-like to $Z\gamma$ where the significance of the signal is maximum.

Student award:

Yes

Level for award:

PhD

Poster Session / 67

In Vitro antiproliferative effects of berberine in phthalocyanine-mediated photodynamic therapy on MCF-7 Breast Cancer Cells with Overexpressed P-Glycoprotein

Author: Alexander Chota[1]

Co-authors: Blassan George [2]; Heidi Abrahamse [3]

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Multidrug-resistance (MDR) is one of the common challenges seen in cancer therapy. This phenomenon has led to the development of novel therapeutic strategies in which chemotherapeutic drugs are administered in combination with photodynamic therapy (PDT). PDT is a two-staged treatment that employs the administration of a photosensitizing agent which is followed by low laser irradiation. In the presence of molecular oxygen, the irradiated photosensitizer (PS) induces the generation of cytotoxic reactive oxygen species that are aimed at destroying precancerous and cancerous cells. This study aimed to assess tumor cell proliferation rates and evaluate the cell death mechanism 24 h post-treatment with the combination of berberine and zinc phthalocyanine tetrasulfonic acid (ZnPcS4) in MDR MCF-7 breast cancer cells with overexpressed P-glycoprotein (P-gp). MDR MCF-7 breast cancer cells will be treated with optimized concentrations of BBR and ZnPcS 4 and later irradiated by using a 680 nm diode laser at a fluency of 10 J/cm 2 . Morphological changes and adenosine triphosphate proliferation will be performed to determine the cytotoxic effect 24 h post treatment. The determined 50 % inhibitory concentration (IC 50) will be used to evaluate cell death mechanisms induced by individual therapies as well as in combination therapy. All experiments will be run 4 times (n=4), and the raw data will be analyzed by using SPSS statistical software version 27 at a 0.95 confidence interval. This study will provide an insight of the therapeutic benefits of combining chemo-toxic and phototoxic drugs in MDR cancer.

Student award:

Yes

Level for award:

PhD

Nuclear, Particle and Radiation Physics / 68

Explaining new type of multi-lepton excesses at the LHC with singlet scalar extended 2HDM model

Author: Abhaya Kumar Swain[1]

Co-authors: Thuso Mathaha [2]; Mukesh Kumar [3]; Bruce Mellado [3]; Xifeng Ruan [3]

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The shortfall of the Standard Model (SM) has led the particle physics community to search for a plethora of physics models beyond the SM (BSM). Owing to many recent studies on multi-lepton final states in proton-proton collisions at the LHC, it has become evident that several anomalous features of the LHC data can be explained through the addition of new scalar bosons to the 2HDM model. The anomalies can be well described by a 2HDM+S model, where the mass of the heavy scalar $m_H \approx 270$\,GeV, the mass of the singlet scalar $m_S \approx 150$\,GeV. In this talk, we will discuss a new set of excesses recently reported by the ATLAS and CMS analyses of multi-lepton final states. Mainly the talk will focus on the CP-odd scalar of the 2HDM+S model and how it can explain those excesses. With the motivation from a number of experimental searches, we have looked at the heavy (pseudo)-scalars in the mass range $400 - 600$\,GeV. The heavy pseudo scalar in this parameter space dominantly decays to ZH and $t\bar{t}$ which then produces four top and four lepton in the final state. Here we will discuss the multi-lepton final state in conjunction with the multi-lepton excesses that are recently observed at the LHC.

Student award:

No

Level for award:

N/A

Poster Session / 70

Facile Zn and Ni co-doped hematite nanorods for efficient photocatalytic water oxidation

Author: Joan Talibawo[1]

Co-authors: Diale Mmantsae [2]; Justine Sageka Nyarige [3]; Marie Chantal Cyulinyana [4]; Pannan Isa Kyesmen [5]

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In this work, we report the effect of zinc (Zn) and nickel (Ni) co-doping of hydrothermally synthesized hematite nanorods prepared on fluorine-doped tin oxide (FTO) substrates for enhanced photoelectrochemical (PEC) water splitting. Seeded hematite nanorods (NRs) were facile doped with a fixed concentration of 3 mM zinc and varied concentrations of 0, 3, 5, 7, and 9 mM of nickel. The doping of the hematite NRs had no noticeable impact on the surface morphologies of all the samples. They demonstrated a largely uniform topology of vertically aligned NRs with slight inclinations. The nanorods showed high photon absorption within the visible spectrum due to their bandgaps which ranged between 1.9 – 2.2 eV. The highest photocurrent density of 0.072 mA/cm2 at 1.5 V vs. RHE was realized for the 3 mM Zn/7 mM Ni co-doped NRs sample. This photocurrent was 279 % higher compared to the value observed for pristine hematite. The Mott-Schottky results reveal an increase in donor density values with increasing Ni dopant concentration. The 3Nm Zn/7mM Ni NRs and 3Nm Zn/9mM Ni NRs samples produced the second-highest and highest donor concentrations of 2.93 and 3.00 × 1019 (cm-3) respectively, which were at least 3.4 times higher than that of pristine hematite. This contributed to the highest photocurrent density obtained for the 3Nm Zn/7mM Ni NRs sample. This work demonstrated the role of Zn and Ni co-dopants in enhancing the photocatalytic water oxidation of hematite nanorods for the generation of hydrogen.

Student award:

Yes

Level for award:

PhD

Nuclear, Particle and Radiation Physics / 71

Comparing $2HDM + S$ and $2HDM + S + N$ models to explain multi-lepton excesses at the LHC

Author: Srimoy Bhattacharya[1]

Co-authors: Andreas Crivellin [2]; Abhaya Kumar Swain [1]; Mukesh Kumar [1]; Xifeng Ruan [1]; Bruce Mellado [1]; Guglielmo Coloretti [3]

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After the discovery of the Higgs boson at the Large Hadron Collider (LHC), the ATLAS and CMS Collaborations have concentrated to confirm its properties via measurements of different couplings, decay width, and differential distributions of relevant observables. In this context, recent studies on multi-lepton final states in poton-proton collisions unfold some deviations from the Standard Model predictions. A plethora of BSM models are being considered in the literature, including additional scalar/vector bosons, fermions or exotic BSM objects to explain these anomalous features of the LHC data. In fact, the existence of non-zero masses for the neutrinos is clearly an interesting BSM scenario that is expected to be studied both at present and future colliders. With this motivation, in this talk, we will compare two different models, containing two new hypothetical scalar bosons, H and S, which can describe those multi-lepton anomalies reasonably well. In the first model, named $2HDM + S$, we consider the neutral scalar H decays into a lighter one S and the SM Higgs h i.e. $H \to Sh$. Secondly, a model with heavy neutrinos N is introduced $(2HDM + S + N)$ where the dominant decay of the heavy higgs $H \to S(\to NN)S^*(\to NN)$ is considered to analyze various multi-lepton final states to explain the excess.

Student award:

No

Level for award:

N/A

Theoretical and Computational Physics / 72

First Principles Study of Vanadium decorated Graphene; effect on hydrogen storage and H2S sensing

Author: El Hadji Oumar Gueye[1]

Co-author: Mmantsae Diale [1]

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We conducted theoretical investigation of the structural and electronic properties of Vanadium-functionalized graphene and its effect on hydrogen storage and H2S sensing. Vanadium (V) was an effective addition required for enhancing the properties of graphene sheet. In fact, we found that up to four H2 molecules could be adsorbed by V-functionalized graphene with an average binding energy between 0.966–0.683 eV. Our calculations predicted that the adsorption energy of H2S molecule near the V/graphene (2.192 eV) is remarkably higher (by ~5.0 times) than that on the pristine graphene (0.490 eV), indicating that Vanadium decoration could significantly enlarge the interactions between adsorbate and adsorbent. Then, our results also predict V-functionalized graphene is a potential hydrogen storage medium and H2S sensing for on-board applications.

Student award:

Yes

Level for award:

PhD

Poster Session / 73

Computational Study on Surface Reconstruction of Co9S8

Author: Nontobeko Zavala[None]

Co-authors: Peace Mkhonro ; Phuti Ngoepe

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The Co9S8 is an important source of cobalt. The milling of the cobalt Co9S8 mineral exposes different surface and as such there are few or one surface that dominates during the crushing. The thermodynamic stable surface is less reactive and is of importance for mineral extraction. Computational method can determine the most stable surface and the preferred cleavage either through reconstruction or perfect surface cleavage. The current study investigates the surfaces of Co9S8 and their reconstruction behaviour using density functional theory (DFT). The relaxed bulk structure was found to have a lattice parameter of a = 9.790 Å, which agrees with experimental value of a = 9.928 Å. The (100), (010), (110), (101) and (111) surface were cleaved from the relaxed bulk structure and those that possessed dipole were reconstructed. The computed surface energies for the un-reconstructed and reconstructed surface showed that the reconstruction results in lower surface energies and therefore stable surfaces. In particular the reconstructed (111) surface was the most stable surface amongst the low miller index surfaces. This was also complimented by the crystal morphology, which displayed the (111) surface as the dominant plane. The study has demonstrated that the Co9S8 mineral preferred to cleave along the (111) surface and in addition showed that the reconstruction of surface is paramount in identifying the preferred mineral cleavage.

Student award:

Yes

Level for award:

Hons

Astrophysics / 74

A Closer Look at Potential Exoplanets Targets from the Nooitgedacht Observatory

Author: Henriëtte Vorster[1]

Co-author: Bruno Letarte [2]

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[2] *Centre for Space Research, NWU*

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Surveys like KELT and TESS searches for transiting extrasolar planets, and have found many potential candidates. The optical telescope at the Nooitgedacht Observatory is ideal for follow-up observations of these candidates, and to collect more data of specific promising candidates. Candidates that are suitable for observations were identified. The suitability of candidates depends on the magnitude of the host star, the decrease in magnitude during the transit, and the angle at which the star is located when the transit begins. From numerous observations, the capabilities of the optical telescope at the Nooitgedacht Observatory are established and refined. The data collected from the suitable candidates was processed using aperture photometry and compiled as a light curve. The light curve was then analyzed to study the transits and compared them to prior data obtained from previous observations. We present the light curve of exoplanet WASP 80-b and conclude that it is the ideal type of exoplanet to observe from the Nooitgedacht Observatory

Student award:

Yes

Level for award:

MSc

Poster Session / 75

Implementation of the LED Integrator panel for the Prometeo system in the ATLAS Tile Calorimeter

Author: Onesimo Mtintsilana[1]

Co-authors: Bruce Mellado [2]; Jalal Abdallah [3]; Pavle Tsotskolauri [4]

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During ATLAS Phase-II Upgrade almost every electronics component of the Tile Calorimeter (TileCal) will be upgraded. The new on-detector readout electronics system requires a new portable system that will certify its correct functionality during the assembly, installation and maintenance periods. Portable readout module for tile electronics (PROMETEO) is an upgrade of the current MobiDICK system that was used to test current electronics during the Long Shutdown 1 and 2. It represents an independent and completely autonomous system that includes all necessary components to verify the correct functionality of TileCal on-detector electronics during assembly, installation and maintenance. PROMETEO must be able to check the following things: connection with mini-drawers (MD), connection with the daughterboard (DB) and the mainboard (MB), photomultiplier tubes (PMT), and many more. In order to check the response of the PMTs to light pulses, an LED system is required to generate light pulses that mimic physics pulses. The LED Integrator panel will be integrated into PROMETEO Graphical User Interface and the purpose of LED light injection is to check entire read-outchain and timing,which includes data from PMTs, FENICS cards, Mainboard, Daughterboard and PPr/CPM. Results will be presented.

Student award:

Yes

Level for award:

PhD

Theoretical and Computational Physics / 76

An Introduction to Lattice QCD: The Metropolis Algorithm and the Anharmonic Oscillator

Authors: Blessed Arthur Ngwenya[1]; William Horowitz[1]; Alexander Rothkopf[2]

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We provide a broad introduction to lattice QCD, which is a non-perturbative technique used to study strongly coupled QCD. Lattice QCD is a regularisation of QCD, where Euclidean space-time is discretised on a hypercubic lattice with spacing a, and the quark fields are placed on sites while gauge fields are placed on the links between these sites, then their interactions are simulated in thermal equilibrium. Lattice calculations require some basic input parameters, and in order to obtain physical results, one has to take the continuum and infinite volume limits. We employ the Markov Chain Monte Carlo (Metropolis) algorithm and present results of the following quantities for the anharmonic oscillator with various quartic couplings; acceptance rates, equilibration times, ground state probability densities compared to Schrodinger solutions, ground state energies and the energy differences of various excited states.

Student award:

Yes

Level for award:

PhD

Astrophysics / 77

Taking the Nooitgedacht telescope to the next level

Author: Rigardt Hug[1]

Co-author: Bruno Letarte [2]

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The Centre for Space Research / Physics group at the NWU has an optical telescope located at Nooitgedacht, a 45min drive from the Potchefstroom campus. Since 1998, it has been used for practical astronomy experiments for undergraduate 3rd-year physics students. Initially a 30cm telescope, it has been upgraded a decade ago to a 40cm telescope. Additionally, the telescope has been used for public outreach activities, and for Hons and MSc projects, including my own. I will describe here what are our plans for this optical telescope, from getting a perfect pointing solution for the telescope, to getting the spectrograph software in working order, and getting the photometric zero points for our CCD camera. This will be presented in the context of the major upgrades happening in 2022 to the site, including a new radio telescope and several space physics instruments, along with major infrastructure upgrades.

Student award:

Yes

Level for award:

MSc

Astrophysics / 78

Primordial Black Holes and the SZ effect

Authors: Justine Tarrant[1]; Geoff Beck[1]

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Primordial black holes are a much-studied candidate for dark matter. In the mass regime where their conjectured Hawking evaporation is significant, they have been subject to many constraints via X-rays, gamma-rays, and even radio emission. Previously the Sunyaev-Zel'dovich effect (SZE) has been considered to place further limits on the primordial black hole abundance via the effects of their accretion of ambient gas. In this work we will present a novel means of placing such limits, using the SZE induced by electrons produced via Hawking radiation in galaxies and galaxy clusters.

Student award:

N/A

Level for award:

N/A

Physics of Condensed Matter and Materials / 79

Media Structured for Nonlinear Optics

Author: Wagner Tavares Buono[1]

Co-author: Andrew Forbes [1]

[1] *University of the Witwatersrand*

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Since the first demonstration of nonlinear optics (second harmonic generation) it is known that it cannot happen in free space: these processes need a medium interaction to happen. It is very common to see lasers with inbuilt frequency conversion enabled by nonlinear crystals. Those crystals, for example, are a medium specifically tailored to maximize the conversion of one specific wavelength into another. This tailoring can go from the microscopic size of the crystal cells to the macroscopic orientation of their cutting angles. In this work we compiled the different materials used to enable nonlinear optical processes and the physical mechanisms that are behind this. We observed that many different media can be used, including sparse gas jets, cold atoms, crystals, metasurfaces, dielectric micro resonators, and many others. These materials present different optical phenomena such as high-harmonic generation, frequency conversion and cross-wavelength modulation. This summary can inspire the development of new structure materials for novel optical devices.

Student award:

No

Level for award:

N/A

Astrophysics / 80

Studying gas flows in the SUNBIRD starburst galaxies and LIRGs

Author: Petro Janse van Rensburg[1]

Co-authors: Moses Mogotsi [2]; Petri Väisänen [2]; Matthew Bershady [3]

[1] *UCT/SAAO*

[2] *SAAO, SALT*

[3] *SAAO, UCT, UW-Madison*

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Gas flows are an important aspect of galactic feedback and the regulation of star formation in galaxies. Nearby starburst galaxies and LIRGs provide an extreme environment where feedback and the changes due to it can be studied in great detail. The aim of my project is to search for traces of outflows and inflows in a sample of nearby starburst galaxies and LIRGs in the SUNBIRD survey, and to characterize them using observations of the stellar, and neutral and ionized gas kinematics. The SUNBIRD survey contains over 40 starburst galaxies and LIRGs. Its science goals are to calculate the total SFR in the nearby universe and to perform an in-depth study of star formation in LIRGs. The relationship between the gas flows, star formation and other galaxy properties will be used to study feedback and the fueling of star formation, which in turn will help us to understand galaxy evolution. As a first step, the gas flows were studied using long-slit spectra from the Southern African Large Telescope. I will present preliminary results from this data. The neutral and ionized gas kinematics can be traced through the NaD absorption lines and Hα emission line, respectively. We modelled the gas with multiple components of Gaussian and Gauss-Hermite functions, and the stellar component was modelled with pPXF. We then compared best-fit models, the gas and stellar kinematics as well as emission-line ratios in order to identify and characterize the gas flows in and around these galaxies.

Student award:

No

Level for award:

N/A

Photonics / 81

Orbital and spin angular momentum interaction in second harmonic generation

Authors: Wagner Tavares Buono[1]; Braian Pinheiro da Silva[2]

Co-authors: Daniel Schneider Tasca [3]; Leonardo Justino Pereira [3]; Khaled Dechoun [3]; Antonio Zelaquett Khoury [3]

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Light can have spin angular momentum (SAM) and orbital angular momentum (OAM). While spin angular momentum is related to circular polarization and can only be either $\hbar$ or $-\hbar$, OAM is related to the vortex phase structure and is equal to l$\hbar$ where l is the number of screw dislocations in the phase profile (or topological charge). In paraxial wave optics these two physical properties are regarded as independent. In this work, we show that is possible to combine these two quantities in the nonlinear regime. We exploit the non-collinear configuration of a type-II second harmonic generation to analyze all possible outputs of this process. We show that the generated beam has OAM equal to the sum of inputs OAM and SAM. This work unveils a novel type of interaction of degrees of freedom of light and we hope it can inspire discoveries of new types of light-matter interaction.

Student award:

No

Level for award:

N/A

Photonics / 82

Fourier Ptychographic Microscopy for high-resolution, large field of view imaging

Author: Eugene Fouche[1]

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

[1] *Stellenbosch University*

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

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Fourier Ptychographic Microscopy (FPM) is an imaging technique that can be used to obtain high-resolution, large field of view images of a sample. The technique is based on acquiring a number of low-resolution, large field of view images and combining them to produce one high-resolution, large field of view image of the sample. This relatively new technique was first described in 2013 . Its key feature is the ability to keep the large field of view offered by a low numerical aperture (NA) objective lens, while at the same time acquiring images with a resolution that is comparable to objective lenses with a much higher NA. In microscopy, there is usually a trade-off between field of view and resolution, but with FPM, we can have both a large field of view and a high resolution. In the reconstruction process, the phase of the sample is also retrieved. The implementation of FPM (using a conventional microscope and a programmable LED array) is relatively simple and cheap, so it is a promising way of increasing imaging performance, without resorting to expensive or complex setups. An overview of FPM and how it relates to other microscopy techniques will be given, providing context and highlighting the advantages offered by FPM. The concept and experimental implementation will be explained, together with results from simulations investigating the recovery process of

the high-resolution image. Additionally, simulation results that demonstrate FPM's ability to correct for aberrations will be shown. These simulations will be complemented with preliminary experimental results.

Student award:

Yes

Level for award:

MSc

Poster Session / 83

Study of systematic uncertainties and spurious signals of resonant $H \to Z\gamma$ production at ATLAS Experiment

Author: Gaogalalwe Mokgatitswane[1]

Co-authors: Nalamotse Joshua Choma [2]; Salah-Eddine Dahbi [3]; Bruce Mellado [4]; Xifeng Ruan [3]

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

[2] *Wits University*

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This work examines the assessment of systematic uncertainties and quantification of probable false signals on the fitting signal yield to Higgs-like production in the $Z\gamma$ final state, where the Z boson decays leptonically. Several sources of systematic uncertainties for the measured observables are considered such as detector systematic uncertainties from detector effects and modelling systematic uncertainties due to modelling of signal and the background processes. To estimate the contribution of each source in the overall uncertainty, large-scale Monte Carlo events simulation has been performed where the events correspond to an integrated luminosity of 139 fb^{-1} dataset recorded by the ATLAS experiment in proton-proton collisions during the LHC Run 2. The study implements a machine learning algorithm approach in the form of a deep neural network classifier response function score cut-based analysis as well as an inclusive analysis.

Student award:

Yes

Level for award:

PhD

Astrophysics / 84

From setting up a new telescope to optimizing astrometric solutions.

Author: Jane Mankhubu Letsoalo[None]

Co-author: Bruno Letarte [1]

[1] *Centre for Space Research, NWU*

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The physics building on the Potchefstroom campus has a new optical telescope on it. It is the old 30 cm that used to be at the Nooitgedacht observatory in 1998. We decided to give it a second life, obtained a new mount and refurbished it for public outreach purposes. This project was to setup a new telescope, from the roof anchoring to the electrical connection, to the balancing and polar alignment . Basically getting all parts, including software to function properly. We are now in the final phase of making this observatory ready for the public. When it comes to scientific observations, we have tested and optimized methods of plate solving for accurate astrometric solutions. I will discuss here how we go from detector coordinates (X,Y) to astronomical coordinates (RA, DEC) on images taken at the Nooitgedacht observatory.

Student award:

Yes

Level for award:

MSc

Poster Session / 85

Alpha Iron Oxide (α-Fe2O3) Nanoparticles doped with Ruthenium for Gas Sensing Properties.

Authors: Cebo L Ndlangamandla [1]; Ntokozo God-knowledge Cebekhulu[2]; Steven S Nkosi[None]; Sundarry A Ogundipe[1]

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Increased air pollution in the city and environment affects human health negatively. WHO data shows that 91% of the world's population lives in areas where air quality exceeds the safe levels. Carbon monoxide extremely toxic exposer to about 80-100 parts per million may have a high risk of serious health problems, according to the (NIOSH). In the market, the CO sensors are operated at high temperatures and are not portable. Therefore, there is a great need to develop portable CO sensors that can operate at low temperatures.CO gas was detected by using hematite doped with ruthenium chloride as a sensing material. A simple chemical precipitation method was used to synthesize hematite doped with ruthenium chloride in this study. We examined the characteristics of the synthesized hematite nanoparticles by X-ray diffraction (XRD), transmission electron microscopy (HRTEM), scanning electron microscopy (SEM), X-ray photoelectron spectroscopy (XPS), Brunauer- Emmett-teller (BET), (TGA) Thermogravimetric analysis and the kenosis-Tec machine was used to study the gas sensing properties of the material

key word: doping, XRD, HRTEM,SEM.XPS, BET, TGA, and kenosis Tec machine.

Student award:

Yes

Level for award:

MSc

Theoretical and Computational Physics / 86

Measurement-Based Quantum Network Coding on a Noisy Superconducting Processor

Author: Hjalmar Rall[1]

Co-author: Mark Tame [2]

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Measurement-Based Quantum Network Coding (MBQNC) is a recently introduced short-depth protocol for simultaneous transmission of quantum information through a bottleneck in a quantum network. MBQNC is studied here in the context of quantum information transfer within a noisy superconducting processor. We adapt the protocol to run on the new IBM Q falcon superconducting quantum processors by introducing a novel transpiling scheme and perform an experiment showing significant improvement in the final state quality of the protocol when compared to previous work. An analytical noise model based on depolarizing noise is developed which matches the experimental data with high accuracy, and the major source of noise propagation in the protocol is identified.

Student award:

No

Level for award:

N/A

Theoretical and Computational Physics / 87

Using linear spectroscopy to accurately determine the Hamiltonian of a light-harvesting complex

Authors: Towan Nöthling[1]; Johan Nothling[2]

Co-authors: Tomáš Mančal [3]; Tjaart Krüger [1]

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Linear optical spectroscopy is a crucial analytical tool in biology, chemistry, materials science, molecular physics, and various other disciplines, but is hard to simulate exactly—even for small model systems. In this presentation we give an overview of different linear spectroscopy techniques and briefly discuss approximate methods and an exact method for the calculation of linear spectra. We also investigate the validity of the approximate methods by comparing their spectra to the exact spectra of a dimer. We apply the best method in a spectral fitting procedure, called Particle Swarm Optimization (PSO), to determine the Hamiltonian of the light-harvesting complex CP29 of plants. The latter is thought to act as a conduit, and perhaps energy switch, for excitation energy collected by the plant's photosynthetic antenna apparatus. Using our calculated Hamiltonian for CP29, we model excitation energy flow through this complex and discuss its possible roles in the harvesting of light by plants.

Student award:

Yes

Level for award:

PhD

Poster Session / 88

AI in Medical Assay

Author: Temweka Chirwa[1]

Co-authors: Kennedy Otwombe [1]; Simon Connell [2]; Charis Harley [2]; Firdaus Nabeemeeah [1]; Floris Swanepoel [1]; Neil Martinson [3]

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Modelling, machine learning and measurement, in collaboration with medical research, can lead to improved medical assays. In this project, lateral flow urine lipoarabinomannan (lam) assays are used as a diagnostic test for tuberculosis (TB) for people living with human immunodeficiency virus (HIV). It is used when patients may be too weak to produce sputum for standard TB tests such as GeneXpert and MGIT TB cultures. However, the interpretation of the lam assay has been seen to be very subjective as the lines provided by the test can vary significantly in intensity. We aimed to develop an image-based algorithm that would standardise the interpretation of these assays. During the study, over 300 images of lam assays were collected from participants using different smartphones, in different environmental and lighting conditions such as background colours, colour temperature, light intensity and shadow casts. Using these images of the assays, the algorithm, based on deterministic and machine learning methods, would isolate regions of interest (ROI), detect test markings and classify each assay as either positive or negative for TB. The computer-aided interpretation of medical assays, such as TB Lam assays, can be used to minimise the subjectivity related to the reading of these results.

Student award:

Yes

Level for award:

PhD

Nuclear, Particle and Radiation Physics / 89

Compatibility of the CMS dilepton spectra with the Neutral Scalar with Mass around 151 GeV

Author: Srimoy Bhattacharya[1]

Co-authors: Bruce Mellado [2]; Abhaya Kumar Swain [2]; Xifeng Ruan [2]; Mukesh Kumar [2]; Guglielmo Coloretti [3]; Andreas Crivellin [4]

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The measurements related to the different properties of the newly discovered Higgs boson (h) at the LHC by ATLAS and CMS indicate that this 125 GeV boson is compatible with the Standard Model (SM). However, this does not exclude the existence of additional scalar bosons as long as their possible mixing with the SM Higgs is sufficiently small. In a recent phenomenological analysis, a search for narrow resonances with $S \to \gamma\gamma, Z\gamma$ along with leptons, di-jets, bottom quarks and missing energy was reported. The global significance of the excess at $m_S = 151.5$GeV is 4σ, whereas a combination with the multi-lepton anomalies gives a significance larger than 5σ. Moreover, a recent CMS study in the W boson pair in proton-proton collisions presented an excess in dilepton channel associated with the $0, 1$ jet ggH tagged categories. There it shows an excesses around 150 GeV. With this motivation, in this talk, we will compare two different models (namely, $2HDM + S$ and $2HDM + S + N$), containing two new hypothetical scalar bosons, H and S , which can explain these dilepton excesses reasonably well. For $2HDM + S$, we consider the neutral scalar H decays into a lighter one S and the SM Higgs h i.e. $H \to Sh/SS^*$. On the other hand, in $2HDM+S+N$, the dominant decay of the heavy higgs $H \to S(\to NN)S^*(\to NN)$ is considered to analyze the dilepton states to explain the excess.

Student award:

No

Level for award:

N/A

Poster Session / 90

Structural stability of some gold (Au) and silver (Ag) nanoparticles

Authors: Malesela Walter Makgoba[1]; Thuto Mosuang[2]; Rapela Maphanga[3]; Mokete Mahladisa[2]; Malili Matshaba[2]

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The classical molecular dynamics is used to study Au and Ag nanoparticles focusing mainly on their structural stability. The structures were modelled at various temperatures in an NVT Evans ensemble. As such, the many-body Sutton-Chen potential was initiated to describe the interactions between atoms in both nanoparticles. Variation of total energy with temperature was investigated for both Au and Ag nanoparticles; in the process, entropy was calculated. Radial distribution functions were utilised to predict the most probable Au and Ag nanoparticle structures. To probe the mobility of Au and Ag atoms in their systems, the mean square displacements (MSD) were plotted, in which the diffusion constants were calculated to be 0.58 Å2/ ps for Au and 1.87 Å2/ ps for Ag atoms.

Student award:

Yes

Level for award:

PhD

Poster Session / 91

Upgrade of ATLAS Tile Calorimeter TTC system for Phase-II test-beam campaigns

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The Tile Calorimeter (TileCal) is the central hadronic calorimeter of the ATLAS experiment at the Large Hadron Collider (LHC). The LHC Phase-II upgrades will take place during the Long Shutdown 3 period (2026-2028), leading into the High Luminosity LHC (HL-LHC). The HL-LHC will have the capability to deliver up to five times the LHC nominal instantaneous luminosity in 2029. The TileCal Timing, Trigger and Control (TTC) system of the test-beam facility is being upgraded for the Phase-II test-beam campaigns. A new TTC interface module, the ATLAS Local Trigger Interface (ALTI) is being deployed during the Long Shutdown 2 period (2019-2022) of the LHC, as part of Phase-I upgrades. The ALTI is a 6U VME64x module which provides the interface between the Level-1 Central Trigger Processor and the TTC optical broadcasting network, to the Front-End electronics. The ALTI integrates the functionalities of the Local Trigger Processor, Local Trigger Processor interface, TTC VME bus interface and the TTC emitter modules, which are currently used in the experiment. The upgrade involves a new configuration with additional features due to increased amount of programmable logic resources. The status of the upgrade activities is presented.

Student award:

No

Level for award:

PhD

Space Science / 92

Constraining the Cross-field Diffusion of Jovian Electrons

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Jupiter is a quasi-stationary point source of energetic electrons, which are observed at Earth to display a thirteen month periodicity caused by the varying magnetic connection between Earth and the Jovian magnetosphere. The observation of Jovian electrons at Earth during times when Earth is not well magnetically connected to Jupiter implies that the electrons must have propagated across the background magnetic field. Particle drifts are not expected to be important for these energies, therefore perpendicular diffusion must be responsible. Unfortunately, the exact pitch-angle and energy dependences of the perpendicular diffusion coefficient are currently uncertain. We present a new stochastic differential equation model for both the isotropic and focussed transport of energetic electrons in the inner heliosphere. Comparing the computed spectra of Jovian electrons during best and worst magnetic connectivity at Earth with spacecraft observations, we constrain the amount of pitch-angle scattering and cross-field diffusion in the inner heliosphere for realistic turbulence conditions. We investigate two different theories of perpendicular diffusion, each predicting different spatial, energy, and pitch-angle dependencies.

Student award:

Yes

Level for award:

PhD

Poster Session / 93

A study of top quark pair production in association with a high energy photon at the LHC

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We provide a study of the ratio of the top quark pair in association with a photon to the top quark pair to improve the precision of NLO QCD predictions for the proton proton $\rightarrow t\bar{t}$ process in the dilepton top quark decay channel. The top quark pair production cross-section has been measured at LO and NLO in proton-proton collisions at $\sqrt{s}$ = 13 TeV. The events with exactly one electron and one muon, at least two jets, one of which is a b-tagged, are selected. Monte Carlo simulations at leading-order and next-to-leading-order theoretical calculations are used to link many observables. Photon kinematic variables, the angular separation between the two leptons, and angular variables associated with the photon and the leptons are among the variables. This channel is selected because it provides a clean signal while limiting all the background contamination.

Student award:

Yes

Level for award:

PhD

Photonics / 94

Investigating the morphology of an optically trapped particle using Mie scattering

Author: Anneke Erasmus[1]

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

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Using optical tweezers, we trap microscopic polystyrene beads suspended in water and determine their diameter using Mie scattering theory. Using a near infrared laser, the optical trap is formed near the focus by a high numerical aperture lens. The particles have a higher refractive index than the surrounding medium and the focused light creates a strong gradient force which traps the transparent, dielectric particles. The trapped particle is illuminated with broadband white light. Mie scattered light from the particle is collected in the epi direction by a microscope objective and measured on a spectrometer. Due to total internal reflection, specific wavelengths resonate within the spherical cavity. These resonances are commonly referred to as whispering gallery modes, or morphologically dependent resonances. These resonances can be identified on the spectrum of the Mie scattered light. By comparing the wavelength of these resonance peaks to that of theoretical simulations, we can precisely determine the diameter of the particle in the trap. Here, the analysis of these measurements will be discussed. The system has been expanded to optically trap micron sized aerosol droplets in air using a counter propagating optical trap. The droplet is trapped in the overlap of the foci of the two counter propagating beams. Using a similar Mie scattering theory method as described above, the diameter of the trapped water droplet is to be determined. The system and preliminary trapping results will be discussed here.

Student award:

yes

Level for award:

PhD

Poster Session / 95

H I Size–Mass: MIGHTEE-HI vs TNG50

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Scaling relations provide insight into galaxy evolution. While the Tully-Fisher relation may be one of the most well known HI-based scaling relations. A fundamental scaling relation for disc galaxies is the HI size mass relation. This relations shows a tight correlation between the diameter of a HI disc , D_{HI}, and its enclosed HI mass, m_{HI}. The correlation suggests a somewhat constant HI surface density within the D_{HI} for most galaxies. This applies to galaxies regardless of their morphology, mass or environment. Thus hinting that all gas-rich galaxies experience a similar evolutionary process. In this work we present the HI size-mass relation for simulated galaxies from the TNG50 cosmological simulation. We compare it to the observational results from the MIGHTEE-HI survey. IllustriusTNG is a suite of cosmological magnetohydrodynamical simulations of different volumes and resolutions. In our work we use TNG50, which is the most computationally expensive and highest resolution realization of the IllustrisTNG simulation project. MIGHTEE-HI is the neutral hydrogen (HI) emission project within the MIGHTEE survey. This is one of the first deep, blind, medium-wide interferometric surveys for HI. The project aims at extending our knowledge of HI emission upto z = 0.6. Our goal is to investigate to which degree the TNG50 galaxies follow the observational results, and to predict the cosmic evolution in the HI size-mass relation to be expected when the MIGHTEE-HI survey will be completed to full depth.

Student award:

yes

Level for award:

PhD

Photonics / 96

Photobiomodulation at 830 nm modulates proliferation and migration of wounded fibroblast cells

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Wound healing is a complex and dynamic process that involves restoring damaged tissue structure and function. Delayed wound healing often advances to chronic non-healing wounds due to reduced cellular proliferation and migration. Photobiomodulation (PBM) involves the application of low-powered light typically in the visible red and near-infrared (NIR) spectrum to modulate cellular mechanisms and has been shown to speed up healing in vivo; however, the underlying mechanisms are not well understood. This study aims to determine the effect of PBM using NIR light at 830 nm with 5 J/cm2 on the proliferation and migration of wounded human fibroblasts. Commercially acquired human fibroblast cells (BJ-5ta, ATCC® CRL-4001™) were utilised, and two cell models, namely, normal and wounded (central scratch assay), were designed. Cell models were incubated for 24 and 48 h post-irradiation, followed by different investigational tests for cellular morphology and migration rate (inverted microscopy), and proliferation (BrdU, flow cytometry). PBM at 830 nm with 5 J/cm2 modulates cell proliferation and migration and may aid in the enhanced wound repair process observed in vivo.

Student award:

Yes

Level for award:

MSc

Photonics / 97

Photodynamic Efficacy of a Chlorophyll based Photosensitizer Pheophorbide a against Resistant Breast Cancer Cells

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

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Effectiveness of anticancer therapies like chemotherapy and radiotherapy is primarily limited by development of multidrug resistant cancer cells, leading to enhanced progression, invasiveness and tumour metastasis with poor clinical outcome. Clinical findings suggest that employing mechanistically distinct therapies can overcome the resistance induced by another treatment. Photodynamic Therapy (PDT), a photochemical based anticancer treatment modality is a promis-

ing strategy to kill chemotherapeutic drug resistant cancer cells. Mechanistically PDT makes use of a light sensitive drug, photosensitizer (PS) which when excited with light of appropriate wavelength generates Reactive Oxygen Species leading to the destruction of tumour mass. Several plant-based PSs have been used for their phototoxic efficacy as well as being natural compounds they induce minimum side effects. In this study, Pheophorbide a, a chlorophyll derivative is being used as a potential PS to induce cell death in P-glycoprotein over-expressing Doxorubicin (DOX) resistant breast cancer MCF-7 cells. DOX resistant cancer cells were treated with different concentrations of Pheophorbide a followed by irradiation with 660 nm red laser at a light dose of 10 J/cm2. The Pheophorbide a induced phototoxicity was evaluated by 3-(4,5-dimethyl-2-thiazyl)-2,5-diphenyl-2H-tetrazolium bromide (MTT) proliferation assay and by analysing cellular morphological changes, live dead assay and cell death assay. All experiments were performed thrice (n=3) and results obtained were analysed for statistical significance. Results showed that the pheophorbide a can induce photodynamic cell death in resistant cancer cells. Thus, the obtained results suggest the utilization of chlorophyll-based PS as a rational therapeutic intervention for the eradication of chemodrug-resistant cancer.

Student award:

No

Level for award:

N/A

Astrophysics / **98**

Spectral and temporal analysis of 16 short Gamma-Ray Bursts detected by the Fermi Space Telescope with know redshift

Author: Dimakatso Jeannett Maheso[1]

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Gamma-ray bursts (GRBs) are highly energetic impulses of $\gamma-$rays that are classified into two major categories, long and short GRBs. Their distinction lies in their duration (T_{90}) which is calculated from the photon flux accumulation over time. The former lasts for more than 2s whilst the latter lasts for less than 2s with their prompt emission being in the keV to GeV energy band. Short GRBs are typically spectrally hard with spectral index, $\alpha \approx -1$ and the relation between their duration and spectral index depicts a weak inverse correlation. In this study, a sample of sources with known redshift made up of 15 short GRBs detected by *Fermi* Gamma Ray Burst Monitor (GBM) and one intermediate GRB, GRB100816A were selected for spectral studies in the energy range 10 - 900 keV. Most sources in the sample have low energy photons detected by the *Fermi*-Large Area Telescope (LAT) hence LLE photons except for GRB090510A, which is the brightest source in the sample thus has a considerable number of high energy photons with the highest energy photon energy of 29.9 GeV. The counts obtained from the GBM data were binned and their most prominent peaks were utilised for spectral and temporal analysis. Only 12 sources from the sample had prominent peaks including the double peaked GRB111117A. The peaks were fitted using the modified version of the Norris function. The function has the capability to explain the spectral evolution of GRBs which is achieved from the the spectral lags of the function.

Student award:

Yes

Level for award:

MSc

Astrophysics / **99**

Spatially resolved stellar kinematics of the CLoGS brightest group early-type galaxies

Authors: Clinton Stevens[1]; Ilani Loubser[1]

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Galaxy groups within the local Universe contain over 60% of all observable galaxies. Furthermore, galaxy groups host the majority of both baryonic and dark matter content in the Universe. Therefore galaxy groups are excellent laboratories for studying galaxy evolution. Of particular importance are the brightest group early-type galaxies (BGEs) roughly located at the centre of each group's gravitational potential well. By studying the stellar kinematics of these BGEs, we hope to better understand the mass-assembly histories of these galaxies. The Complete Local-Volume Groups Sample (CLoGS) is a statistically complete survey of 53 galaxy groups in the optical, X-ray, and radio bands. We measure the spatially resolved stellar kinematics of the BGEs of 19 of these groups. The spectra of these galaxies are obtained via optical spectroscopy with the Southern African Large Telescope (SALT). The stellar kinematics are obtained with the full-spectrum fitting software pPXF by Cappellari (2017). The radial profiles of both the stellar rotational velocity and the stellar velocity dispersion of some of these BGEs are presented. We find a diverse range of stellar kinematics for the BGEs, for example, some BGEs show strong rotation and others no rotation.

Student award:

Yes

Level for award:

MSc

Photonics / **100**

Links and Twists within the Stokes Field

Author: Pedro Ornelas[1]

Co-authors: Keshaan Singh [1]; Robert de Mello Koch [1]; Andrew Forbes [1]

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Skyrmions are a class of stable quasi-particles with non-trivial topological structures categorized by integer invariants called skyrme numbers. In terms of field configurations, a skyrmion is formed by the twisting of field lines into links between said field lines where the stability originates from the energy requirement to form or break any of these linkages. It is this topological stability which has made the study of skyrmions appealing in many fields such as condensed matter physics where the stability of so called magnetic skyrmions created on the surface of meta-materials has allowed for the development of new memory storage devices. Although originally formulated in the language of particle physics, the generality of the skyrmion definition allows for the creation of analogous structures in different fields. Here we present a formalism to create the Optical Skyrmion within the Stokes Field, using structured light techniques. This Optical Skyrmion exists in the plane perpindicular to the direction of propagation, with a characteristic polarization layout which achieves every possible polarization state and where the skyrme number indicates the number of times this structure repeats itself. Here we employ the use of structured light techniques to create and categorize skyrmions with different skyrme numbers and textures. Furthermore, we show the advantages of using non-diffracting spatial modes to create optical skyrmions. The categorization of these topological vector beams as skyrmion beams allows for a new degree of freedom in vector mode creation which may have intriguing applications in areas such as optical communication and cryptography.

Student award:

Yes

Level for award:

MSc

Photonics / **101**

Teleporting into high dimensions

Authors: Bereneice Sephton[1]; Adam Valles[2]; Isaac Nape[3]; Mitchell Cox[1]; Fabian Steinlechner[4]; Thomas Konrad[5]; Juan Torres[2]; F Roux[6]; Andrew Forbes[7]

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By exploiting entanglement as a resource, information can be conveyed between two destinations with quantum teleportation. Here, the nonlocality between an entangled pair of entities allows one to transmit information by employing the entangled pair as a channel between two destinations. Indirect (Bell) measurements, between one of the entangled entities and a state one desires to transmit then allows the information to be conveyed to the other party, moderated by classical communication. From the fragility of the quantum-mechanical nature being exploited, the technique is largely of interest across a variety of quantum information tasks and forms a salient toolbox from quantum computing to security and quantum networks.

While being demonstrated with continuous, discrete and hybrid approaches in addition to multiple degrees of freedom in a single photon, the highest dimension achieved to date is limited to three-dimensions. These increased dimensions, however, requires an ancillary photon pair for every increase in dimension. Consequently, it comes at the cost of complex, resource intensive experiments which challenges the scalability of the scheme. Here, in lieu of the traditional linear implementation of the entangling step for teleportation, we employ a non-linear approach, allowing us to side-step the scalability issue. We implement a teleportation scheme with photons whereby teleportation is achieved without ancillary photons and demonstrate teleportation beyond this 3-dimensional mark. Furthermore, we show that on-demand teleportation of spatial states is possible with the freedom that allows the user to choose the types of spatial modes from orbital angular momentum to the pixel basis.

Student award:

Yes

Level for award:

PhD

Astrophysics / **102**

A study of the baryon cycle in groups at different stages of assembly

Author: Sriram Sankar[1]

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Multiphase studies of the baryon cycle in groups at different stages of assembly combined with the multi-wavelength characterization of galaxies in the groups will inform us of the gas kinematics, group dynamics, galaxy properties, and subsequently the evolution of both groups and galaxies. While some works find increased star formation suppression events in groups, several others find enhanced star formation due to gas supply from satellite galaxies, mergers, and accretion from the cosmic web. This dichotomy of gas-rich and gas-poor groups has been linked to the stage in group evolution with the former being in early and the latter in late stages of assembly. Even though it is well known that galaxies shape and are shaped by their environments, the relative contribution of environmental and internal galactic processes still remains poorly understood. We study the baryon cycle in two nearby low-mass, gas-rich, late-type dominated, and relatively isolated groups where the biggest members show varying levels of tidal interaction. The high spatial & spectral resolution, sensitivity, and wide field-of-view of MeerKAT enable us to detect HI down to N(HI) ~ 3x10^{19} cm^{-2} and to probe a major extent of the group. We explore previously known and unknown dwarf members, tidal interactions, outflows, etc. to accurately characterize the group environments and to study the kinematics of the neutral gas in the group. Resolved studies of such unique laboratories that encapsulate several key processes of the baryon cycle spanning the ISM, CGM, and IGrM are crucial for constraining galaxy evolution models.

Student award:

Yes

Level for award:

MSc

Poster Session / **103**

Photobioinhibitory Effect of Laser on Resistant MCF-7 Cancer Cell Line

Author: Nosipho Fakudze[1]

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Cancer affects individuals globally and breast cancer is the leading cancer in women in South Africa. The most common new cases of cancer include breast cancer, prostate, lung, and colorectal cancers. Photobiomodulation is a non-invasive treatment that can be used in the treatment of tendinopathies, osteoarthritis, nerve injuries, wound healing, and some malignancies. Photobiomodulation has mixed finding when it comes to cancer treatment with results of no effect and some with positive effects. This study aimed to investigate the inhibitory effect of a 680 nm laser on Doxorubicin (DOX) resistant MCF-7 cancer cells. These cells were treated with 5 µM Dox alone and the same concentration of Dox combined with 20 J/cm2 laser irradiation. The findings of this pilot study suggests that cells treated with Dox and laser has a significant cytotoxic effect of decreased cell proliferation and morphological damage compared to the untreated control cells and laser treated cells alone. These findings invites further investigation to explore any possible combination of laser irradiation in the treatment of cancer that are resistant to chemotherapy.

Student award:

Yes

Level for award:

MSc

Photonics / 104

Exploring the photodynamic potency of BMOV against breast cancer and breast cancer stem cells following laser irradiation at 405 nm

Author: Bhawna Uprety[1]

Co-author: Heidi Abrahamse

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The serendipitous discovery and tremendous success of cisplatin paved way for the design and applications of transition metal-based anticancer agents. Likewise, another breakthrough in cancer treatment has been the introduction of photodynamic therapy, which uses a photosensitizer to generate reactive oxygen species and kill cancer cells. Recently, research has been focused on combining these two aspects, i.e., photodynamic therapy using organometallic complexes to harness maximum therapeutic effects. This *in vitro* study explores the effect of photodynamic therapy (PDT) using bis(maltolato)oxovanadium(IV) (BMOV) at 405 nm at different fluencies of 1, 1.5, and 2 J/cm2, in targeting breast cancer (MCF7). The cells were treated with IC50 concentration of BMOV (3.06 μM) followed by irradiation with 405 nm laser after 4h of treatment. The change in cellular morphology was observed using inverted microscopy. The cell death was analyzed through ATP proliferation and LDH cytotoxic assays. The morphology of MCF7 cells explained the degree of toxicity induced by photoirradiation at 405 nm in the presence of BMOV. Reduced ATP and increased LDH levels also implicated the cytotoxic effect of the extract towards MCF7. Furthermore, the optimized dose was also found to be effective against breast cancer stem cells (CD44+). However, the viability of normal mammary epithelial cells (hTERT-HME1) was not affected by BMOV and laser irradiation. The findings of the study suggest the possible application of laser irradiation at 405 nm with oxidovanadium (IV) complexes against breast cancer as well as cancer stem cells.

Student award:

No

Level for award:

N/A

Applied Physics / 105

Unmasking phase with ghost imaging

Authors: Bereneice Sephton[1]; Isaac Nape[2]; Chané Simone Moodley[1]; Jason Francis[1]; Andrew Forbes[3]

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In ghost imaging, an object can be imaged by interrogating a photon that has not interacted with it. One of the entangled photons in a pair interacts with the object while the spatial distribution of the second photon is measured. Due to the correlations, the spatial properties of the non-interacting photon carries information about the object despite never having contact with it. An image of the object is then built up by repeatedly measuring the non-interacting photon spatial state. This has led to many advantages such as low-intensity imaging of photosensitive samples, dual-wavelength illumination and detection and improved resolution.

Traditionally, ghost imaging was used to obtain the object intensity only. This, however, excludes useful phase information which is important for objects such as biological samples. To obtain this, many methods have been proposed and demonstrated with majority relying on interference to induce changes in the spatial amplitude or observing generated diffraction patterns. Here we present phase reconstruction imaging that side-steps the need for alignment sensitive and complex setups; this, by instead exploiting correlations already isolated in many reconstruction algorithms and used in vanilla ghost imaging setups. We do so by using only two projective measurements with conventionally used spatial interrogation masks such as Hadamard or random masks. Accordingly, we show accurate phase reconstruction for complex phase-only objects. It follows that no changes to the vanilla ghost imaging setup is needed, but rather only an additional projective measurement for each spatial mask being used to build up the image.

Student award:

Yes

Level for award:

PhD

Physics of Condensed Matter and Materials / 106

Synthesis and modification of Boron Nitride nanotubes using ion implantation

Author: Lehlohonolo Lisema[1]

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Boron Nitride (BN) nanotubes were grown on Silicon (Si) substrates using chemical vapor deposition at temperatures ranging from 900 to 1100 ℃. Ion implantations were carried out with boron (B+) ions at energies of 150 keV and fluences of 1x10^14 and 5 x10^14ions/cm^2. Raman analysis revealed a peak at 1367/cm, which is an indication of the sp^2 hybridized BN planar bonding attributed to the high frequency mode for the hBN peak, but which is more clearly characterized at 1100 ℃. The glancing incidence X-ray diffraction (GIXRD) analysis revealed a well-defined peak at angles of 51-57°, indicating the hBN (004) peak. SEM images show BN nanotubes and BN nano particles of various shapes and sizes.

Student award:

Yes

Level for award:

PhD

Poster Session / 107

Multi-channel, turbulence resistant Quantum Key Distribution

Author: Pedro Ornelas[1]

Co-authors: Isaac Nape [2]; Andre de Oliveira [3]; Paulo Souto Ribeiro [3]; Andrew Forbes [4]

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Quantum hybrid entanglement between two photons occurs when the two photons in question are entangled non-locally in different independent degrees of freedom. In our case, if we measure the polarization of one photon, we may infer what the spatial mode of the other will be, and vice versa. The resilience of polarization to turbulence and the ability to encode a large amount of information into the spatial degree of freedom implies that hybrid entanglement offers significant improvements to conventional Quantum Key Distribution protocols, which conventionally make use of only the polarization degree of freedom. Here we make use of an all-digital approach to couple spatial information to polarization thereby accessing higher order spatial modes than what would be allowed by static elements. In doing so, we are able to create multiple channels through which simultaneous communication may occur thereby boosting peer-to-peer communication speeds and allowing for simultaneous multi-party communication. We also demonstrate the technique's resilience to turbulence by sending every photon carrying the polarisation information of each channel through turbulence. We believe this novel technique would be of value to the Quantum Optics and Quantum Information communities.

Student award:

Yes

Level for award:

MSc

Applied Physics / **108**

An Internet Of Things (IoT) pilot project as a primer for the future development of IoT technology for particle physics detector data acquisition systems

Author: Ryan Mckenzie[1]

Co-authors: Edward Nkadimeng [2]; Ling Cheng [2]

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Data AcQuisition (DAQ) systems are highly susceptible to technological development due to the intricate relationship between their design and currently available hardware. As a result, they are required to continuously evolve alongside one another. This when coupled to the manner in which particle detectors such as ATLAS are required to evolve in order to accommodate ever-increasing instantaneous luminosities provides a unique opportunity for the development of novel DAQ systems. Once such technology can broadly be referred to as IoT. IoT can be defined as wireless communication amongst various devices themselves as well as an external network. The technology has broad application to current and future detectors. The Wits Institute for Collider Particle Physics is undertaking a pilot project in order to develop the core skills required for the future development of IoT technology within particle detectors. This project involves the creation of a system composed of a mesh network with individual nodes consisting of a sensor array. The nodes will implement embedded Tiny Machine learning in order to process data from the sensor array before the data is transmitted to an external network. An overview of the project will be provided with an IoT use case within particle detectors being discussed and will culminate in the presentation of the pilot project.

Student award:

Yes

Level for award:

PhD

Poster Session / **109**

Computational Modelling Study on the Stability Li1.2Mn0.8O2 Cathode Material

Authors: Vusani Mikosi[None]; Phuti Ngoepe[None]; Cliffton Masedi[None]; Kemeridge Malatji[None]; Refiloe Maphoto[None]

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: Due to the rising demand of renewable energy, lithium-ion batteries have attracted much attention with Li2MnO3 being a perfect candidate to use as the cathode material. This is due to its high energy density and specific capacity. However, Li2MnO3 suffers from poor cycling stability and voltage fade which limits its practical application. In this work the built monoclinic Li1.2Mn0.8O2 is doped with Ti and Nd to attain the fundamental understanding of the crystal cycling stability. With the application of first-principles calculations combined with the ground state search, this study will generate phases of the Ti and Nd doped Li1.2Mn0.8O2 clusters. The ground state search was able to generate 20 and 136 Li-Ti-Mn-O and Li-Nd-Mn-O new phases respectively which are thermodynamically stable with negative enthalpy of formation. The cross-validation score of the Li-Ti-Mn-O system was found to be less than 5 meV/atom which indicate accuracy of ground-state search calculations allowing the temperature profile to be implied on the different phases which showed that phase transition occurs at 1200K. Building of Li1.2Mn0.8O2 shows an improvement on the thermodynamic and electronic stability of Li2MnO3. These findings pave way for further investigations of Li1.2Mn0.8O2 as a function of temperature.

Student award:

Yes

Level for award:

Hons

Astrophysics / **110**

Cosmological Evolution through non-linear electrodynamics

Authors: Carissa De Klerk[None]; Amare Gidelew[1]

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Many observations have shown that the universe is expanding at an accelerated rate. The reason for this is, however, unknown. General relativity and standard cosmology seem to fail in explaining the early and late-time acceleration of the universe. There have been several suggested solutions to explain this phenomenon such as dark energy and modified theories of gravity, however none of which are yet confirmed to be the correct explanation. Here we attempt to explain the inflation and late-time cosmic acceleration by adding non-linear electrodynamic contributions into the Einstein Field Equations.

Student award:

Yes

Level for award:

MSc

Theoretical and Computational Physics / 111

The Physics of Core-Collapse Supernovae

Authors: Njabulo Mkhwanazi[1]; Busisiwe Mbuyisa[2]; Wandile Nzuza[3]

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The core-collapse supernovae(CCSN) can be described as an explosion that occurs when a massive star ($\sim 8 \times M_{\odot}$) dies, where $M_{\odot}$ is the astronomical symbol representing solar mass. The later supernovae(SN) explosion yields to a shock wave distribution. In this study, the computations specifically looking at the shock wave (or simply shock) distribution were performed. Hence, the Taylor Sedov solution was used together with physics related assumptions involved in simplifying the equations. This so-called Sedov solution is used to calculate the energy released in a SN explosion, the typical radius and velocity of the propagating shock. For Crab Nebula SN remnant, the energy released was found to be $\sim 1.236 \times 10^{61}\ eV$. In general, this means that the shock is approximately $10^{30}\ eV$ more powerful than a lightning bolt (that is, $6.242 \times 10^{27} eV$). Thus, the shock radius was found to be $\sim 9.556 \times 10^{16}\ m$, the meaning behind this is that the radius of the blastwave is $10^{10}\ m$ times longer than the $R_{\odot}$ (radius of the Earth). Lastly, the velocity of the propagating shock wave was found to be roughly $1.349 \times 10^{6}\ m/s$. This generally means that the shock travels with a speed close to the speed of light ($c = 3 \times 10^{8}\ m/s$).

Keywords: Core-Collapse Supernovae, Taylor Sedov Solution, Supernova remnant, Blastwave, Shock wave

Student award:

Yes

Level for award:

MSc

Poster Session / 112

Multi-Scale Modelling of P2 and O2 Type Materials for Utilization as Core-Shell Materials

Authors: Precious Makhubela[None]; Raesibe Ledwaba[None]; Kenneth Kgatwane[None]; Phuti Ngoepe[None]; Nkgaphe Tsebesebe[None]

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The increasing demand for energy and the threat from global warming make electrical energy storage a worldwide policy objective. As such, sodium-ion batteries are currently evolving as a viable substitute for lithium-ion batteries due to the abundant availability and reasonable cost of sodium. Sodium transition metal oxides (NaMO2) with a P2 structure exhibit good Na+ ion conductivity and manganese-based compounds provide a high working potential vs. Na+/Na, and high capacity. Hence, the materials are promising sodium-ion battery cathode materials. However, the layered nature of these materials means that they are prone to structural rearrangements at high voltage or low Na contents, phase transformations and Na+ ion/vacancy ordering transitions, resulting in capacity fade and poor reversibility. In this work, the density functional theory was used to investigate the structural, electronic, and mechanical properties of the P2 and O2 type NaMnO2 and LiMnO2 structures. The electronic band structures illustrated the conductivity of the materials and density of states were used to check the electron contribution at the fermi level. Thus, the electron contribution at the fermi level is due to the p state of oxygen and the d state of Manganese. The structures converged with 6x6x6 k-points and 600eV energy. Moreover, elastic constants and phonons curves compared in details stability of the materials.

Student award:

Yes

Level for award:

Hons

Physics for Development, Education and Outreach / 113

Challenges pre-service students have while practicing to answer questions using context-content alignment problem-solving strategy

Authors: Paul Molefe[1]; Mphiriseni Khwanda[1]; Buyi Sondezi[1]

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Solving problems in physics involves the contextual understanding of the problems, the identification of tools needed to solve the problem including both conceptual and mathematical, and lastly the evaluation of the answer if it makes sense. The stages are not usually followed since students mainly focus on solving every physics problem mathematically using a formula and in the end, students are unable to evaluate if the answer is making sense. The present research wishes to propose a context-content alignment problem-solving strategy that will help students to identify the context of the problem, select the suitable rule(s), principles, laws, or theory of physics, and later align the principle(s), rules or laws with the mathematical tools necessary to solve the problem. After the mathematical solution, students must evaluate the calculated answer if it makes sense. The context-content alignment problem-solving strategy was developed based on the concept of scientific explanation. According to scientific explanation, each explanation consists of a claim, evidence, and reasoning. The research wishes to explore challenges pre-service students have while practicing to answer questions using a context-content alignment problem-solving strategy.

Student award:

No

Level for award:

N/A

Poster Session / 114

Computational Study bulk and Surface RuO2 as a catalyst in Li-air Batteries

Author: Mmeshi Hiine[None]

Co-authors: Khomotjo Maenetja ; Phuti Ngoepe ; Brian Ramogayana

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Lithium-air batteries have long been regarded as one of the best choices due to their high specific energy (11,400 Wh/kg). Catalysis is one of the most effective techniques used to improve electrochemical performance and influence the production of stable discharge products during cycling in lithium-air batteries. Despite several studies addressing the effect of catalysis in Li-air batteries, the reactivity and catalytic effect of ruthenium oxide (RuO2) are not fully understood. In acidic conditions, RuO2 performs exceptionally well and lasts a long time in the oxygen evolution reaction(OER). Ru-based catalysts are generally considered to be the most efficient oxygen reduction reaction (ORR) catalysts. In this study, we use first principle density functional theory calculations to investigate the surface study of RuO2. Which will form a foundation for adsorptions of lithium and coadsorptions of oxygen. The B/G ratio is greater than 1.75 implies RuO2 is ductile. All the elastic constants were determined to be positive, indicating that the RuO2 is mechanically stable. Low Miller index {(001), (100), (010), (011), (110), (111)} surfaces were modelled, and we found the (110) surface to be the most stable. The constracted morphologies also indicated the (110) surface plane as the most dominant.

Keywords: Lithium-air batteries, Catalyst, oxygen evolution reaction(OER), oxygen evolution reaction(OER), Density functional theory(DFT),

Student award:

Yes

Level for award:

Hons

Applied Physics / 115

Threading a Laser Through the Eye of a Needle: Multimode Fibre Coupling in Turbulence

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The unequal access to reliable internet connectivity between urban and peri-urban areas remains an issue of concern in many developing countries, including South Africa. A major reason for this so-called 'digital divide' is the unequal distribution of fibre infrastructure, which is usually due to economic or geographic reasons. This could be mitigated through the deployment of Free Space Optical (FSO) communication, which would extend the optical network to marginalized areas, without the need for more fibre infrastructure. FSO systems would provide access to a wider and unlicensed spectrum, allowing for faster and cheaper internet connectivity. Despite its many benefits, modern FSO technology remains too expensive and inaccessible to low-income residents of peri-urban areas. The cost of such technology could be significantly improved by hacking off-the-shelf fibre hardware, such as small form-factor pluggable (SFP) transceiver modules. However, unlike in fiber optical networks, a light beam propagating in free space is faced with a number of attenuation factors such as divergence, atmospheric turbulence and beam wander. These factors increase the complexity of coupling light into hardware kilometers away. As such, the optimization of light coupling is a crucial step to be taken if off-the-shelf fibre hardware is to be used in FSO applications. This talk will focus on the optimization of light coupling from free space into an SFP module, by analyzing different coupling mechanisms to determine the optimum method.

Student award:

Yes

Level for award:

MSc

Astrophysics / 116

Tracing water masers at their smallest scale with VLBI

Author: Jakobus Vorster[1]

Co-authors: James Chibueze; Johan van der Walt [2]; Gordon MacLeod [3]

[1] *Centre for Space Research*

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The recent accretion burst event in the high mass star forming region NGC6334I have given us rare insights into the mechanisms behind the formation of high mass $> 8M_{\odot}$ stars. An important tracer in the study of star forming regions is astrophysical masers, especially 22 GHz water masers, which have also been studied in NGC6334I. There are still many open questions about water masers, such as the response of water masers in variable radiation environments and their excitation in turbulent shock environments. This study reports multi-epoch high resolution Very Long Baseline Interferometry (VLBI) observations of 22 GHz water masers before and during the accretion burst event in NGC6334I. We report two main results. There was a significant change in water maser spatial morphology with the onset of the burst. These results are helpful in constraining the effect of variable radiation fields om 22 GHz water masers. Secondly, we also identified 35 microstructures with linear sizes of $0.5 - 2.5$ AU with Gaussian spectral profiles. These microstructures have been found in other sources as well, and are likely water masers at their smallest scales.

Student award:

Yes

Level for award:

MSc

Physics of Condensed Matter and Materials / 117

Thermal stability of diketopyrrolopyrrole-based terpolymers with tunable broad band absorption for polymer solar cells

Authors: Leonato Tambua Nchinda[1]; Newayemedhin A. Tegege[2]; Tjaart P.J. Kruger[1]

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[2] *Department of Physics, Addis Ababa University, Ethiopia.*

Corresponding Author: nchindaleonato@gmail.com

Organic solar cell (OSC) research has advanced significantly during the past few years with the introduction of new polymers. The molecular engineering of terpolymers has enabled easy morphological control in binary devices over ternary blends and power conversion efficiencies (PCEs) exceeding 18% have been recorded. However, in contrast to photovoltaics based on inorganic semiconductors such as silicon, OSCs degrade during illumination and in the dark. In this regard, we examined the thermal stability of a series of terpolymers comprising one electron donor and two types of electron acceptors, blended with $PC_{71}BM$. The terpolymers exhibited very broad absorption spanning from 300 to 900 nm, illustrating the success of the terpolymer approach. The absorption spectra were blue-shifted with increasing temperature, suggesting a decrease in the conjugation length of the polymers. The photoluminescence yield also increased with the temperature. Thin films of the terpolymers blended with $PC_{71}BM$ were degraded at 85 ℃ and characterized as a prospective active layer for OSCs by absorption, photoluminescence, AFM, TEM, Raman, and time-correlated single-photon counting (TCSPC). The fresh films displayed a PCE of 5.7% with a short-circuit current density of 15.2 mA/cm^2, indicating good complementarity in the absorption of the donor and acceptor materials. A comparative analysis of key features of the absorption and photoluminescence spectra in association with the morphological characterization results served as an indicator of the thermal stability of the structural and photophysical properties of the terpolymers.

Student award:

Yes

Level for award:

PhD

Physics of Condensed Matter and Materials / 118

Highly methane responsive nanosensor layer based on mesoporous nanostructured belts-like Indium Oxide

Author: Mosima Kgomo[1]

Co-authors: Katekani Shingange ; Nemufulwi Murendeni [1]; Hendricks Swart [2]; Gugu Mhlongo [1]

[1] *CSIR*

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This work focuses on development of mesoporous 1-D belt-like In2O3 nanostructures derived from a single-step electrospinning method as an effective approach to produce active sensing layers based on In2O3 with high active surfaces to make full use of the sensing activity of all nanostructures. The annealing temperature effect on methane sensing behavior of these belt-like In2O3 nanostructures was further evaluated. Structural, surface area and porosity as well as surface defects analysis were performed to gain more insight pertaining to the observed gas sensing trends arising from annealing temperature variation. The In2O3 sensor produced at an annealing temperature of 550 ℃ displayed the highest sensitivity of 0.011 ppm, lowest limit of detection of 2 ppm and faster response-recovery times of 36 and 44 s under low operating temperature of 100 ℃. Findings from detailed analysis demonstrated that enhanced sensing capability towards methane in this case stems from

synergistic effects of the higher surface area and the larger proportion of the intrinsic surface defects. Further, 1-D belts-like nanostructures of In2O3 composed of small-sized particles offered large active surface area and formed well aligned porous structure for the diffusion of methane gas molecules into and/or out of the sensing film thus contributing to enhanced sensor performance. The mesoporous 1-D belt-like In2O3 nanostructures with high surface area and excellent sensing properties demonstrates a promising application in gas sensor for monitoring and detecting methane released in the agricultural sector.

Student award:

Yes

Level for award:

PhD

Poster Session / **119**

Kernel Density Estimation based simulations of Monte-Carlo events at LHC

Authors: Nidhi Tripathi[1]; Bruce Mellado[2]; Xifeng Ruan[3]; Salah-Eddine Dahbi[3]

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We have developed a machine learning-based generative model to estimate the kernel density of the data using the Gaussian kernel and then have generated additional samples from this distribution. This model uses scikit-learn to generate a list of particle four-momenta from the proton-proton collisions produced at the Large Hadron Collider (LHC). We demonstrate the ability of this approach to reproduce a set of kinematic features, that are used for the search for new resonances decaying to Z(ll)γ final states at the LHC. This model is constructed to take the pre-processed Zγ events and generate sample data with accurate statistics, mimicking the original distributions and achieving better performances compared to the standard event Monte-Carlo generators.

Student award:

Yes

Level for award:

PhD

Theoretical and Computational Physics / **120**

Cavity QED based open quantum walks

Authors: Ayanda Zungu[1]; Ilya Sinayskiy[2]; Francesco Petruccione[3]

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

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Open quantum walks (OQWs) have been introduced as a new type of quantum walks that are entirely driven by the dissipative interaction with external environments and are defined in terms of discrete completely positive trace-preserving maps on graphs [1-3]. In this contribution, we discuss a possible experimental scheme for the implementation of OQWs. The scheme is based on a model consisting of a weakly coupled atom-field system in the dispersive regime inside a high-Q resonator (Q~10^12) [4]. This setup implements an OQW on the line with a two-level atom (driven by a laser) playing the role of the "walker" and the Fock states of the cavity mode as lattice sites of the OQW. The master equation for this system is solved analytically using generating functions for the zero-temperature case and the dynamics of the observables are presented for various parameters.

Keywords: Open quantum walks; quantum optics

References: [1] S. Attal, F. Petruccione, C. Sabot, and I. Sinayskiy, 2012 *J. Stat. Phys.* **147**, 832. [2] S. Attal, F. Petruccione, and I. Sinayskiy, 2012 *Phys. Lett.* A **376**, 1545. [3] H. Breuer and F. Petruccione, 2002 *The Theory of Open Quantum Systems* (Oxford University Press, Oxford). [4] M. Brune et al., 1996 *Phys. Rev. Lett.* **76**, 1800–1803.

Student award:

Yes

Level for award:

PhD

Poster Session / **121**

Finite System Size Correction in ϕ^4 Theory NLO scattering

Authors: Jean Du Plessis[1]; William Horowitz[2]

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Using a novel regularization technique, we compute for the first time the NLO finite system size corrections to $2 \to 2$ scattering in massive ϕ^4 theory. This is a useful first step to get insight into the effect of finite system sizes present in heavy-ion collisions at the LHC. Previously an equation of state for the relativistic hydrodynamics encountered in heavy-ion collisions at the LHC has been calculated using lattice QCD methods. This leads to a prediction of very low viscosity, due to the nature of the trace anomaly calculated. Finite system corrections to this trace anomaly could challenge this calculation, since the lattice QCD calculation was extrapolated to an effectively infinite system. To verify the robustness of this trace anomaly it is beneficial to add the finite system corrections that will be encountered. We construct a massive ϕ^4 theory while imposing periodic boundary conditions on n of the 3 spatial dimensions. In order to compute the corrections to NLO $2 \to 2$ scattering we employed a novel regularization technique, derived a generalization to a formula originally proposed by Ramanujan and derive a new analytic continuation to the generalized Epstein Zeta function. We find that the results we obtain pass nontrivial analytic consistency checks. Finally the finite size corrections to the total cross section, running coupling and effective coupling is explored analytically as well as numerically, in order to estimate the size of such finite system corrections in massive field theories.

Talk is based on arXiv:2203.01259

Student award:

Yes

Level for award:

Undergraduate

Applied Physics / 122

The Vacuum Arc Ion Thruster

Authors: Paul Stansell[1]; Phil Ferrer[1]

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The Vacuum Arc Thruster (VAT) is a simple electric propulsion system for small satellites, providing low thrust at moderate specific impulse. In this work the VAT is investigated as a plasma source for a high performance ion thruster. Spacecraft figures of merit are presented and the relevant literature is reviewed. Several inductive energy storage arc circuits were built and their electrical performance characterised. The arc current pulse shape was adjusted from triangular to square in order to provide more uniform ion current density. Total ion currents were measured for planar and coaxial thruster designs, as well as for different cathode materials. A ballistic pendulum for individual arc pulse impulse bit measurements was built and its performance is discussed. The grid setup used to extract the ions into the beam as well as the extractor power supply design are presented. Attention is given to beam formation and neutralisation. Finally, the overall improvement in performance over the VAT is presented and the advantages and disadvantages of the ion thruster system are discussed.

Student award:

Yes

Level for award:

MSc

Physics of Condensed Matter and Materials / 123

Phase Stability of Li2Mn1-xTMxO3 (TM= Ni, Co, Cr and Ru) Cathode Material Using Cluster Expansion and Monte Carlo Simulations

Author: Mamonamane Mphahlele[1]

Co-authors: Cliffton Masedi [2]; Kemeridge Malatji ; Phuti Ngoepe [2]; Raesibe Sylvia Ledwaba [2]

[1] *university of Limpopo*

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Li2MnO3 has received great attention as potential cathode material due to its higher capacity, low cost and non-toxicity. However, its application is obstructed by its poor rate performance and structural degradation during cycling. Cationic dopants have been used to reduce the collapse of the structure and they tend to improve the performance of cathode materials. As such, it is highly desirable to identify new doped structures as a remedial technique to optimize the properties of Li2MnO3. In the current study, Cluster Expansion and Monte Carlo simulations were utilized to investigate the phase stability of Li2Mn1-xTMxO3 system (TM=Ni, Co, Cr and Ru). The binary ground state diagrams generated using Cluster Expansion yielded 73, 65, 90 and 83 new stable phases of Li2Mn1-xNixO3, Li2Mn1-xCoxO3, Li2Mn1-xCrxO3 and Li2Mn1-xRuxO3, respectively. Monte Carlo simulations were used to determine high temperature properties for entire range of TM concentrations (0≤x≤1) and phase diagrams were constructed. The findings predicted Li2Mn0.83Ni0.17O3, Li2Mn0.5Co0.5O3, Li2Mn0.5Cr0.5O3 and Li2Mn0.5Ru0.5O3 as the most stable phases of doped Li2MnO3. These structures may be useful in future applications as electrode materials for lithium-ion batteries.

Student award:

Yes

Level for award:

MSc

Photonics / 124

Communicating through turbulence using classical-entanglement

Author: Keshaan Singh[1]

Co-authors: Isaac Nape [2]; Angela Dudley [3]; Andrew Forbes [4]

[1] *University of the Witwatersrand*

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The classical concurrence (i.e. non-separability) of vector beams has the intriguing property that it is invariant to general unitary transformations, most notably pure phase aberrations such as those induced by propagation through atmospheric turbulence. Free space communication using structured light aims to increase data transmission rates by encoding simultaneous signals in superpositions of spatial modes which carry independent data streams. The efficacy of these systems is severely affected by atmospheric turbulence due to the induced modal crosstalk. We propose a method of encoding information into a basis formed by the discretized concurrence of classical vector beams. We show how the discretization of the concurrence into n elements will result in the ability to encode d= ln(n)/ln(2) simultaneous bit streams. We demonstrate the efficacy of the concept in a dynamic experiment. We believe this robust encoding scheme will be of value to the optical communication community.

Student award:

Yes

Level for award:

PhD

Applied Physics / 125

Comparison between the empirical, machine and deep learning techniques to predict global solar irradiance for Mutale area in Limpopo Province, South Africa

Authors: Thalukanyo Whitney Murida[1]; Mphephu Ndivhuwo[2]; Sophia Mulaudzi[1]; Eric Maluta[1]

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The prediction of solar irradiance for certain regions is of utmost importance in guiding solar power conversion systems with a specific focus on design, modelling, and operation. In addition, the selection of proper regions with sufficient solar irradiance also plays a significant role for the decision-makers responsible for future investment policies about green energy. The lack of weather stations and measured solar parameter in most areas in the developing countries have contributed to the development of prediction models for solar irradiance. However, reliable prediction of solar irradiance is dependent on the availability of quality data and also the prediction methods used. Empirical models have been developed and used in the past; however, in recent times intelligent algorithms have proved to have more predictive power due to the availability of high-frequency data. Against this background, this study use two empirical models namely: the Clemence model and Hargreaves and Samani model to predict the global solar irradiance in Mutale station area in the Limpopo province in South Africa. Furthermore, machine learning and deep learning techniques namely: Support Vector Machines (SVM), Random Forest (RF) and Long-Short Term Memory

(LSTM) networks were also used to predict global solar irradiance in the same area. To assess the efficiencies of these empirical and machine models, the estimated values for the global solar radiation was compared against the recorded data from the Mutale weather station

Student award:

Yes

Level for award:

MSc

Nuclear, Particle and Radiation Physics / **126**

Search for resonant production of strongly-coupled dark matter in proton-proton collisions

Author: Hannah van der Schyf[1]

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A collider search for semi-visible jet final state arising from dark matter, using Run 2 data recorded with the ATLAS detector at the CERN LHC with a center-of-mass energy of 13 TeV is presented. For this search the hidden sector is hypothesized to couple to the standard model via a heavy leptophobic Z' mediator. Semi-visible jets are an unusual final state, where the visible states in the shower are standard model hadrons and the strongly coupled hidden sector contains dark quarks which result in dark hadrons. This gives a final state consisting of a jet aligned with missing energy due a mixture of stable, invisible dark hadrons and visible hadrons from an unstable subset of dark hadrons that promptly decay to SM particles. The resonant production and decay of such a mediator will result in a dijet system of semi-visible jets, leading to missing energy aligned with one of the jets, a signature ignored by most dark matter searches.

Student award:

Yes

Level for award:

MSc

Astrophysics / **127**

Simulating the radio emissions of dark matter for new high-resolution observations with MeerKAT

Author: Michael Sarkis[1]

Co-author: Geoff Beck [1]

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Recent work has shown that diffuse radio observations by MeerKAT - and eventually the SKA - are well suited to provide some of the strongest constraints yet on dark matter annihilations, particularly in dwarf spheroidal galaxies. To make full use of the observations by these facilities, accurate simulations of the expected dark matter abundance and diffusion mechanisms in these astrophysical objects are required. However, because of the computational costs involved, various mathematical and numerical techniques have been developed to perform the calculations in a feasible manner. Here we present a comparison of the various methods commonly used, outlining the applicability of each one, while also demonstrating a novel technique for the solution of the diffusion equation. These considerations are becoming ever more important as the hunt for dark matter continues, especially in this new era of precision radio observations.

Student award:

Yes

Level for award:

PhD

Applied Physics / **128**

Fast, cheap, variable sensitivity wavefront sensor for applications in communication to microscopy and beyond

Author: Keshaan Singh[1]

Co-authors: Angela Dudley [2]; Andrew Forbes [1]

[1] *University of the Witwatersrand*

[2] *CSIR National Laser Centre*

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Wavefront sensing is a branch of metrology essential in applications ranging from microscopy, astronomy and optical manufacturing to laser design, free-space communication and ophthalmology. Dominating the industry are the ubiquitously used Shack-Hartmann sensors, which suffer from resolution versus acquisition rate trade offs; as well as inteferometric sensing, which has superb sensitivity but is vulnerable to environmental instability. The transport of intensity equation is an expression of the conservation of energy which relates propagation dynamics of the (easily observable) intensity to the wavefront of an optical field. This technique has been primarily applied in quantitative phase imaging/microscopy where small propagation distances are required to avoid interference effects from diffraction due to sharp phase features. In order to sense small and/or slowly varying wavefronts a larger propagation distance should be considered. We present a wavefront sensor which utilizes holographic propagation using the angular spectrum technique, applied with a micro-mirror device. Additionally, the multiplexing of multiple holograms allows for single shot measurements of intensity gradients over tuneable propagations distances. We demonstrate the effectiveness of the technique in both static, dynamic and adaptive experiments. We believe this will be of value to the larger wavefront sensing community.

Student award:

Yes

Level for award:

PhD

Poster Session / **129**

Reactive Molecular Dynamics Simulations of the Atomic Oxygen impact on Poly(2,5)-benzimidazole

Author: Ernst Ellis[1]

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In lower Earth orbit (LEO) a spacecraft and its electronics are exposed to an array of different radiation. One of the more destructive types of radiation that takes place in LEO is that of heavy ions. The most abundant heavy ion in the LEO range is atomic oxygen (AO), with a flux rate of $10^{15} AO/cm^2 s$ and energy up to $5eV$. To mitigate or reduce the degree of destruction, various coatings are applied to the devices. Some studies have tested a wide range of coatings from black paint (polyvinyl alcohol) to silicone coatings, among these tests some polymer composites have shown positive results warranting further study. The polymer considered in this work is poly(2,5)-benzimidazole (ABPBI), due to its stability in mechanical and chemical properties at temperatures up to $200°C$. To test if ABPBI is a suitable material is a difficult feat given the harsh conditions it would ordinarily experience. The approach taken in this work is to setup a suitable molecular dynamics framework that can be used to compliment experimental setup and then extend studies, beyond the limitations of what can be replicated in the laboratory. The molecular dynamic simulations use ReaxFF, a reactive force field to more accurately evaluate the degradation of ABPBI through hypervelocity AO.

Student award:

Yes

Level for award:

MSc

Physics of Condensed Matter and Materials / 130

Structural and optical properties of TiO2 photoelectrodes fabricated for photoelectrochemical water splitting

Author: Nyasha Suliali[1]

Co-author: Johannes Reinhardt Botha [1]

[1] *Nelson Mandela University*

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Hydrogen production by photoelectrochemical water splitting (PECWS) is becoming topical, as clean methods of producing hydrogen are now a necessity. TiO2 is a wide band gap semiconductor material, which is suitable for PECWS by virtue of ease of nanofabrication, excellent photosensitivity and chemical stability among other factors. The present study explores the structural and optical properties of photoelectrodes developed by carefully transferring anodically synthesized TiO2 nanotubular thin films onto transparent conductive glass. Fourier Transform Infrared Spectroscopy measurements are presented to give insight into light absorption properties of the bi-layer photoelectrodes. The photocurrent density of the photoelectrodes is characterised in a three-electrode electrochemical setup. A reliable mechanism of transferring the delicate thin films and the influence of the synthesis parameters on optical response are discussed.

Student award:

No

Level for award:

Postdoc

Poster Session / 131

Using Machine Learning to Model and Predict the Effects of Atmospheric Turbulence on Lasers

Author: Steven Makoni[1]

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Free-Space Optical (FSO) communication links have utilized Orbital Angular Momentum (OAM) modes as channels in Mode Division Multiplexing (MDM) systems. OAM modes suffer from turbulence-induced OAM crosstalk which degrades the performance of FSO communication links. OAM crosstalk flow with a certain extent of memory. Analytical models exist to predict OAM crosstalk are memoryless, probabilistic and do not describe OAM crosstalk evolution with time. This research proposes an alternate approach to model the OAM crosstalk using machine learning. Such a memory model can potentially be used in the future to optimize crosstalk mitigation techniques such as forward error techniques by introducing predictive capabilities on OAM modes. The temporal correlations in time series data were learned by the model. Lateral displacement, tilt angle and OAM crosstalk coefficients were generated and measured from a laboratory link. These measured variables were used to train and test the machine learning model. Finally, an analytical expression approximated the OAM crosstalk and was compared with the machine learning model OAM crosstalk prediction.

Student award:

Yes

Level for award:

MSc

Applied Physics / 132

Computational Fluid Dynamics in the ATLAS Detector

Author: Matthew Connell[1]

[1] *University of Johannesburg*

Corresponding Author: rsamconn@gmail.com

The fluid flow and temperature environment of the planned upgrade of the ATLAS inner Tracker is investigated by computational simulation in order to inform design and assure specifications are met. This is done using Computational Fluid Dynamics. The essence of the this approach is that fluid dynamics equations that would be analytically unsolvable for most cases can be approximated to a high degree of accuracy by dividing the geometry into a mesh of millions of tiny cells and solving the equations for each cell individually. The results of adjacent cells must be made to be physically consistent and the simulation can be iterated until solutions converge to the desired accuracy. From this we get distributions for flow, temperature, humidity and almost any other desired quantity, allowing us to understand the environment within the detector and advise on the positioning of sensors. This presentation describes the fluid dynamics simulations, from the specification of the simplified geometry, identifying the physics processes to be included, and finally to results , which are discussed to assess the validity of the model and its significance for the Inner Tracker design process.

Student award:

Yes

Level for award:

PhD

Poster Session / 134

Simulation of a malaria nanoplasmonic biosensor based on extraordinary optical transmission

Author: A.S. Kiyumbi[1]

Co-author: M.S. Tame [1]

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In this study we present the theoretical analysis and optimization of a 2D photonic crystal grating made from gold (Au) for sensing Plasmodium falciparum (Pf) parasites. The study is based on a previous reported plasmon sensor, which is the first experimental demonstration of Plasmodium detection in whole blood samples by directly probing antibody-antigen interactions with extraordinary optical transmission (EOT). The sensor is made of equal distance periodic circular nanoholes on a gold planar surface. When probed by TM polarized light, these nanoholes give rise to EOT resonant peaks resulting from the hybridisation between surface plasmon polaritons (SPPs) and optical modes inside nanoholes. By monitoring these transmission spectrum peaks, the induced refractive index perturbation due to Pf-antibody-antigen interactions can be accurately measured.

Student award:

Yes

Level for award:

PhD

Physics of Condensed Matter and Materials / 135

Phase stability prediction of mixed Li2S1-xSex system

Authors: Cliffton Masedi[1]; Phuti Ngoepe[1]

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Recent rechargeable batteries are mainly based on conventional lithium intercalation chemistry, using lithium transition metal oxides as cathode material with typical capacities of 120-160 mA.h/g. The low energy density and/ or high cost of these cathode materials have limited their large scale production and application in Li ion batteries. Exploration of new cathode materials is consequently necessary to realise more efficient energy storage systems. Lithium sulphur cells have a promise of providing 2-5 times the energy density of Li-ion cells, however, they suffer poor cycling performance. Improvements that are effected by using Li/SeSxsystem in different electrolytes have been reported. In the current study we employ computational modelling methods to explore stability, structural and electronic properties of discharge products formed in the Li/SeSx battery, which has potential to offer higher theoretical specific energy and remedies the challenges that Li-S battery encounters. First principle methods were used to calculate thermodynamic properties of Li2S and Li2Se, which agreed with available experimental results. A cluster expansion technique generated new stable phases of Li/SSex system and Monte Carlo simulations determined concentration and temperature ranges in which the systems mix. Interatomic Born Meyer potential models for Li2S and Li2Se were derived and validated and used to explore high temperature structural and transport properties of mixed systems.

Student award:

No

Level for award:

N/A

Physics for Development, Education and Outreach / 136

Assessment of energy supply and use in households of Mudavula village in Collins Chabane Municipality in Limpopo province

Authors: Busisiwe Mbuyisa[1]; Sophie Mulaudzi[1]; David Tinarwo[1]; Eric Maluta[1]

[1] *University of Venda*

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With the ever-increasing energy challenges, globally and in South Africa, the diversification in the energy mix with a high proportion of alternative energy sources is becoming imperative. In Mudavula village, most households are connected to the national electricity grid (ESKOM). This study assesses the state of energy supply and usage in Mudavula village in Limpopo Province, focusing on the impacts of poverty, unemployment, and lack of funding on the exploitation of available renewable energy sources. The paper presents a deep analysis of the energy use and renewable energy production from the solar home systems (SHS) installed in some households in the study area. The study applied qualitative and quantitative research methods to investigate community members' perceptions and choices regarding the use of PV systems, SHS, and ESKOM electricity. An online google form questionnaire was used to collect the data. The study found that most of those with grid electricity connections still use traditional firewood for all their heating and cooking needs due to the high costs of electricity. The energy mix in the village presents a unique situation that warrants a detailed study to develop other possible pathways for ensuring access to affordable, reliable, sustainable, and modern energy towards achieving sustainable development goals. This study will inform the community about the opportunities available to minimize biomass.

Student award:

Yes

Level for award:

Hons

Photonics / 137

Resolution enhancement in quantum ghost imaging by machine intelligence

Authors: Chané Simone Moodley[1]; Andrew Forbes[1]

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Quantum ghost imaging is an alternative imaging technique which utilises pairs of entangled photons to reconstruct an image. Information from either one of the photons alone does not allow for image reconstruction, rather the image is reconstructed by using the correlations that exist between the photon pair. Interestingly, these photon pairs can be either degenerate or non-degenerate in nature. Due to the scanning nature of spatially resolving detectors, necessary to detect one of the photon pair, and the inherent low light levels of quantum experiments - imaging speeds are inefficient and scale quadratically with the required resolution. To overcome these limitations, we implemented a series of deep learning and machine learning algorithms to achieve early object recognition and to super-resolve the reconstructed image. In applications where object discrimination is important, we achieved a 5x reduction in image acquisition times, recognising the object and stopping the experiment early while maintaining all necessary object information. While in applications that require a high-resolution image, we super-resolved the images to a resolution 4x greater than the measured resolution, without the lossy aspects that occur with image resampling. This, therefore, leads to faster and more efficient image acquisition times without losing fine details of the image. Our techniques were tested on both degenerate and non-degenerate imaging systems but can extend to many systems that are of quantum nature. We believe that these intelligent algorithms, implemented in ghost imaging, will prove valuable to the community who are focusing their efforts on time-efficient ghost imaging.

Student award:

Yes

Level for award:

PhD

Physics for Development, Education and Outreach / 138

A modal approach to teaching and understanding paraxial light propagation

Authors: Chané Simone Moodley[1]; Hend SROOR[2]; Valeria Rodriguez-Fajardo[3]; Qiwan Zhan[4]; Andrew Forbes[1]

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Corresponding Author: chane13.m@gmail.com

Traditional propagation calculations in photonics textbooks and courses pose a daunting task for beginners. The angular spectrum method is a complex numerical calculation that requires knowledge of 2D Fast-Fourier Transorms (FFTs) and their inverses, additionally it lacks physical insight into the nature of propagation making it relatively complicated for many students to fully grasp. The need to develop an approach to model this fundamental calculation in an easy-to-understand-and-apply manner is crucial to the growth of educational resources in photonics. We, therefore, developed an intuitive and instructive method to propagate arbitrary optical fields from a modal perspective allowing for a clear, fast and comprehensive calculation. We decompose an initial field at the plane z = 0 into an appropriate basis with a known z-dependent propagation function. Each basis ele-

ment in the decomposition can be propagated analytically, and therefore, so too can the entire initial field which may not have any known analytical propagation rule. To illustrate the ease of implementation and accuracy of the approach, we compare it to the numerical angular spectrum approach, showing excellent agreement, and then validate the method by experiment. We believe that this approach is a powerful and intuitive resource for educational institutions specialising in optics and photonics.

Student award:

Yes

Level for award:

PhD

Applied Physics / **139**

Reconstructing a quantum ghost image without a camera

Authors: Chané Simone Moodley[1]; Andrew Forbes[1]

[1] *University of the Witwatersrand*

Corresponding Author: chane13.m@gmail.com

Pairs of entangled photos are used to reconstruct an image in the application area known as quantum ghost imaging. It is the correlation between the photon pair that allows for the reconstruction of the image, as opposed to single photon detection. The entangled photons are spatially separated into two independent paths, one to illuminate the object and the other which is collected by a spatially resolving detector. Initially, ghost imaging experiments accomplished spatially resolving detectors by moving a single-pixel detector throughout a transverse scanning area. Advancements consisted of using ultra-sensitive cameras to avoid a system consisting of physically moving detectors. Ultra-sensitive cameras are, however, expensive and have limited spectral sensitivity. Here we demonstrate an alternative by utilising a spatial light modulator and a bucket detector to spatially resolve what is detected. Historically, imaging speeds have been slow and inefficient due to the quadratic increase in the scanning capability for spatially resolved detectors and the low light levels associated with quantum experiments. Here we additionally utilise deep learning algorithms to improve both image reconstruction time and resolution. We demonstrate this with a non-degenerate ghost imaging setup where the physical parameters such as the mask type and resolution are varied and controlled on a spatial light modulator. Thereby answering the question: can we image an object without using a camera?

Student award:

Yes

Level for award:

PhD

Photonics / **140**

Broadband Beam Shaping Using Digital Micromirror Devices

Author: Leerin Michaela Perumal[1]

Co-authors: Angela Dudley [2]; Andrew Forbes [3]

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The appeal of beam shaping and wavefront control for coherent broadband sources has always been imbedded within the idea that the techniques and or devices implored to accomplish this, could allow one to modulate any wavelength of light using a single optical device. In recent years phase-only devices such as spatial light modulators (SLMs) have been explored to modulate and control the wavefront of broadband sources. However, the cost and calibration of these devices can be dire when compared to amplitude-only devices such as digital micromirror devices (DMDs). Since DMDs require no wavelength-dependent calibration process and are polarization independent, it Is plausible to suggest that they could be used for broadband modulation. In this work we will offer a demonstration of how this can be accomplished. We therefore offer a single cost-efficient and versatile tool for the modulation of broadband or, in theory, any desired wavelength of light which may have applications in the fields of optical communication, information processing or detection and imaging.

Student award:

Yes

Level for award:

MSc

Applied Physics / **141**

Construction of the Solar Trough Cavity Receiver

Author: Phil Ferrer[1]

Co-authors: Khaled Mohamad ; Marie Chantal Cyulinyana ; Victor Kaluba

[1] *wits*

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Over the past years, we have developed a unique receiver geometry which allows for efficient conversion of solar energy at elevated temperatures in a solar trough unit. Due to the directional nature of the cavity, where the opening is facing the parabolic mirror, the focal length of the mirror is unconventional, and required its own design. Further, the location of the focal plane in relation to the receiver, and all related complications, needed to be simulated for maximum efficiency. The simulation have suggested design optimisations, and we present how these considerations are used in the construction of a 14kW solar trough prototype.

Student award:

No

Level for award:

N/A

Astrophysics / **142**

MeerKAT's view on galaxy clusters: Diffuse radio emission in MeerKAT Galaxy Cluster Legacy Survey (MGCLS)

Author: Konstantinos Kolokythas[1]

Co-authors: Tiziana Venturi [2]; Ilani Loubser [1]; Kenda Knowles [3]

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[2] *INAF—Istituto di Radioastronomia*

[3] *University of KwaZulu-Natal, Durban (UKZN), SARAO*

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Galaxy clusters are the largest gravitationally-bound structures in the Universe, with their baryonic mass being distributed between the constituent galaxies and the ionized plasma of their intracluster medium (ICM). As such, radio observations of galaxy clusters are powerful tools for the detection of diffuse cluster-scale synchrotron emission, which carries information about the cluster formation history. Observations using Square Kilometre Array precursor and pathfinder instruments are nowadays opening up a new window on diffuse cluster sources and challenge our simple classification scheme (radio halos, mini-halos, and radio relics), making clear the need for an update of our current knowledge. Towards this direction the MeerKAT telescope carried out a program of long-track observations of galaxy clusters in L-band which became the MeerKAT's Galaxy Cluster Legacy Survey (MGCLS), consisting of ~1000 hours, observing 115 galaxy clusters at 1.28 GHz spread out over the Southern sky. In this talk, I will present an overview of the MGCLS, focusing on the diffuse emission detected in galaxy clusters showing a few significant examples to reveal both the much-improved radio images compared to previous observations, as well as new discoveries that open up new areas of investigation in cluster formation and evolution.

Student award:

No

Level for award:

N/A

Nuclear, Particle and Radiation Physics / **143**

Measurement of the leptonic charge asymmetry in \ttw production using the trilepton final state in proton-proton collisions at centre-of-mass energy of 13 TeV using the ATLAS experiment

Authors: Cameron Garvey[None]; JAMES KEAVENEY[1]; Sahal Yacoob[1]

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A measurement of the leptonic charge asymmetry (A_C^ℓ) in top quark pair production in association with a, W boson ($t\bar{t}W^\pm$) is presented using the trilepton final state. The A_C^ℓ is sensitive to new physics beyond the standard model, such as the axigluon and as a result, a measurement of the A_C^ℓ could prove useful in searches for new physics. The data set used in this measurement consists of proton-proton collisions at the Large Hadron Collider (LHC) at a $\sqrt{s}$ = 13 TeV, which was recorded using the ATLAS experiment and corresponds to an integrated luminosity of 139 fb^{-1}.

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. To calculate the A_C^ℓ the pseudorapidities of the two leptons that decay from a top quark and a top anti-quark are required. As such lepton-top association was implemented using machine learning which correctly identified leptons decaying from top quarks in 72% of $t\bar{t}W^\pm$ events.

The extraction of the A_C^ℓ is done using a profile likelihood fit to the event yields in multiple regions defined in terms of the positive and negative difference of absolutes between the pseudorapidities of the charged leptons from top quark and top anti-quark decays. A preliminary blinded result, which includes a comprehensive set of systematic uncertainties, of the leptonic charge asymmetry is given by A_C^ℓ = -8% $\pm$ 17%. The dominant source of uncertainty is due to the limited size of the data set. Further data acquired at the LHC over the next decade should reduce the impact of the dominant uncertainty of the measurement of the A_C^ℓ in $t\bar{t}W^\pm$.

Student award:

Yes

Level for award:

PhD

Applied Physics / **144**

Simulation Modelling the Conductivity of Metal Oxide Gas Sensors from the First Principles

Authors: Blessing Mvana Nhlozi[1]; Betty Kibirige[1]

[1] *University of Zululand*

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It is beneficial to construct a model that will aid in the development of ways to analyze a system qualitatively or quantitatively in any study. The goal of this research was to create a system that imitated physical adsorption on the surface of Metal Oxide gas sensors from the ground up. A mathematical expression was developed that relates time to the amount of adsorbed gas molecules. Python was used to create a simulation environment. The findings were compared to experimental data from the literature.

Student award:

Yes

Level for award:

Hons

Photonics / **145**

Flatptop beam shaping for use in optical fiber

Author: Ashley Phala[1]

Co-authors: Angela Dudley [1]; Andrew Forbes [1]

[1] *University of Witwatersrand*

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Laser beams structured with a uniform flattop profile have become a topic of interest in industrial fields such high-power beam delivery directly to the point of contact for laser cutting, welding and additive manufacturing. These applications require fibre delivery of the optical mode to the point of contact. Here, we generate and tailor a flattop profile using a spatial light modulator. We propagate the flattop into a few mode fiber and compare the Stokes polarimetry measurements before and after the fiber, as well as the modal decomposition of the initial and emerging flattop modes to determine their modal content.

Student award:

Yes

Level for award:

MSc

Photonics / **146**

Wavelength calibration of a monochromator system

Author: Irma Rabe[1]

Co-authors: Pieter Du Toit [1]; Rheinhardt Sieberhagen [1]

[1] *NMISA Photometry & Radiometry scientist*

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A new system for measurement of spectral power responsivity of detectors, utilising a monochromator system, was implemented at NMISA and characterised. The monochromator system includes sources of optical radiation, input optics, order sorting filters, a scanning double monochromator, diffraction gratings and output optics. As part of the characterisation, wavelength calibrations were performed in the wavelength regions of 200 nm to 400 nm and 600 nm to 1 100 nm. This was done by measuring the relevant spectral lines of wavelength standards selected from the NIST Atomic Spectra Database, and applying corrections for ambient conditions using the Engineering Metrology Toolbox of NIST. The monochromator steps corresponding to the spectral peaks measured were determined using the steep-side method. A linear fit of the spectral peaks versus the corresponding monochromator steps provided the wavelength calibration equations. These were then used when scanning the wavelength regions with the monochromator software. Uncertainty of measurement analyses were performed for each of the wavelength calibrations to determine the uncertainty associated with the wavelength position of the monochromator and its influence on the spectral power responsivity of a detector.

Student award:

Yes

Level for award:

MSc

Poster Session / **147**

The investigation between covariability of energy fluxes and CO2 flux exchanges at Skukuza Kruger National Park by Eddy Covariance technique

Author: Lufuno Takalani[1]

Co-authors: Humbelani Thenga [2]; Mohau Mateyisi [2]; Eric Maluta [1]; Sophie Mulaudzi [1]

[1] *University of Venda*

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The contribution of the Kruger National Park South Africa ecosystem to Carbon uptake and emission is highly variable across the years due to perturbations in vegetation cover as driven by large herbivores and inter annual climate variability. The quantification of the contribution of savanna ecosystems to the global carbon budget is still highly uncertain. This can account for by unavailability of CO2 measurements as well as changes in patterns of land use. This study explores the simultaneous changes in CO2 flux exchanges and energy fluxes to understand the response of vegetation to climate variability. We have investigated the covarability between energy fluxes such as sensible heat flux, latent heat flux and net radiation and CO2 flux exchange by Eddy Covariance technique at Skukuza Kruger National Park South Africa. The patterns of the energy fluxes and net ecosystem exchange(NEE) during 1st January 2017 and 2018 shows the ecosystem as a sink of Carbon with average of -11,6177 umol.m-2.s-1 daytime, +4,6354 umol.m-2.s-1 nighttime, -8,3959 umol.m-2.s-1 daytime, +6,3479 umol.m-2.s-1 nighttime, respectively. CO2 fluxes showed similar trends during the hydro-ecological year with average of +0,8455 umol.m-2.s-1 and +0,1102 umol.m-2.s-1 annual increase from 2017 and 2018,respectively. While the energy flux increases with a decrease in carbon sink over that period from H = 67,3488 w/m2 , LE = 78,7404 w/m2 and Rn-MET = 86,4002 w/m2 up to H = 82,3075 w/m2 , Rn-MET = 99,0331 w/m2 and down LE = 40,4249 w/m2 contribution of the change from dry year to wet year for 2017 and 2018 ,respectively. The increasing in energy fluxes and CO2 flux exchanges shows connection that have large implications to the Skukuza area and its response to inter-annual variability.

Keywords: Net ecosystem exchange, energy fluxes, carbon sink, eddy covariance

Student award:

Yes

Level for award:

MSc

Applied Physics / **148**

Tailoring Noise Invariant Light for Robust Optical Communication

Authors: Asher Klug[1]; Cade Ribeiro Peters[1]; Andrew Forbes[2]

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Long distance optical communication has long relied on the use of single mode optical fibres to transport information. This method is limited because only one mode may be used thus restricting the rate at which data can be transferred. Conversely, free space propagation can make use of multiple modes, allowing for a much greater rate of data transfer. The main obstacle to overcome in free space optical communication is atmospheric turbulence. The atmosphere undergoes many fluctuations in temperature and pressure which in turn create random fluctuations in the refractive index. This turbulent behaviour can greatly alter any shape of structured light travelling through the atmosphere thus making long range propagation of structured light very difficult for encoding information. Several methods have been put forward to compensate for this including the use of machine learning, adaptive optics for pre-and post-correction and iterative routines. In our approach, we aim to find shapes of light that will remain robust through atmospheric turbulence by treating the atmosphere as a single unitary operator and then calculating the eigenstates (also called eigenmodes) of the operator. The effectiveness of this technique was demonstrated by using a structured light modulator to simulate the effects of atmospheric turbulence. We then compare these effects on both our calculated eigenmode and an eigenmode of free space. Our results show that the calculated eigenmode remains significantly more robust through turbulence than the eigenmode of free space. These results and the ability to calculate the eigenmodes of complex media will be very useful in many fields such as imaging and free space optical communication.

Student award:

Yes

Level for award:

MSc

Applied Physics / **149**

Modal Description of Optical Elements

Author: Pedro Ornelas[1]

Co-authors: Wagner Tavares Buono [1]; Andrew Forbes [2]

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[2] *U. Witwatersrand*

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Optical modal decomposition is a very well-known technique of expressing some arbitrary field as a linear superposition of spatial modes that form a complete and orthogonal basis, not unlike the reconstruction of some signal via a combination of sinusoidal functions with varying frequencies. The reconstruction of a field created out of a superposition of modes chosen from some pre-selected basis has been shown to not only be successful, but with careful selection of the variable beam waist of the basis, it has been demonstrated that the modal decomposition can be optimized to reduce the number of required modes used to accurately describe the field. We are however, not limited to this kind of field, in principle any arbitrary field should have a modal description however such an arbitrary field may require an impractical amount of modes to accurately describe it. Here we investigate the effect of changing the beam waist and switching between different complete and or-

thogonal bases to reduce the number of modes required to describe some field with high fidelity. We demonstrate the effectiveness of our method by reconstructing the phase and intensity of an arbitrary image and by way of example we reconstruct the field of an OAM mode passing through a triangular slit. We then propagate the modal descriptions of these fields and compare our results to the angular spectrum method of propagation. The recreation of truly arbitrary fields extends the practicality of modal decomposition as a computational and experimental technique and by extension it would allow for the accurate description of the propagation dynamics of a larger array of fields including those that interact with any chosen optical element.

Student award:

Yes

Level for award:

MSc

Photonics / **150**

A New Angle on the Tilted Lens

Authors: Wagner Tavares Buono[1]; Cade Ribeiro Peters[1]; Andrew Forbes[2]

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[2] *U. Witwatersrand*

Corresponding Author: 1843828@students.wits.ac.za

Passing a beam through an aberrated optical system can result in unwanted changes to both the phase and amplitude of the beam. These changes can greatly degrade many important properties of the beam such as the resolution, spot size in focusing and the beam quality factor. These aberrations are generally corrected for using pre- or post-corrective optics or other methods. The ideal solution for overcoming these issues would be to find the structures of light that remain unchanged when passing through these aberrated systems, also called the eigenmodes of the system. In this work we show that these modes can be calculated by treating the optical system as an operator and then finding the eigenstates of the operator. We experimentally confirm the effectiveness of the method by making use of the topical example of the tilted lens, which is a highly astigmatic system that has been used to measure the topological charge of OAM modes. We find the eigenmodes of the tilted lens analytically and demonstrate their practical robustness using an experimental setup. This work has many applications in the fields of optics, imaging and optical communications.

Student award:

Yes

Level for award:

MSc

Photonics / **151**

The Most Robust Modes Through Atmospheric Turbulence

Authors: Cade Ribeiro Peters[1]; Asher Klug[1]; Andrew Forbes[2]

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Corresponding Author: 1843828@students.wits.ac.za

Long distance optical communication has been dominated by the use of single mode optical fibres. These fibres can only accept one mode of structured light thus limiting the rate and which information can be sent and received. Conversely, free space propagation can make use of multiple

modes which open up additional degrees of freedom to store information thus making information transfer significantly faster. The downside of free space propagation is the effects of atmospheric turbulence. There are many fluctuations in our atmosphere due to temperature and pressure variations which in turn create random fluctuations in the refractive index. This turbulent behaviour can greatly alter the shape of structured light travelling through the atmosphere thus making its long range propagation difficult for encoding information. It has been shown that certain shapes of light can remain robust and maintain their shape while travelling through atmospheric turbulence (the so-called eigenmodes of turbulence). In this work we will show that it has also been observed that while there are a large number of theoretical eigenmodes for a given instance of turbulence, only some of these modes perform well in practice. We will also show that the eigenmodes that remain robust in practice share several useful and unique properties that make them easily identifiable and easy to find when presented with the many eigenmodes for a given turbulence operator. This work has many useful applications including uses in the fields of imaging and optical free space communications.

Student award:

Yes

Level for award:

MSc

Poster Session / **152**

Threading a laser through the eye of a needle: Multimode Fibre Coupling in Turbulence

Author: Fortune Iga[1]

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The unequal access to reliable internet connectivity between urban and peri-urban areas remains an issue of concern in many developing countries, including South Africa. A major reason for this so-called 'digital divide' is the unequal distribution of fibre infrastructure, which is usually due to economic or geographic reasons. This could be mitigated through the deployment of Free Space Optical (FSO) communication, which would extend the optical network to marginalized areas, without the need for more fibre infrastructure. FSO systems would provide access to a wider and unlicensed spectrum, allowing for faster and cheaper internet connectivity. Despite its many benefits, modern FSO technology remains too expensive and inaccessible to low-income residents of peri-urban areas. The cost of such technology could be significantly improved by hacking off-the-shelf fibre hardware, such as small form-factor pluggable (SFP) transceiver modules. However, unlike in fiber optical networks, a light beam propagating in free space is faced with a number of attenuation factors such as divergence, atmospheric turbulence and beam wander. These factors increase the complexity of coupling light into hardware kilometers away. As such, the optimization of light coupling is a crucial step to be taken if off-the-shelf fibre hardware is to be used in FSO applications. This poster will present the optimization of light coupling from free space into an SFP module, by analyzing different coupling mechanisms to determine the optimum method.

Student award:

Yes

Level for award:

MSc

Astrophysics / 153

Constraining the properties of Dark Matter using multi-messenger observations of dwarf galaxies

Author: Raees Noorbhai[1]

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The next generation of telescopes in the gamma-ray, neutrino and radio domains have opened up a promising new avenue through which we can utilise multi-messenger astronomy to understand the nature of Dark Matter. An analysis of neutrino observations with KM3NeT and radio observations with MeerKAT illustrate this potential for DM indirect detection. A comparative analysis of gamma ray observations using CTA and LHAASO further illustrates how the unprecedented sensitivities of the new telescopes exceed those of previous generations. We consider a DM model involving a TeV WIMP that couples exclusively with SM Leptons, via a heavy mediator. It is a generalization of the multiple hypotheses posited to explain the excess Wukong flux detected in late 2017. We simulate the expected indirect emissions from DM Annihilation and Decay in the gamma-ray and neutrino domains, along with the radio domain through the mechanism of synchrotron radiation. One ultra-faint dwarf spheroidal galaxy, Reticulum II, is chosen as the primary observational target. It is DM-dominated, with high astrophysical J and D factors. For comparison, we consider one classical dwarf, Sculptor. Thus, using conservative estimates of the telescope sensitivities, we forecast and interpret strong non-detection upper bounds on the WIMP Annihilation Cross Section and Decay Rate.

Student award:

Yes

Level for award:

MSc

Applied Physics / 154

Analysis of bulk materials using fast neutron transmission analysis

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The non-destructive elemental analysis of materials is of interest to many industries, and fast neutron based techniques are of particular interest due to their sensitivity to low mass elements such as H, C and O. Neutron interactions are strongly energy dependent, and produce a variety of characteristic radiation signatures such as prompt and delayed gamma rays, or transmitted and scattered neutrons. Exposing a sample to a field of neutrons, and measuring the subsequent radiation signatures can be used to determine the sample composition. Examples of established neutron based techniques include delayed gamma ray neutron activation analysis (DGNAA), prompt gamma ray neutron activation analysis (PGNAA), fast neutron scattering analysis (FNSA) and fast neutron transmission analysis (FNTA). The n-lab is a fast neutron laboratory at the University of Cape Town, and has been previously been deployed in the analysis of bulk samples using fast neutrons. Presented in this work are the results from recent FNTA measurements of 14.1 MeV neutrons incident on graphite (C) and high-density polyethylene (C_2H_4). Transmitted neutron energy spectra were unfolded from pulse height spectra measured with an EJ301 organic liquid scintillator for a range of sample dimensions. From the unfolded neutron energy spectra, the elemental effective removal cross sections for carbon and hydrogen were determined for 14.1 MeV neutrons, and compared to results obtained from Monte Carlo simulations.

Student award:

Yes

Level for award:

PhD

Applied Physics / 155

Validation of the Monte Carlo Detector Effects model for the UCT POLARIS Compton camera

Authors: Frank Smuts[1]; Steve Peterson[1]; Nicholas Hyslop[1]; Paul Maggi[2]; Jerimy Polf[3]

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The benefit of proton therapy will only truly be realized once an experimental in-vivo dose verification system has been developed. The use of a Compton Camera (CC) allows detection of the secondary radiation, specifically Prompt Gammas (PG), produced at the location of the dose deposition. The UCT Polaris detector is composed of two separate stages with two CdZnTe positron-sensitive crystals per stage, configurable in an orthogonal or face-to-face alignment. Previous work has shown that the CdZnTe crystals experience significant deadtime when exposed to a high dose-rate proton beam. The Monte Carlo Detector Effects (MCDE) model was developed to replicate these deadtime effects. The goal of this work was to adapt the MCDE model to the UCT Polaris detection system, to allow for new detector configurations and to broaden the applicability of the model to high-activity gamma sources. The MCDE model results are compared to measured data from both a positron source in face-to-face configuration and a proton beam in orthogonal configuration. The observed differences between the measured and simulated results point to an overestimation in the underlying Geant4 model and to a change in one of the timing parameters used in the MCDE model. A two-parameter optimization code was run to improve the overall comparison between simulation and experiment, providing the most extensive validation of the MCDE model to date.

Student award:

Yes

Level for award:

Hons

Nuclear, Particle and Radiation Physics / 156

A search for tWZ production with the ATLAS detector using the three and four lepton final states in proton-proton collisions at $\sqrt{s}$ = 13TeV

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The production of a single top quark with an associated W and Z boson (tWZ) is a rare Standard Model process which has never before been measured. This process is sensitive to the top quark electroweak coupling found in some Beyond Standard Model theories such as Standard Model Effective Field theory and may hold information for constraining these theories. A previous search has been performed for tWZ production using 139 fb^{-1} of proton-proton collision data at a centre of mass energy of 13 TeV recorded at the ATLAS detector. The search was performed across the tetralepton and trilepton final states and have been combined to further increase the sensitivity of the analysis. This analysis was expanded to include a comprehensive set of systematic uncertainties. The work presented will include new preliminary blinded results for the cross section of tWZ production.

Student award:

Yes

Level for award:

MSc

Poster Session / **157**

Setting up an environment to monitor and analyse ATLAS Tile Calorimeter detector control system temperatures

Author: Lungisani Phakathi[None]

Co-authors: Betty Kibirige [1]; Juraj Smiesko ; Filipe Martins

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The purpose of the work is having a solid and flexible environment of web interface, to rich that a well set environment is invaluable for Tile-in-One (Tio). Plugin based system for assessing the quality of data and conditions for ATLAS Tile Calorimeters is known as the Tile-in-One. The TiO is a collection of small sized independent web tools called plugins, designed to make it easier for a user to evaluate Tile Calorimeter (TileCal) data. TiO platform aims to integrate individual TileCal web tools into a single common services and data, as old interfaces are slowly falling behind and are harder and harder to maintain. The TiO web platform should allow large flexibility and eade of maintenance so that it would be friendly to the plugin developers as well. The set-up of an environment was done in a way that it can query Data Control System (DCS) to provide temperature data through a dedicated interface called DCS Data Viewer (DDV). Based on the possibility to query those data, new environment is being developed under the following strategy: Centos 8 was installed inside the virtual box to easily access CERN internal network. This strategy ensures that DDV tool is used very well to query the Tile DCS temperature data which is subsequently transformed to a form suitable for the visualizing library.The visualization tool allows use to interact with the plots. Currently the set-up is done for easy access to the network and since this is on the development a status of a drawer is shown. The focus is having stable environment and concentrated on finding an intuitive way to display not only the status of one particular module, but the whole detector as well.

Student award:

Yes

Level for award:

MSc

Poster Session / **158**

A modified Zinc Oxide (ZnO) gas sensor approach to detect oxidizing gases

Authors: Lungisani Sipho Phakathi[None]; Betty Kibirige[1]

Co-author: Sanele Scelo Gumede

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Selective detection of gases such as nitrogen dioxide (NO2), carbon monoxide (CO), carbon dioxide (CO2), and various volatile organic components is necessary for air quality monitoring and safety. There are several metal oxide gas sensors (MOGS), but the focus of this study was Zinc Oxide (ZnO); an n-type MOGS. NO2, an oxidising gas was the target gas. The aim of this study was to establish the possible enhancement of a gas sensor selectivity by the introduction of signal conditioning electronics circuitry such as the Wheatstone bridge in tandem with an operation amplifier circuit. Exposing electronics enhanced ZnO MOGS system to NO2 resulted in a negatively increasing voltage output between 0 and -3.5 V. This range of voltages is sufficient to run a micro-controller, with the assumption that a reducing gas would result in a positively increasing voltage, a micro-controller could be conditioned to select between an oxidizing and a reducing gas.

Student award:

Yes

Level for award:

Hons

Poster Session / **160**

The effect of ferromagnetic elements (Fe, Ni) on the magnetic properties of MnPt alloy

Author: Ramogohlo Diale[1]

Co-authors: Phuti Ngoepe [2]; Maje Phasha [3]; Joseph Moema [3]; Hasani Chauke [4]

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The L10 MnPt alloy is useful for magnetic recording and spintronic applications due to its high ferromagnetic stability. Previous studies showed that this alloy maintains its ferromagnetism at room temperature. In this study, first-principles method was used to investigate the effect of partial substitution of Mn in MnPt with ferromagnetic elements M (M= Fe, Ni). The ground-state properties of the binary Mn50Pt50 are found to agree with the available experimental data and others theoretical results. The heats of formation of L10 Pt50Mn50-xMx alloys were found to be negative, suggesting that the alloys are thermodynamically possible to form. Furthermore, L10 Pt50Mn43.75M6.25 was predicted to be the most stable structure (displaying the lowest heats of formation) when the c/a ratio is 1.11 compared to other competing ratios. A ferromagnetic state can be attained in Pt50Mn50-xMx by a small difference in the tetragonality ratio from 1.1 to 1.3. The elastic constants, Bulk, Shear and Young's moduli were also calculated. Finally, the ductility of Pt50Mn50-xMx was evaluated using the B/G ratio, Cauchy pressure and Poisson's ratio σ. As a result, a first-principles method was successfully used to understand the magnetism and stability of Pt50Mn50-xMx alloys upon introduction of ferromagnetic Fe and Ni.

Student award:

No

Level for award:

N/A

Poster Session / **161**

Vibrational and thermodynamic properties of monazite-type LnPO4 (Ln=La, Ce): A first Principles study

Author: Lebogang Motsomone[1]

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

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Monazite is an ore mineral consisting of various rare earth elements (REEs), thorium (Th), and uranium (U). These components are utilized in numerous modern areas of technology, including metallurgy, catalysis, and magnetic fields. This monazite mineral has a notoriously stable structural conformation, making the conventional cracking process extremely inefficient. However, new innovative technologies (e.g., thermal cracking) have been proposed for improving the extraction of REEs (such as La,Ce and Nd), Th and U. In this study, we evaluate theoretical considerations relating to these thermal processes on the inherent monazite structure. First-principles calculation based on density functional theory was used to investigate vibrational and thermodynamic prop-

erties of monazite systems. It was found that the lattice parameters of LaPO4 and CePO4 monazite correlate well with experimental values to within 5% error. The heats of formation value for LaPO4 (-0.766 eV/atom) is more negative than for CePO4 (-0.729 eV/atom), suggesting the most stable structure. The vibrational instability of LaPO4 and CePO4 systems emanates from the observed soft mode by the phonon dispersion curves. Furthermore, monazite systems were found to exhibit electron excitation at a temperature of about 500 K. The findings assisted in understanding the physical movement of atoms, crystal packing and thermodynamic structure of monazite at evaluated temperatures.

Keywords: Monazite, Density functional theory, Thermodynamics properties

Student award:

Yes

Level for award:

MSc

Space Science / **163**

Enhanced Vacuum Arc Thruster with Pulsed Magnetic Fields

Author: Tristan Rencken[None]

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The implementation of a pulsed magnetic field to the plasma of a vacuum arc thruster allows the increased collimation of ions with the plasma plume and increases the thrust directed along the normal of the thrusters. The magnetic field is generated with a capacitive discharge coil which can achieve magnetic field strengths up to 300mT.The coaxial design of the Vacuum Arc Thruster allows for the adjustment of the magnetic field alignment in order to direct the ions within the plasma plume and induce thrust vectoring. Numerical simulations using Particle-In-Cell methods and Experimental methods show a good agreement. We will discuss the correlation between the plasma plume ion distribution and the magnetic field strength at various angles of alignment, and show how the magnetic field configurations effect the overall thrust performance of the Vacuum Arc Thruster.

Student award:

Yes

Level for award:

MSc

Poster Session / **164**

preparation of erbium activated orthovanadate-phosphate by chemical bath deposition

Authors: Mosidi Mokoena[1]; Selepe Joel Motloung[2]; Kamohelo George Tshabalala[2]; Francis Dejene[3]

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In this work, erbium (Er3+) activated Yttrium orthovanadate-phosphate (YV0.5P0.5O4) nanomaterials were prepared by chemical bath deposition. The concentration of Er3+ was varied between 1 and 10 mole percentage. The structure, surface morphology, elemental composition and optical analysis were carried out by X-ray diffraction (XRD), scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), Fourier – transform infrared spectroscopy (FTIR), and UV–vis spectroscopy (UV). XRD results showed that all the samples have a tetragonal zircon structure. Furthermore, the results showed that the crystallite size increases with Er3+ concentration. SEM shows that the particles were in nano-range and portrayed various shapes. The presence of all the elements forming YV0.5P0.5O4: Er3+ was verified by EDS. FTIR results showed a series of absorption peaks in the range of 650 to 4000 cm-1 and it confirmed the EDS results. Diffuse reflectance spectra (DRS) revealed a broad absorption band in the UV-region which is attributed to the absorption of VO43-. Other f⟶f transitions of Er3+ were also observed at 380, 407, 451, 489, 523, 546 and 654 nm and were attributed 4I15/2 – 4G11/2, 4I15/2 – 4FJ (J= 3/2, 5/2, 7/2, 9/2), 4I15/2 – 2H9/2, 2H11/2 – 4I15/2, and 4S3/2 – 4I15/2 electronic transitions of Er3+. Lastly, The estimated band gaps were found to range between 3.76 and 3.81 eV.

Student award:

Yes

Level for award:

MSc

Physics of Condensed Matter and Materials / **165**

Impact of rapid thermal annealing on the properties of different Ag layer thicknesses Ag/ITO bilayer films

Author: Emmanuel Rasiel Ollotu[1]

Co-authors: Justine Sageka Nyarige [2]; Margaret Samiji [3]; Mmantsae Diale [4]; Nuru Mlyuka [3]

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This study involved rapid thermal annealing of Ag/ITO bilayer films of different Ag layer thicknesses in nitrogen gas at a typical kesterite precursor crystallization temperature. AFM analysis showed a thermally stable surface with fewer high peaks/valleys for the annealed thinner Ag layer bilayer films with relatively normally distributed homogeneous grains. Annealing also increased shrinkage of lattice parameters, changes of the underlying ITO crystal preferential orientation and diminished delafossite (AgInO2) peaks with increasing Ag layer thickness bilayer films. Annealing achieved compressed crystallite size for thinner and tensile crystallite size for thicker Ag layer bilayer films. Un-annealed bilayer films showed enhanced electrical conductivity with increasing Ag layer thickness, however, increasingly deteriorated with annealing. Increasing the un-annealed bilayer films' Ag layer thickness increasingly reduced solar transmittance with maintained a similar shape as the un-annealed ITO films. We observed nearly similar spectral and average transmittance for annealed as the un-annealed ITO films; however, these differed for the annealed bilayer films of different Ag layer thickness. Annealing reduced the band gaps of ITO films and these bilayer films, however, within the bandgap ranges reported for ITO films. Thinner Ag layer bilayer films provided relatively suitable properties for application in bifacial CZTS solar cells back contact. This study extends the use of Ag/ITO bilayer films in optoelectronic applications that require present processing conditions.

Student award:

No

Level for award:

PhD

Theoretical and Computational Physics / **166**

Rapidity Distributions of Pb+Pb and Au+Au from the microscopic Ultra-relativistic Quantum Molecular Dynamics (UrQMD 3.3) model

Author: Thendo Emmanuel Nemakhavhani[1]

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The Ultra-relativistic Quantum Molecular Dynamic model (UrQMD 3.3) is a microscopic model based on a phase space description of nuclear reaction and it can now support the Large Hadron Collider energies (LHC) of up to a $\sqrt{(s_{nn})}$ = 14 TeV. This model is used to simulate the ultra-relativistic heavy-ion collisions of a finite matter between two Pb+Pb and Au+Au collisions at an energy of E_{ecm} = 200 GeV and t = 400-2 fm/c. The simulated results are then used to calculate the rapidity distributions and particle ratios of both mesons particles (π, ρ, and K) and baryons particles (p and $\bar{p}$). The rapidity results show that at early time t fm/c the rapidity of all three light mesons is maximum at mid-rapidity and that of (p and $\bar{p}$) are depicted at mid-rapidity for both Pb+Pb and Au+Au collisions. The particle ratios between different particle species are then compared between that of Pb+Pb collision with that of Au+Au Collision. The results are in good agreement with the previous studies done.

Student award:

Yes

Level for award:

MSc

Space Science / **167**

Simulating Solar Energetic Particle Transport As Observed By Solar Orbiter

Author: Jaclyn Stevens[1]

Co-author: Du Toit Strauss [2]

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Modelling solar energetic particles allows for the prediction of incoming solar radiation events as a way to protect against their potential harmful impact in space. Using omni-directional intensity and anisotropy data from the Solar Orbiter spacecraft for a solar event during December 2020, the particle transport in the turbulent interplanetary medium is simulated. The mean free path as a function of rigidity is derived and compared to theoretical estimates. The derived mean free path can be used in future predictive models to forecast the solar energetic particle intensity.

Student award:

Yes

Level for award:

Hons

Physics of Condensed Matter and Materials / **168**

Structural and magnetic properties of $Co_xNi_{(1-x)}Cr_2O_4$ (x = 0.75, 0.80, 0.85) nanoparticles

Author: Mariam Jacob[1]

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

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The $Co_xNi_{1-x}Cr_2O_4$ (x = 0.75, 0.80, 0.85) were synthesized by co-precipitation technique [1]. The doping of Ni at the Co site was increased in order to understand how this affects the morphology, structural and magnetic properties. All the samples were prepared using co-precipitation techniques and calcined at 900 ℃ to achieve crystalline and pure phase samples. The structural properties of samples were studied using x-ray diffraction (XRD) techniques. The peaks in the XRD profile obtained were well matched with the cubic crystal structure of $CoCr_2O4$ (JCPDS card no. 00-022-1084) having the space group of Fd-3m [2]. The particle size and morphology of the material were obtained by transmission electron microscopy (TEM). The particle size was observed to be non-uniform, thus, the particle size for each sample was determined through analyzes of several TEM micrographs and using a log-normal distribution function [3]. The magnetic behaviour of the samples was studied in both the zero-field cooled warm (ZFCW) mode and the field-cooled warm (FCW) mode [4]. The Curie temperature (T_C) values vary as doping concentration changes. The T_C value decreases from 90 ± 0.5 K to 81 ± 6 K as Ni increases from x = 0.75 to 0.85. In addition, the spiral order transition temperature (T_S) decreases as the concentration of Ni increases. The magnetic field dependent magnetization measurements, M(μ_0 H), measured with different probing fields under the ZFC protocol at different constant temperatures. For all the samples, the coercivity decreases with an increase in temperature. The hysteresis loop does not show classical saturation for all the samples and this behaviour has been reported previously [5]. The magnetic saturation is calculated by linear extrapolation of high field magnetization to zero fields. Also, the samples show an increase in magnetic saturation near the T_C and after T_C the magnetic saturation decreases. The magnetic parameters are determined by using the fitting function [6]: $M=M_S$ $((2/(\pi))\{\arctan[(H+H_C)/H_C]\tan(\pi S/2)\})+\chi H$ The paramagnetic component of the three samples were subtracted and loop is fitted with a simple Langevin equation [7] and the saturation magnetisation values were calculated from the fit. References [1] Y. Cesteros, P. Salagre, F. Medina, J.E. Sueiras, Chem. Mater., 12, 2 (2000) 335. [2] G. Lawes, B. Melot, K. Page, C. Ederer, M.A. Hayward, Th. Proffen, R. Seshadri, Phys. Rev. B 74, (2006) 024413. [3] R. R. Irani, C. F. Callis, Particle Size: Measurement, Interpretation and Application. John Wiley and Sons., New York, (1964). [4] B. L. Choudhary, U. Kumar, S. Kumar, S. Chander, S.Kumar, S. Dalela, S,N. Dolia, P.A. Alvi, J.Magn.Magn.Mater.,166861, (2020) 507. [5] P. Mohanty, A.R.E. Prinsloo, B.P. Doyle, E. Carleschi, C.J. Sheppard, AIP Adv., 8 (2018) 056424. [6] S. Duhalde, M. F. Vignolo, F. Golmar, Phys. Rev. B 72., (2005) 161313. [7] M. Knobel, W. C. Nunes, L.M. Socolovsky, E. De Biasi, J. M. Vargas,J. C. Denardin, J. Nanosci. Nanotechnol.,8 (2008) 2836.

Student award:

Yes

Level for award:

PhD

Poster Session / 169

Electronic, elastic, and transport properties of copper sulphide

Author: MOSHIBUDI RAMOSHABA[1]

Co-author: THUTO MOSUANG [1]

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A full potential all-electron density functional method within generalised gradient approximation is used to investigate the electronic structure of copper sulphide. The electronic structure suggest a semi-metallic material with a zero band gap. Elastic calculations suggest a hard material with the bulk to shear modulus ratio of 0.381. The transport properties were estimated using the Boltzmann transport approach. Electrical conductivity, Seebeck coefficient, and thermal conductivity suggest a potential p-type plasmonic character.

Student award:

Yes

Level for award:

PhD

Astrophysics / 170

Constraining the multipolar magnetic field of millisecond pulsar PSR J0030+0451 via X-ray light curve fitting

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

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The Neutron star Interior Composition Explorer (NICER) was installed aboard the International Space Station (ISS) in 2017 with the major aim of gaining 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 with insights into the magnetic field structure of an NS which further helps us in understanding the morphology of the surface hot spots.

Recent studies suggest strong evidence for a multipolar magnetic field for the millisecond pulsar PSR J0030+0451 using NICER data, while also constraining the parameter space for the magnetic field configuration. We are refining the dipole plus quadrupole model of Kalapotharakos et al. (2021)[1], by including a more general magnetic field configuration, going up to an l=3 component of the multipolar field, and using Markov chain Monte Carlo (MCMC) methods to fit the NICER X-ray light curves.

Exploring the general magnetic multipolar parameter space using MCMC would help us constrain the field structure, and eventually the stellar mass and radius more robustly. In this talk, the newly implemented multipolar field configuration will be highlighted, and some preliminary results of exploring the parameter space using MCMC for the vacuum case will be shown.

Student award:

No

Level for award:

N/A

[1] https://ui.adsabs.harvard.edu/abs/2021ApJ...907...63K/abstract

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Physics of Condensed Matter and Materials / 171

Ab initio and Cluster Expansion study on Magnesium Spinel (MgX2Z4: where X=Sc, Y and In; Z=S and Se)

Authors: KHUMBULANI TIBANE[1]; Cliffton Masedi[1]; Phuti Ngoepe[1]

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Magnesium-ion batteries are facing major setbacks when it comes to the identification of cathode materials which will demonstrate capacities and voltages identical to lithium-ion systems. Then, in this study, we make use of first-principle based calculations to study the stability of the discharge products MgSc2S4, MgSc2Se4, MgY2S4, MgY2Se4, MgIn2S4, and MgIn2Se4 whereby we investigate their structural, mechanical, and electronic properties, and their phase stability. Computational technique was employed utilising the ab initio density functional theory through the Vienna Ab initio Simulation Package code within the generalised gradient approximation in the form of Perdew-Burke-Ernzerhof exchange correlation. Heats of formation shows that all structures are stable. Calculated elastic constants indicate that the structures are mechanical stable which is in good agreement with the phonon dispersion curves. The total density of states indicates that all structures are semi-conductors. Phonon dispersion curves shows that the structures are vibrational stable due to no soft modes observed along the gamma region. Following these discoveries, we employed the Universal Cluster Expansion code, which is a machine learning code. We added Selenium to Sulphur since Selenium has the advantage of prolonging the lifespan of S. It is found that MgSc2S1-xSex, MgY2S1-xSex, and MgIn2S1-xSex systems, generated 97, 61, and 12 new mixed stable phases, respectively. Now the results found in this study aimed to give an insight on the stability of solid electrolytes and in order to provide inspiration for future Research and Development in magnesium-ion batteries.

Student award:

Yes

Level for award:

MSc

Poster Session / 172

Machine Learning Models for Predicting the Density of Sodium-ion Battery Materials

Author: Keletso MONARENG[1]

Co-authors: PETER SENAUOA NTOAHAE [1]; Rapela Maphanga [2,3]

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With unprecedented amounts of materials data generated from experiments, density functional theory and high-throughput density functional theory calculations, machine learning techniques provide the ability to accelerate the discovery and design of novel materials. In this paper, machine learning models that are capable of predicting the densities of sodium-ion battery (SIB) cathode materials were developed. Different machine learning models were developed and validated using SIB materials' properties calculated from DFT as input dataset, with the models' efficiency based on elemental properties of materials constituents as feature vectors. Machine learning models based on Bayesian ridge, gradient boosting regressor, light gradient boosting machine, extra trees regressor, random forest algorithms, and orthogonal matching pursuit were developed and evaluated. Extra trees regressor was found to be the best model in predicting the materials density with accuracy measures of 0.95 and 0.09 for coefficient of determination and mean square error, respectively. Also, the results show that maximum mass specific heat capacity and variance of DFT energy per atom descriptors are the most essential in accurately predicting the materials density.

Student award:

Yes

Level for award:

MSc

Applied Physics / **173**

MicroPEPT: A step towards hybrid PEPT detectors

Author: Robert van der Merwe[1]

Co-authors: Tom Leadbeater ; Stephen Peterson [1]; Andy Buffler [1]; Michael van Heerden [2]; Alice Mcknight [1]

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Positron Emission Particle Tracking (PEPT) measures the trajectory of a freely moving radioactive tracer particle, and enables the non-invasive study of dynamic systems from engineering to medicine. PEPT performance is limited by the activity achievable in radiolabelling a suitable tracer particle, and the fixed geometry of conventional detector systems. In investigating phenomena on micro-scales, recent development of advanced instrumentation has been required to offset these limitations.

A modular bismuth germanate oxide (BGO) scintillator array, with detection modules derived from CTI/Siemens PET scanners, has been constructed and coupled to a recently developed data acquisition system. This array consists of 1024 detector elements (512 pixels of 6.75 x 6.25 x 30 mm and 512 pixels of 4.1 x 4.0 x 30 mm) giving a field of view of 150 mm x 196 mm x 101 mm. Detector efficiency, spatial resolution, timing resolution, and deadtime parameters for this system were determined, informing on the overall system performance and compatibility of different detection modules. Sensitivity profiles were measured and compared to numerical model validation demonstrating reasonable agreement. These results indicate the applicability of modular BGO scintillator arrays in addressing small scale flow phenomena, and lead the direction of future work in combining the BGO system with a pair of high resolution pixelated semiconductor detectors for the first time.

Student award:

Yes

Level for award:

MSc

Physics of Condensed Matter and Materials / **174**

Development of Machine Learning Models for Predicting Energies of Sodium-ion Battery Materials

Author: Keletso MONARENG[1]

Co-authors: Rapela Maphanga [2,3]; PETER SENAUOA NTOAHAE [1]

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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 regression techniques are applied to a large amount of density functional theory calculated data to develop machine learning models capable of accurately predicting the formation and total energy of sodium-ion battery (SIB) cathode materials. Thus, Feature vectors importance derived from properties of materials' chemical compounds and elemental properties of their constituents was evaluated and found average covalent radius and average single bond covalent radius to be the most important descriptor for predicting the formation and total energy. Amongst various algorithms that were evaluated Bayesian ridge model was found to be the best model in predicting the formation energy and total energy, with accuracy of 0.99, 0.98 and 0.01, 0.03 for coefficient of determination and mean square error, respectively. The results show that the descriptors used to predict the energies have predictive capability with a high accuracy

Student award:

Yes

Level for award:

MSc

Theoretical and Computational Physics / **175**

Quantum spectrum of tachyonic black holes in a brane-anti-brane system

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Recently, some authors have considered the quantum spectrum of black holes . This consideration is extended to tachyonic black holes in a brane-anti-brane system. In this study, black holes are constructed from two branes which are connected by a tachyonic tube. As the branes come closer to each other, they evolve and make a transition to thermal black branes. It will be shown that the spectrum of these black holes depends on the tachyonic potential and the separation distance between the branes. By decreasing the separation distance, more energy emerges and the spectrum of the black hole increases.

Student award:

No

Level for award:

N/A

Poster Session / 176

Structural, stability and vacancy properties of both defect free and defected 2D h-BNNSs

Authors: Magopa Tshepho Mcdonald Kekana[1]; Thuto Mosuang[2]

Co-authors: Mokete Mahladisa [3]; Lucky Sekhwivilhu [4]

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The structural, stability and vacancies properties of both defect free and defected 2D h-BNNSs were studied using the classical molecular dynamics (MD) approach. The calculations were performed in the NVT Evans and NPT hoover ensembles using the Tersoff potentials with the Verlet leapfrog algorithm to obtain reliable structural properties and energies for defect free, boron (B) and nitrogen (N) vacancies. B and N defect energies were calculated relative to the bulk defect free total energies, and the results suggest that N vacancy is the most stable vacancy as compared to the B vacancy. The radial distribution functions and structure factors were used to predict the most probable structural form. Mean square displacements suggests the mobility of B and N atoms in the system, which is increasing with an increase in the surface area of the nanosheets. Results obtained are compared with the bulk defect free h-BNNSs.

Student award:

Yes

Level for award:

MSc

Physics of Condensed Matter and Materials / 177

Magnetocaloric effect in Dy based chromium oxides

Author: Eugene Sibanda[None]

Co-authors: Charles Sheppard [1]; Aletta Prinsloo [2]; Pankaj Mohanty [2]

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Rare-earth based chromium oxides have attracted substantial research attention over the years because their unusual properties, such as magnetocaloric effect (MCE) [1-5]. An interesting member of these materials is RCrO$_4$, belonging to a family of ABO_4-type oxides, where A is a rare-earth and B = P, As, Cr, V. RCrO$_4$ compounds crystalize in zircon or monazite-type structure depending on the size of the trivalent rare-earth ion and the B element [1]. The RCrO$_4$ compounds are of significance because of the outer shell configuration ($3d^14s^0$) of the rare and unstable Cr^{5+} ion and the anomalous super-exchange formed by the zircon-type structure. RCrO$_4$ with R = La, Nd, Sm, Eu and Lu behave antiferromagnetically (AFM), while the remaining oxides in the RCrO$_4$ compound family are ferromagnetic (FM) [1-4]. The magnetic orders of RCrO$_4$ are dependent on the structure, based on the variation in the Cr–O–R bond angles and the interatomic distances [1]. In these materials, the R and Cr moments order simultaneously at the same temperature and the R^{3+} and Cr^{5+} ions, both influence the MCE [4]. In the present work, the magnetic and MCE properties of sol-gel synthesized DyCrO$_4$ rare-earth compound are studied. The as-synthesized sample was found to have an amorphous phase. Calcination of the amorphous powder at 500 ℃ for 2 h, transformed the hydroxide into DyCrO$_4$ oxide. Transmission electron microscopy (TEM) analysis of DyCrO$_4$, showed that the sample is agglomerated, and grain boundaries are indistinguishable. For both samples, the selected area electron diffraction (SAED) patterns confirmed the crystallinity, with the energy dispersive spectroscopy (EDS) verifying the pure elemental composition. The susceptibility as a function of temperature, χ(T), shows paramagnetic (PM) to FM transition for DyCrO$_4$ at 21.6 ± 0.1 K. The positive value of Curie-Weiss temperature, $_{CW}$, confirms the FM behaviour of DyCrO$_4$ sample below the Curie temperature, T_C. The maximum entropy change, ΔS_M (T, H), is observed at about 21.96 K, close to the FM transition of the sample. This observation shows that Dy^{3+} and Cr^{5+} ions both influence the MCE, as Dy and Cr moments order simultaneously at the same temperature, with T_C = 21.6 ± 0.1 K [4]. The transition temperatures observed in the (T) curves are further confirmed with M(μ_0, H) measurements. Further calcining the amorphous powder at 900 ℃ resulted in the formation of DyCrO$_3$ having orthorhombically distorted perovskite structures [5]. The MCE properties of the DyCrO$_3$ [5] and DyCrO$_4$ samples showed that both samples are good for MR application, with DyCrO$_4$ showing more efficiency than DyCrO$_3$ by have high maximum ΔS_M (T, H) and rate of cooling power (RCP) values. The cause of the observed anomaly in magnetic transition and MCE will be discussed.

References [1] F.A. Fabian, et al, 2020. J. Alloys Compd., 815, p.152427. [2] E.C. Pascual, et al, 2010. Phys. Rev. B, 81(17), p.174419. [3] E. Climent-Pascual, et al, 2007. Solid State Sci., 9(7), p.574-579. [4] E. Palacios, et al, 2016. Phys. Rev. B, 93(6), p.064420. [5] E.T. Sibanda, et al, 2022. AIP Advances, 12(3), p.035342.

Student award:

Yes

Level for award:

MSc

Photonics / 178

Quantum Photonic Entanglement

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Co-authors: Christine Steenkamp [2]; Mark Tame [3]

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Path entanglement is an essential tool with regards to quantum information and communication protocols. We shall discuss the generation and measurement of path entangled photon states using pairs of single photons initially generated by Spontaneous Parametric Down-Conversion (SPDC). Path entanglement is generated through the use of a Mach-Zender (MZ) interferometer in one arm of the SPDC setup. We shall discuss the characterisation of the MZ interferometer as well as standard tests performed to indicate whether entanglement is present including protocols on determining the quality of the entanglement generated. These tests include a second order correlation $\left(g^{(2)}\right)$ measurement and a visibility measurement. These two tests determine the quality of the single photons being generated and the quality of interference of a photon with itself, respectively.

Student award:

Yes

Level for award:

MSc

Photonics / 179

Photobiomodulation at 830 nm influences diabetic wound healing in vitro through modulation of inflammatory cytokines

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Diabetes Mellitus (DM) remains a global challenge to public health and is associated with a delay in wound healing, in part due to increased oxidative stress and pro-inflammatory cytokines. Photobiomodulation (PBM) induces wound healing through diminishing inflammation and oxidative stress and has been used for the successful healing of diabetic ulcers in vivo. This study investigated the effects of PBM at 830 nm and a fluence of 5 J/cm2 on inflammation in an in vitro diabetic wounded cell model. To achieve this, fibroblast cells were cultured under hyperglycaemic conditions, wounded via the central scratch, irradiated, and incubated for 24 and 48 h. Levels of pro-inflammatory cytokines (interleukin-6, IL-6; tumour necrosis factor alpha, TNF-α; and cyclooxygenase-2, cox-2) were measured using ELISA. IL-6 levels were decreased at 48 h, while TNF-α and cox-2 levels were increased at 24 h and 48 h, respectively. PBM at 830 nm with 5 J/cm2 decreased IL-6 and TNF-α levels, however, this study found increased levels in cox-2 48 h post-irradiation. Despite TNF-α and cox-2 being pro-inflammatory cytokines, they have been found to promote healing in the early stages of wound healing. PBM at 830 nm with 5 J/cm2 lowers the release of IL-6 by diabetic wounded cells in vitro and may stimulate the early phases of wound healing through increasing TNF-α and cox-2 levels.

Student award:

Yes

Level for award:

PhD

Astrophysics & Space Science / 180

Neutron monitors as space weather instruments

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Neutron monitors (NMs), on the Earth's surface, have been monitoring the near-Earth cosmic ray flux indirectly for nearly 70 years. These monitors do not detect the primary particles flux, but are sensitive to the secondary particles formed in the Earth's atmosphere during nuclear cascades. More recently, these instruments have been upgraded to provide more accurate and robust measurements, and for the data to be available in a near real-time format for space weather purposes. In this talk we discuss new upgrades and/or modifications to the South African NM network, and how these can lead to the effective near real-time monitoring of radiation exposure at e.g. aviation altitudes. We also discuss new research that can be performed with these old but updated instruments.

Student award:

No

Level for award:

N/A

Physics of Condensed Matter and Materials / 181

Thermal conductivity of Chalcogenides Alloys: Energy and information storage applications

Authors: Daniel Wamwangi[1]; Mmapula Baloi[2]; Bhekumusa Mathe[2]; Lesias Kotane[3]; Rudolph Erasmus[2]; David Billing[2]; Morgan Madhuku[4]

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Chalcogenide alloys exhibit excellent correlated properties essential for thermoelectric and energy storage in non-volatile based memory devices. This work presents an attempt to determine the thermal conductivity using two distinct light scattering methods on chalcogenide alloys in the various structural phases. Thin films of chalcogenide alloys formed from the Pseudo-binary tie line and eutectic phases have been grown using RF magnetron sputtering on (001) Si substrates. Using Cahill's random walk model on the phase velocities of the acoustic phonon modes, the minimum lattice thermal conductivity of the disordered phase is determined to be k < 0.5 W/mK. Our values are in close agreement with those measured by Time domain thermal reflectance (TDTR) for disordered phase for which the phonons are the dominant scatterers. A low thermal conductivity value is essential for thermal management in Phase change random access memory as well as for thermoelectric applications.

Student award:

No

Level for award:

No

Astrophysics / 182

SALT observations of gamma-ray binaries

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Gamma-ray binaries are a small, but growing, subclass of high mass binary systems that show consistent gamma-ray emission up to very high energies. These systems all have compact objects in the mass range of black holes or neutron stars. For only two sources have are pulsed signals unambiguously detected, confirming a neutron star compact object. For the other systems, the binary parameters of the source are only derived from radial velocity measurements of the optical companion. In this talk we review results from our recent SALT observations to better constrain the orbital parameters of three gamma-ray binaries, and discuss what this implies about the production of the observed non-thermal and gamma-ray emission in these systems.

Student award:

No

Level for award:

N/A

Physics of Condensed Matter and Materials / **183**

Structural and magnetic properties of $Co_{(1-x)}$ Cu_x Cr_2O_4 nanoparticles

Author: Shobana Nagaraj[1]

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

[1] *University of Johannesburg*

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$CoCr_2O_4$ is a ferrimagnetic material with a cubic Fd_3m space group belonging to a normal spinel structure attributed to the large octahedral ligand field stabilization energy of Cr^{3+}[1]. These spinels belong to a class of mixed oxides in which the Co^{2+} ions occupy the tetrahedral *A* sites and the Cr^{3+} ions occupy all of the octahedral *B* sites with the general formula AB_2O_4 [2]. Previous studies on spinel compounds have indicated that the Jahn-Teller (JT) effect is responsible for a structural distortion due to the presence of the Ni^{2+} and Cu^{2}+ ions at tetrahedral sites. This distortion is caused by the elimination of the orbital degeneracy, resulting in an ordering of the *d* orbitals and a lowering of the crystal lattice symmetry [3, 4, 5]. In the present work Cu-substituted cobalt ($Co_{(1-x)}Cu_x$ Cr_2O_4, with x=0.10, 0.50, and 0.90) nanoparticles were synthesized by sol-gel [6] method and calcined at 500 ℃. Rietveld refinement of the powder x-ray diffraction (XRD) patterns confirm that the structure is dependent on x, changing from cubic for $Co_{0.90}Cu_{0.10}Cr_2O_4$, to a mixture of cubic and tetragonal for $Co_{0.50}Cu_{0.50}Cr_2O_4$, and pure tetragonal for $Co_{0.10}Cu_{0.90}Cr_2O_4$. This is in agreement with what is expected considering the structures observed in $CoCr_2O_4$ and $CuCr_2O_4$ [7, 8]. The crystallite size (D) was found to be 8±2 nm ($Co_{0.90}Cu_{0.10}Cr_2O_4$), 9±2nm ($Co_{0.50}Cu_{0.50}Cr_2O_4$) and 8±2 nm ($Co_{0.10}Cu_{0.90}Cr_2O_4$), respectively. The size distribution and morphology of the nanoparticles were determined using transmission electron microscopy. The particle sizes of 10±2 nm ($Co_{0.90}Cu_{0.10}Cr_2O_4$), 8±2 nm ($Co_{0.50}Cu_{0.50}Cr_2O_4$), and 26±2 nm ($Co_{0.10}Cu_{0.90}Cr_2O_4$), respectively, was obtained from the TEM. Magnetic properties of the synthesized nanoparticles were studied using a vibrating sample magnetometer. The ZFC and FC curve results show that the two different magnetic phase transitions at T_C = 94 K associated with long-range ferrimagnetic order, while at T_S = 26 K, a spiral magnetic structure is observed [9]. T_S is suppressed for the $Co_{0.50}Cu_{0.50}Cr_2O_4$ sample because of the cubic to tetragonal structural phase transition. The magnetization as a function of applied field measurements, $M(\mu_0 H)$, of Cu-doped $CoCr_2O_4$ nanoparticles indicate that the magnetic properties change from ferrimagnetic to paramagnetic behaviour [10]. The magnetic saturation (M_s), remanence (M_r), and coercivity (H_c) of the samples were obtained from the results of $M(\mu_0 H)$ and will be discussed. **References:** 1. Tsurkan *et al.,* 2018, *Condensed Matter Material Science,* **5605,** 1-5. 2. Nadeem *et al.,* 2020, *Journal of Alloys and Compounds,* **832,** 155031. 3. Wang *et al.,* 2019, *Applied Physics letters,* **115,** 082903. 4. Mohanty *et al.,* 2021, *AIP advances,* **11,** 025113. 5. Ghosh *et al.,* 2021, *Material Science and Engineering B,* **263,** 114864. 6. Arshada *et al.,* 2011, *Journal of Alloys and Compounds,* **509,** 8378–8381. 7. Akyola *et al.,* 2017, *Physica B,* **525,** 144-148. 8. Paul *et al.,* 2015, *Journal of Alloys and Compounds,* **648,** 629-635. 9. Dutta *et al.,* 2009, *Journal of Applied Physics,* **106,** 043915. 10. Gingasu *et al.,* 2015, *Materials Research Bulletin,* **62,** 52–64.

Student award:

Yes

Level for award:

PhD

Poster Session / **184**

Hall Coefficient of (Cr100-xAlx)95Mo5 Alloy System

Authors: B Muchono[1]; C. J. Sheppard[2]; A. R. E Prinsloo[2]

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Hall coefficient (RH) measurements have shown to be an effective method in determining the number density, n=1/(qRH) and the type of majority charge carriers at the Fermi surface (FS) [1-3] of Cr and its alloys. Parts of the Fermi surface sheets that are annihilated during antiferromagnetic (AFM) ordering in Cr based alloys have large effects on the number density resulting in an anomalous behaviour on cooling below the Néel transition temperature, TN [4]. Previous studies on the (Cr100-xAlx)95Mo5 alloy system through electrical resistivity, Seebeck coefficient, thermal conductivity, specific heat, magnetic susceptibility and neutron diffraction measurements have shown that antiferromagnetism is suppressed in the concentration range 1.4 ≤ x ≤ 4.4 [5]. The present study was undertaken in order to extend the previous findings on this alloy system, through Hall coefficient measurements. RH of polycrystalline (Cr100-xAlx)95Mo5 alloys was measured over the temperature range 2 K ≤ T ≤ 380 K in a magnetic field of 4.5 T. Anomalies in the form of an upturn were observed just below the TN for the AFM alloys with x ≤ 1.3 and x ≥ 5.3. In addition to these anomalies, alloys with x = 0, 0.5, 0.9 and 8.6 show a peculiar behaviour below TN, in which RH increases and then decreases depicting a hump on further cooling. Remarkably RH for the alloy with x = 0 shows a sign reversal of majority charge carriers from holes to electrons on cooling below 120 K. The crossover of majority charge carriers disappears by the addition of just 0.6 at.% Al into the alloy with x = 0. The behaviour of alloys with x = 0, 0.5, 0.9 and 8.6 is explained in terms of the two band model in which both charge carriers contribute to magneto-transport properties [6]. The relative magnetic contribution to the Hall coefficient indicate a suppression of antiferromagnetism in the concentration range 1.7 ≤ x ≤ 4.7.

[1] Jaramillo R, Feng Y, Wang J and Rosenbaum T F 2010 PNAS. 107 13631 [2] Yeh A, Soh Y A, Brooke J, Aeppli G, Rosenbaum T F and Hayden S M 2002 Nature 419 459 [3] Lee M, Hussman A, Rosenbaum T F and Aeppli G 2004 Phys. Rev. Lett 92 187201 [4] Sheppard C J, Prinsloo A R E, Alberts H L, Muchono B and Strydom A M 2014 J. Alloys and Compounds 595 164 [5] Muchono B, Sheppard C J, Venter A M and Prinsloo A R E 2018 Physica B Condens Matter 537 212. [6] Cox W R, Hayes D J and Brotzen F R 1973 Phy. Rev. B 7 3580

Student award:

No

Level for award:

N/A

Physics of Condensed Matter and Materials / **185**

Effect of solvents on the extraction and absorption study of natural dye from Bidens pilosa for dye sensitized solar cells

Author: Ronel Ronella Randela[1]

Co-authors: Nnditshedzeni Eric Maluta [1]; Lutendo Mathomu [1]; Rapela Maphanga [2]

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Organic plant-based dye for Dye-sensitized solar cells (DSSCs) have gained a great interest due to their low cost of manufacturing and environmental friendliness. Majority of plants in nature contain pigments such as chlorophyll, anthocyanin and betalain that can be used in DSSCs. In this study, the solvents used to extract dye from B. pilosa leaves as a sensitizer for DSSC were water, methanol, and ethanol. The dye extracted from B. pilosa contained chlorophyll. Ethanol and methanol were more efficient than water according to the noted absorbance at 665 nm. The molecules responsible in exhibiting broader range of absorbance are known to be pheophytin found within the chlorophyll extracted from B. pilosa plant. Furthermore, the optical properties using density functional theory (DFT) was computed to optimize the properties of pheophytin. The UV-Vis optimization indicated the absorbance at 450 – 700 nm while the energy gap was observed at 2.06 eV. The experimental and the theoretical UV-vis results are in agreement and the study shows that dye molecule from B. pilosa is an efficient sensitizer for DSSCs. Keywords: B. Pilosa, Chlorophyll, DFT, DSSCs, Pheophytin

Student award:

Yes

Level for award:

MSc

Poster Session / 186

Characterisation of a new LSO block detector for Positron Emission Particle Tracking

Author: Alice McKnight[1]

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The University of Cape Town Physics Department recently acquired a Siemens Biograph 16 HiRez combined PET/CT scanner manufactured in 2005. Unlike older scanner models utilized by the department in Positron Emission Particle Tracking (PEPT), the Biograph scanner uses modern lutetium oxyorthosilicate (LSO) scintillators with a rapid response time, pixelated into a finer spatial grid. The new scintillating material promises an increased light output and faster decay time resulting in improved spatial resolution and reduced dead time compared to the conventional bismuth germanium oxide (BGO) crystals. Advanced front end data acquisition and processing compliment the new detector physics enabling high (energy, timing, & spatial) resolution measurements with low distortion.

The LSO crystal dimensions are 4 x 4 x 20 mm^3 arranged in blocks of 13 x 13 optically coupled to 4 photomultiplier tubes. Groups of 12 blocks are serviced by a detector controller responsible for analogue front end data acquisition and digitisation. The full scanner contains 12 controllers totalling 24336 crystals arranged in rings of 39 axially and 624 transaxially. Detector blocks and controllers have been extracted from the original device and reconfigured with a customised data acquisition system. Characteristics such as detector efficiency, temporal resolution, energy resolution, and spatial resolution have been investigated and are compared to performance of previous models for further use in PEPT and positron imaging applications.

Student award:

Yes

Level for award:

Hons

Poster Session / 187

Investigation of Structural and Dynamical Properties of Sperrylite (PtAs2) Mineral Based on Molecular Dynamics Simulations

Author: Thapelo Ntobeng[None]

Co-authors: Mofuti Mehlape [1]; peace prince mkhonto [1]; Phuti Ngoepe [1]

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The precious metals are extracted as valuable by-products from sulphides and arsenides- platinum group minerals (PGMs). The growing use of precious metals in the mineral processing industry has developed a deep interest in extracting them from the PGMs. In this study, computational modelling technique, molecular dynamics (MD) is applied to investigate structural and physical properties of sperrylite (PtAs2). The derived and validated Interatomic potentials for MD simulations will be used. Radial distribution functions (RDFs) and mean square displacement (MSD) are used to establish the effect of temperature and pressure on the sperrylite mineral. Simulation details, such as the convergence of results on the simulation time and transport properties, are also discussed. The understanding of the structural and dynamical properties of sperrylite mineral under extreme conditions could pave the way for research on the behaviour of arsenic-containing minerals and sulphide minerals.

Student award:

Yes

Level for award:

MSc

Space Science / 189

The investigation of the skynoise parameter of the Sanae SuperDARN radar

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The skynoise data is monitored by the Super Dual Auroral Radar Network (SuperDARN). It is anticipated that during the periods of increased solar activity, the ionospheric ionization increases, which results in the absorption of radio signals in the ionosphere, hence there would be an expected attenuation of skynoise and interference of the SuperDarn radars signal. This study intended to investigate the skynoise attenuation in the ionosphere measured by the SuperDARN radar at the SANAE IV station (the southern hemispheric SuperDARN radar located in Antarctica). The SANAE radar monitors the skynoise at approximately 12 MHz.

The two aspects of the skynoise: the effect of atmospheric wind and the solar proton events (SPEs) were investigated. The performance of the SANAE radar during the SPEs was evaluated by the number of return echoes for each scan. The skynoise attenuation during each month with SPE was estimated using the quiet day curve (QDC). The QDC was constructed based on the assumption that the days with wind speeds $v15ms^{-1}$ and $K_p2o(A_p7)$ are quiet. The estimated skynoise attenuation at SANAE was also compared with the skynoise attenuation recorded from the Mawson riometer located at a similar magnetic latitude. The Fourier and LombScargle analysis of the skynoise and atmospheric wind speed was performed for months with SPEs.

Student award:

Yes

Level for award:

MSc

Physics of Condensed Matter and Materials / 190

Preparation and characterization of porous ZnFe2O4 hollow fibers with enhanced sensing response and selective detection of acetone

Authors: Murendeni Nemufulwi[1]; Gugu Mhlongo[2]; Hendrik Swart[1]

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Food is among the most traded commodities in the world. As markets grow and mass productions increase, there are concerns of safety during production, distribution, and storage. Highly sensitive and selective semiconducting metal oxide-based gas sensors have shown promising potential in detecting spoilage indicators at every stage of production to curb the risk of food wastage and poisoning. Herein, porous hollow ZnFe2O4 fibers were successfully synthesized using a facile combustion method. The phase structure, microstructure, and morphology of the prepared ZnFe2O4 were characterized by X-ray diffraction, high-resolution transmission microscopy, and scanning electron microscopy. The optimized porous ZnFe2O4 fiber-based sensor revealed superior selectivity and a remarkable response of 210 towards 90 ppm of acetone at an operating temperature of 120 ℃. The excellent sensing capabilities can be attributed to high surface area that exposes surface reaction sites and sufficient gas diffusion across the porous sensing layer, having a significant consequence in selectivity. The prepared sensors can potentially be used for selective detection of acetone in spoiling food.

Student award:

Yes

Level for award:

PhD

Poster Session / 191

Design and construction of a counter propagating optical trap for aerosol droplets

Author: Anneke Erasmus[1]

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

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Micron-sized aerosol droplets can be trapped in air using a counter propagating optical trap. This allows the stationary droplet to be studied. In this work, the aim is to use the scattering of broadband white light from the trapped droplet and Mie theory to study the droplet's morphology. To create the optical trap, two long working distance high numerical aperture microscope objectives focus two counter propagating beams into a sample chamber. The foci of the two beams are overlapped in space and the droplet is trapped at this position. The focusing of the light through the objective creates a gradient force due to the refraction of the light through the droplet since the droplet has a higher refractive index than the surrounding medium. To enable trapping the droplet at a longer distance from the objectives, as necessitated by the sample chamber configuration, longer working distance objectives are used. The objectives have lower numerical apertures and therefore weaker gradient forces are created. To ensure a stable trap and to overcome the scattering forces that the droplet undergoes, two counter propagating beams are used. Here, salt-water aerosol droplets are trapped in air using a near infrared trap laser. The design and construction of the counter propagating optical trap as well as preliminary trapping results will be discussed.

Student award:

Yes

Level for award:

PhD

Space Science / 192

Effects of solar storms on the radiation exposure to aircraft passengers and crew

Author: Rendani Rejoyce Ndanganeni[1]

Co-author: Tshimangadzo Merline Matamba [1]

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In this paper, an investigation of radiation dose enhancement during geomagnetic storms over South Africa will be presented. The radiation exposure during a solar storm at aviation altitude is of interest to the aircrew, the international civil aviation organization (ICAO), and the general public. During solar storms, the radiation environment can change drastically due to ground level enhancement (GLE) or Forbush decrease (FD) phenomena. The two major contributors to the radiation are the ever-present galactic and solar cosmic rays that occur occasionally when there is a solar storm. The objective is to determine how the dose rate change in a chosen route within the region during the ionospheric storm period. Neutron monitor data, ionospheric data, and radiation models are used in this study. The effects of the solar storms on the radiation exposure levels to aircraft passengers and crew will be discussed.

Student award:

No

Level for award:

N/A

Astrophysics / 193

Physics of the Early Universe

Authors: Shonisani Ednah Netshiheni[1]; Remember Ayanda Madonsela [2]

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The discovering of the Cosmic Microwave Background (CMB) radiation in the sixties and its subsequent interpretation, the numerous experiments that followed with the enumerable observation data they produced. We see that the energy in the form of radiation has the equation of state p = ρ/3. This applies to all massless particles. It is also valid for massive particles when they are moving with momenta much larger than their masses. This is known as the extreme relativistic or ER limit opposite to the non-relativistic or NR limit where the momenta are much smaller than the mass of the particles. Matter in the Early Universe, from the study of isotropic of gas at times much before the development of any structure, can be viewed as a gas of relativistic particles in thermodynamics. To provide insight into the behaviour of matter in early stages of the universe. The research framework mainly focuses on discussing the basic ideas that have shaped our current understanding of the Early Universe like the behaviour of matter under extreme conditions. We aim to discuss cosmological observables, principles and solutions which is the physics that governs the scope of this project specifically the relativistic thermodynamics. The simulation and establishment of the data handling analysis work will be based on the number density as a function of temperature, number of particles for both bosons and fermions particles as a function of temperature using high programming language (MATLAB). Temperature is an independent variable and time is kept as reference. The validation of the data analysis will be compared to the cosmological solutions the Empty de Sitter Universe, Vacuum Energy Dominated Universe, Radiation Dominated Universe and the Matter Dominated Universe.

Student award:

Yes

Level for award:

N/A

Space Science / 194

Determining the response of southern hemisphere SuperDARN convection maps to the southward turning of the Interplanetary Magnetic Field

Author: Aviwe Mchithakali[None]

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The Super Dual Auroral Radar Network (SuperDARN) is an international collaboration of High Frequency (HF) radars located in the mid and high-latitude zones of the northern hemispheres and the southern hemispheres. These HF radars operate and transmit signals at a frequency ranging from 8-20 MHz, although in most cases they are operational at frequencies between 10 and 14 MHz. In this study, we determine the response of the southern hemisphere SuperDARN convection maps to sustained changes in the Interplanetary Magnetic Field (IMF) as measured by magnetometers on the ACE satellite during 2011. The focus here was on periods for which the clock angle of the Interplanetary Magnetic Field (IMF) was stable for at least one hour in any quadrant. SuperDARN data from the southern hemisphere was used as results from the northern hemisphere have already appeared in the literature. Cross-correlation was used to determine the time lag between the IMF clock angle and the Cross Polar Cap potential (CPCP) as determined from SuperDARN convection maps.

Student award:

Yes

Level for award:

MSc

Poster Session / 195

First principle studies of structural, elastic, electronic and optical properties of chalcogenide LiAlS2 under pressure

Author: Boitemogelo Phale[1]

Co-authors: PETER SENAUOA NTOAHAE [1]; Rapela Maphanga [2,3]

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In this work, we present the first principles calculations for structural, electronic and optical properties of orthorhombic LiAlS2 under hydrostatic pressure using plane-wave ultrasoft-pseudopotential method within the framework of density functional theory (DFT) as implemented in CASTEP in Material Studio package. The exchange-correlation potential is treated with generalized gradient approximation (GGA).The obtained structural parameters are in good agreement with the available results. The pressure-dependent lattice and elastic constants are obtained using the optimization method. The calculated band structure and density of states predict LiAlS2 to be an insulator with a direct band of 4.21 eV which agrees very well with the theoretical calculation of 4.11 eV. Furthermore, the calculated optical spectra such as absorption, and reflectivity are presented and the results are discussed.

Student award:

Yes

Level for award:

Hons

Physics of Condensed Matter and Materials / 196

Synthesis, Structural, and Magnetic Properties of $CoCr_2O_4/Cu_2O$ nanocomposites

Authors: Thabang Johannes Nkosi[1]; Thabang Johannes Nkosi[1]

Co-authors: Aletta Prinsloo [1]; Charles Sheppard [2]; Pankaj Mohanty [1]

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Nanocomposites have gained interest in current research because of the unique properties and scientific significance it has shown[1-2].It was found that composites that comprise of ferrimagnetic(FiM) and antiferromagnetic(AFM) materials exhibit fascinating magnetic phenomena including proximity effect and exchange bias[2,3].These phenomena manifest due to strong exchange coupling between FiM and AFM material[3].Cu_2O is an AFM material with a monoclinic crystal structure,that undergoes two magnetic transitions at T_{N1}=213K and T_{N2}=230K[3].The novel properties of Cu_2O such as weak FM and superparamagnetic(SPM) are attributed to size effects[4].$CoCr_2O_4$ is a FiM material with a cubic crystal structure, exhibiting three magnetic transitions at TC=93K,Ts=26K,and TL=15K[5].Ts is the temperature associated with the formation of a magnetic conical spin state anomaly due to the spiral ordering causes a multiferroic in a material[5].TL is the temperature associated with the transition from the commensurate to the incommensurate magnetic phase where spiral orderings are fully developed[5]. $CoCr_2O_4$ is a well-studied ternary multiferroic spinel with a conical structure and it manifests itself below Ts.$CoCr_2O_4$ exhibit an exchange bias without mixing with different magnetic material[5]. Rath et al.[7] investigated the magnetic properties of $CoCr_2O_4$ nanoparticles with average size 10-12 nm.SPM behaviour was observed,with a blocking temperature between 50-60K[7].The disordered spin at the surface and distribution of nanoparticle sizes play important roles in the observation of SPM behavior in a material[7].In order to expand on these observations, the present study considers a $CoCr_2O_4/Cu_2O$ composite that was synthesized using two-step methods.The initial step uses the sol-gel method[6] to synthesize the $CoCr_2O_4$ nanoparticles.The sample was calcined at 400 ^oC for 2 hours and characterized using different techniques. Single-phase $CoCr_2O_4$ formed,with the particle size of 12.47±0.50nm, and the particles undergo a FiM from a PM transition at T_C=98K.T_s and T_L were not observed due to the weak Cr-Cr interaction and size effect[8].The following step involves co-precipitation to synthesize the $CoCr_2O_4/Cu_2O$ composite, with cetyltrimethylammonium bromide (CTAB) used as a capping agent.The sample was again calcined at 400 ℃ to adjust the particle size [9].X-ray diffraction (XRD) results confirm the formation of multiphases associated with the Fd-3m and,C12/c1 space groups[4,6] related to the crystal structure of $CoCr_2O_4$ and,Cu_2O, respectively.The average crystallite size was estimated to be less than 43±1nm.Transmission electron microscopy(TEM) was employed to determine the average particle size and morphology.Both $CoCr_2O_4$ and $CoCr_2O_4/Cu_2O$ particles reflected non-uniform sizes and spherical shapes. Magnetic measurements were done using a vibrating sample magnetometer(VSM).The magnetic susceptibility as a function of temperature shows a PM to FiM transition at 94K for composite.The magnetic hysteresis loop shows SPM behaviour at 75K,while no exchange bias was observed at low temperatures for the composite. [1] R. Yassine,et al.Ceram. Int. 48.10(2022):14825-14838. [2] T. Woldu,et al. J. Alloys Compd 691(2017)644-652. [3] P.K. Manna,et al. Phys. Rep. 535.2(2014):61-99. [4] R.S. Bhalerao-Panajkar,et al. Solid State Commun. 151.1(2011):55-60. [5] Y. Yamasaki,et al. Phys. Rev. Lett 96.20(2006):207204. [6] S. Goswami,et al. J. Alloys Compd (2021):161916. [7] C. Rath,et al. J. Supercond. Nov. Magn. 24.1(2011): 629-633. [8] D. Zákutná,et al.Phys. Rev. B 100.18(2019):184427. [9] S. Naz, Sumaira,et al. J. Saudi Chem. Soc. 20.5(2016):585-593.

Student award:

Yes

Level for award:

PhD

Poster Session / 197

ATLAS SoC TDAQ and ATCA OPCUA server implementation on the TileCoM for the ATLAS TileCal Phase-II upgrade

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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 readout electronics system of the ATLAS Tile Calorimeter (TileCal) is required to cope with the new radiation levels and data bandwidth requirements envisaged for the HL-LHC. Numerous sensors will be used to monitor the status of the upgraded readout electronics system to ensure the proper operation of the detector. This paper presents a real-time monitoring system which will be responsible to read and transfer monitoring data to the ATLAS TileCal during the HL-LHC era. This real-time monitoring system, known as Tile Computer-on-Module (TileCoM), includes an implementation of an OPC server and an ATLAS SoC TDAQ system running on a Xilinx Zynq UltraScale+ MPSoC device. The functionality of the TileCoM has been validated using an Avnet Ultra96-V2 ZYNQ UltraScale+ MPSoC evaluation board and Tile Gigabit Ethernet switch.

Student award:

No

Level for award:

PhD

Physics of Condensed Matter and Materials / **198**

Structural and Magnetic Study of $NdCrTiO_5$ Nanoparticles

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Co-authors: Pankaj Mohanty [2]; Aletta Prinsloo [2]; Charles Sheppard [3]

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In a search for superior magnetic materials with novel properties, including magnetization reversal, magnetocaloric effect, spin switching, spin reorientation and exchange bias effect, focus is on multiferroic materials [1-5]. Single phase multiferroic materials exhibits the coexistence of two or more of the ferroic orderings and can find application in memory devices [2]. $RCrTiO_5$ compounds shows interesting magnetic behavior because of the presence of two magnetic sublattices, R^{3+} and Cr^{3+} [1-2]. $NdCrTiO_5$ is one of the compounds from this group, but reports on the magnetoelectric properties of $NdCrTiO_5$ in the bulk form is limited [2-3]. Therefore, this contribution focuses the synthesis, structure, morphology and magnetic properties are discussed for nano $NdCrTiO_5$. The orthorhombic crystal structure with lattice parameters, a, b, c is 7.5715(7), 8.7270(9), 5.7917(8) Å, respectively, was confirmed through x-ray diffraction. The average particle size obtained from the transmission electron microscopy is 33 ± 1 nm, selected area diffraction pattern confirms the crystalline nature of the sample and energy dispersive x-ray spectroscopy confirms the elemental composition. From the temperature-dependent magnetization measurement on the nanoparticles the Néel temperature,T_N , could not be obtained. This is in contrast with the previously observed in bulk samples at 18 and 21 K [2, 3] and might be due to the nano size of the material. Further, the ferromagnetic nature of the material is observed from the magnetization as the function of field measurement with coercivity 0.018 ± 1, 0.019 ± 1 T and exchange bias 0.004 ± 1, 0.003 ± 1 T, at 2 and 10 K, respectively. The observed anomalous properties are discussed considering the size effect.

Keywords: Nanomaterials, $RCrTiO_5$, Magnetic sublattices and Exchange Bias.

References: [1] Das et al.,J. Phys.: Condens. Matter. Vol. 32, p.035802 (2020). [2] Hwang et al., Phys. Rev. B Vol. 85, p.024415 (2012). [3] Saha et al., J Mag. Mag. Mat. Vol. 360, p.34 (2014). [4] Bharati et al., J Mag. Mag. Mat. Vol. 564, p.168862 (2022). [5] Bharati et al., AIP advances. Vol. 12, p.035245 (2022).

Student award:

No

Level for award:

N/A

Nuclear, Particle and Radiation Physics / **199**

Search for new spin-1 or spin-0 boson using ATLAS detector data

Author: Xola Mapekula[1]

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We present a search for a new spin-1 or spin-0 boson where the Standard Model Higgs boson decays into a four lepton final state ($\ell = \mu$ or e) corresponding to the $H \to XX \to 4\ell$. In this scenario, X is the new boson found in the intermediate state, having a mass range of between 15 - 60 GeV. The search is conducted using pp collision data collected with the ATLAS detector at the LHC, where the total integrated luminosity corresponds to 139 fb^{-}1 at a centre of mass energy of $\sqrt{s} = 13$ TeV. No significant deviation from the Standard Model was observed in the data. However, an improvement of a factor between 2 and 4 from the previous iteration of the analysis was observed for the limits that were set on the fiducial cross-section and the branching ratio of the Higgs boson. Limits were also set on the mixing parameter related to the Beyond Standard Model framework used in this analysis.

Student award:

Yes

Level for award:

MSc

Theoretical and Computational Physics / **200**

A new Bell inequality for measuring entanglement in relativistic frames

Author: Jonathan Hartman[1]

Co-authors: Simon Connell [1]; Christian Engelbrecht [1]

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There has been much discussion about quantum entanglement with respect to relativistic frames in the recent literature. By now, the violations of the original Bell's inequality as well as the updated CHSH inequality (as proposed by Clauser et el.) has been well confirmed by experiment. However, this only applies when the relativistic effects are small enough that they can be neglected. As the literature suggests, if relativistic effects are significant, then the Bell correlations, even for entangled pairs, are altered by a relativistic effect called the Thomas-Wigner rotation. The effect is such that relativistic quantum mechanics appears to predict a weakening of the Bell correlations when measured in same directions as in the centre of mass frame and this weakening appears to depend on the relative velocities between the frames. This prediction has led to some disagreement in the literature as to whether Bell inequalities can still be violated in relativistic frames, with some authors believing that the maximum violation of Bell's inequality can still be attained, just in different directions and others believing that you can't. This is of particular interest to some research in the area of quantum technology because there are applications, for example in quantum cryptography, that rely on Bell violations in order to work. The worry is whether these applications can still be applied in relativistic regimes. Our view is that of the former, that maximal Bell violations are still attainable and we introduce a new Bell inequality by adding new variables to the CHSH inequality that compensates for the effect of Thomas-Wigner rotation. Nevertheless, the predictions of relativistic quantum mechanics still violate the upper bound of this new inequality (as derived classically) just like non-relativistic quantum mechanics did for previous iterations of the Bell inequality. The only difference is that the quantum mechanical observable constructed from this new version is not affected by the Thomas-Wigner rotation. We thus believe that this observable can be used as new measure for entanglement in relativistic regimes and any technological applications that require the violation of Bell's inequality can be extended to the relativistic regimes by using these new observables.

Student award:

Yes

Level for award:

PhD

Poster Session / **201**

Geant4 Analysis of Secondary Neutrons in Proton Therapy

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The use of proton therapy decreases the damage to surrounding healthy tissue compared to traditional radiotherapy due to the existence of the Bragg peak where most of the beam's energy is deposited. However, secondary particles are produced externally along the beam line and within the patient due to protons interacting with the nuclei in the beam's path. Of particular interest are neutrons produced this way as they are hard to detect through traditional means and have a high biological effectiveness. The Geant4 simulation toolkit was used to model the path of a 191 MeV proton beam through a copper collimator with an inner radius of 50mm, and into a water phantom, corresponding to the 24cm proton beam at iThemba LABS. Examination of the distribution of neutrons along through the depth of the water phantom showed that most internal neutron production occurred before the Bragg peak where the proton energies have lowered, maximising the cross section for neutron producing reactions. 60\% of all neutrons within the phantom are produced internally for a 60mm beam. Although externally produced neutrons contributed 63\% of the dose due to neutrons for this beam radius and 82\% for a 75mm beam. As a proportion of the total dose, the neutron dose made up .62, .95 and 1.26\% for beams of 39, 60 and 75 mm respectively. The simulation was also used to measure the spectra and fluences of neutrons through different areas which would correspond to the placement of neutron detectors for future experiments. The placements were chosen to verify where neutron production and attenuation occurs within a treatment scenario.

Student award:

Yes

Level for award:

Hons

Poster Session / **202**

Electrodeposition of CdTe Thin Film Effect of Deposition Temperature from acetate precursor for Solar Energy Application

Author: Ahmed Ahmed Yimamu[None]

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Cadmium Tel lurid (CdTe) thin film can be synthesized by using low cost two electrode electrodeposition method in aqueous acidic solution contained cadmium acetate dihydrate1.M $Cd(CH_3OO)_2, 2H_2O$ as cadmium precursor and 1ml Tellurium dioxide TeO_2 as Tellurium precursor on glass substrate(FTO) florin doped thin oxide with sheet resistance of 7 ohm/square. The main aim is to study the effect of deposition temperature the film were deposited different temperature at 50, 60,70 and 85^oc and for each film the structural, compositional, phonon vibrational, morphological and optical properties of the resulting films have been characterized using glancing incidence X-ray diffraction, energy-dispersive X-ray (EDX) spectroscopy, Raman spectroscopy, scanning electron microscopy (SEM) and UV–Vis spectrophotometry respectively.

Student award:

Yes

Level for award:

PhD

Poster Session / **203**

Effects of size and Cr substitution on the structural and magnetic properties of α–CoV2O6

Author: Murei Mulibana[1]

Co-authors: Pankaj Mohanty [1]; Aletta Prinsloo [1]; Charles Sheppard [2]; Bincy Susan Jacobs [3]

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α–CoV_2O_6 is a well-investigated one-dimensional spin chain system [1–4]. Most of the studies are focused on bulk polycrystalline and single-crystalline α–CoV_2O_6. The compound orders antiferromagnetically below 15 K [2] and has been shown to exhibit field-induced metamagnetic transitions below T_o. This study investigates how the structural and magnetic properties of this compound are influenced by size reduction and the presence of antiferromagnetic (AFM) Cr ions. Thus, structural and magnetic properties of Cr substituted powder α–CoV_2O_6, prepared using a wet chemical synthesis method, are presented. Most of the samples were calcined at 500 ℃, while the α–CoV_2O_6 sample was calcined at 450 ℃ in order to study the effect of size reduction. Temperature-induced size reduction of α–CoV_2O_6 was confirmed using transmission electron microscopy (TEM) analysis. The average particle size of Cr substituted samples decreases with increasing Cr wt.%. Elemental concentrations were confirmed using energy dispersive spectroscopy (EDS). X-ray diffraction (XRD) studies show that all samples have a single phase. Average crystallite sizes, lattice parameters, and bond angles were calculated using Williamson-Hall [5] and Rietveld refinement [6]. These data revealed minor changes in these parameters with size reduction and Cr substitution. Temperature, field, and time dependence of magnetization, M(T), M(μ_0H), and M(t), respectively, measurements were performed to explore the magnetic properties. Zero-field cooled (ZFC) and field cooled (FC) M(T) data at 0.1 T revealed an antiferromagnetic ordering below T_o = 16 K. An enhancement of AFM was observed with size reduction and Cr substitution in M(T) data below 5 K in the form of an increase in magnetization. Increasing field strength to 2.5 T causes a shift in T_o and a spin-glass-like irreversibility occurs at T_s between ZFC and FC curves which persist even at 5 T. Spin-glass-like freezing behavior at low temperatures was confirmed by M(t) data. M(μ_0H) isotherms revealed a three-step metamagnetic transition below T_o from a low field AFM state to a high field ferromagnetic (FM) state through an intermediate state. The stability of the steps depends strongly on temperature. A sizeable hysteresis with remanence magnetization was observed for M(μ_0H) isotherms measured below 5 K. Finally, the study provides direct observations of the coexistence of multiple magnetic states in powder α–CoV_2O_6. The dependence of structural and magnetic properties on Cr substitution and size will be discussed.

[1] He Z *et al.*, Journal of the American Chemical Society, **131**, (2009), 7554–5. [2] Lenertz M *et al.*, *The Journal of Physical Chemistry C*, **115**, (2011), 17190–6. [3] Nandi M and Mandal P, *Journal of Applied Physics* **119**, (2016), 0–9. [4] Shu H *et al.*, *Journal of Magnetism and Magnetic Materials*, 407, (2016), 129–34. [5] Desai K R *et al.*, *Physica B: Condensed Matter* **614**, (2021), 413054–9. [6] Toby B H and Von Dreele R B, *Journal of Applied Crystallography* **46**, (2013), 544–9.

Student award:

Yes

Level for award:

MSc

Astrophysics / **205**

Preparing to welcome the global astronomy community to Africa in 2024

Author: Vanessa McBride[1]

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In 2024, for the first time in the 100 year history of the International Astronomical Union, the General Assembly will take place on the African continent! This meeting encompasses more than logistics; it represents the vision of a dedicated cohort of African astronomers, and an opportunity to welcome the global astronomy community to Africa. We will present the current status of plans for General Assembly in 2024, and how we may align with existing physics and astronomy initiatives on the continent to create the broadest possible impact in research, education, outreach and development.

Student award:

No

Level for award:

N/A

Physics of Condensed Matter and Materials / **206**

First-Principle Studies of Cubic Ti2AlV and Tetragonal TiAl2V Structural Stability

Author: DAVID TSHWANE[1]

Co-author: Rosinah Modiba [1]

[1] *CSIR*

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TiAlV intermetallic alloys are used as a key functional material in various industries due to their superior properties. However, our understanding of their structural phase stabilities is still limited and remains confined. In this work, density functional theory approach was employed to investigate the structural, mechanical, and electronic stability of cubic Ti2AlV and tetragonal TiAl2V phases. The stabilities of these structures were determined using the heat of formation, the density of states, and elastic properties. The calculated heats of formation values revealed that the tetragonal phase is energetically more stable than the cubic Ti2AlV phase. In addition, our computational results showed that both phases are mechanically stable, with the Ti2AlV structure exhibiting the greatest resistance to deformation and stiffness.

Student award:

No

Level for award:

N/A

Poster Session / **207**

Tilted Precession Bands in 133Ce and 131Ba

Author: Ignasio Wakudyanaye[1]

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Most nuclei that exist in nature have deformed nuclear shapes. In the A = 130 mass region, nuclei are predicted to show triaxial nuclear shapes at low spins and therefore provide a rich testing ground for nuclear structure theories. Triaxial nuclei have unequal nuclear matter distribution along the three principle nuclear axes. Unlike axially symmetric nuclei, triaxial nuclei can rotate around all three nuclear axes simultaneously which gives rise to 3D Tilted Precession (TiP) bands [1, 2]. Here results from two experiments are presented. The first experiment was carried out in 2019 using the AFRODITE array at iThemba LABS. A new excited rotational band based on the neutron orbital in 133Ce was discovered. Quasiparticle-plus-Triaxial Rot (QTR)or model calculations suggest that the new band has the same intrinsic configuration as the yrast band, but different rotational angular momentum. In general, the bands correspond to a gradual re-alignment of the angular momentum of the valence neutron towards the intermediate axis as the spin increases. Experimental observables including the signature splitting, the excitation energies, the mixing ratios, and the transitional probability ratios of the new band in 133Ce are compared the QTR model and an interpretation of the band as a TiP band is proposed. The data set from the iThemba LABS experiment also revealed a new positive-parity rotational band based on the neutron orbital in 133Ce. The second experiment, aiming at study of 131Ba , was carried out at the XTU Tandem accelerator of Laborotori Nazionali di Legnaro, Italy. This experiment revealed a new positive-parity rotational band based on the neutron orbital. The Nilsson configuration was assigned to both bands in 133Ce and 131Ba. A comparison of the experimentally observed signature splitting and excitation energies with theoretical calculations using the QTR model revealed that an interplay between the effects of triaxiality and the Coriolis associated with single particle s1/2 contributions. This interplay determines the features of the observed bands in 133Ce and 131Ba [3, 4]. 1. E. A. Lawrie, O. Shirinda, and C. M. Petrache, Tilted Precession and Wobbling in Triaxial Nuclei," Phys. Rev. C, vol. 101, p. 034306, Mar 2020. [Online]. Available: https://link.aps.org/doi/10.1103/PhysRevC.101.034306 2. B. F. Lv, C. M. Petrache, E. A. Lawrie, et al. , "Tilted Precession Bands in 135Nd," Phys. Rev. C, vol. 103, p. 044308, Apr 2021. [Online]. Available: https://link.aps.org/doi/10.1103/PhysRevC.103.044308 3. B. Ding, C. M. Petrache, S. Guo, E. A. Lawrie, I. Wakudyanaye, et al., Phys. Rev. C, vol. 104, p. 064304, Dec 2021. https://link.aps.org/doi/10.1103/PhysRevC.104.064304 4. I. Wakudyanaye, "Triaxiality and Rotational Bands in 133Ce", MSc. Thesis, University of the Western Cape, 2021. https://etd.uwc.ac.za/handle/11394/8922

Student award:

Yes

Level for award:

MSc, PhD

Poster Session / **208**

First principle calculation of electronic and optical properties of graphene and mono doped graphene with Ti, Zn, and Ru.

Authors: Lutendo Phuthu[1]; lutendo phuthu[1]

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Graphene is a 2-dimensional material that has received a lot of research attention over the last two decades as it is considered to be a revolutionary material for the future due to its superlative properties. Graphene has a zero band gap energy. This research work reports first principle calculations based on Density Functional Theory (DFT) to study the electronic and optical properties of pure graphene and mono doped graphene with Ti, Zn and Ru atoms. The results show that for a pure graphene, the band gap energy is zero. However, when doped with Ti, Zn and Ru atoms, the gaps of the energy were opened. For the doping, the calculated band gap values for the graphene doped with Ti, Zn and Ru are 0.550 eV, 0.713 eV and 0.786 eV, respectively. The results demonstrated that the band gap of graphene can be opened by addition of Ti, Zn and Ru atoms. For the optical properties of the graphene, the doping with the selected atoms weaken the absorption in the visible region and strengthen the absorption in the infrared region.

Student award:

Yes

Level for award:

PhD

Physics for Development, Education and Outreach / **209**

The impact of simulation experiments on the understanding of the concepts of acceleration and energy

Authors: Oluwatoyin Ewuola[1]; Charles Sheppard[1]; Aletta Prinsloo[1]

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Previous investigations have emphasized that there are many difficulties not only in the teaching of acceleration [1, 2] and energy [3-5], but also in the students learning thereof. As in many other instances, the perceptions regarding these concepts again illustrates that what an expert considers as straightforward mathematical concepts can become rather complex phenomena once it needs conceptual understanding within physical environments [5]. This frequently leads to misunderstanding regarding these concepts amongst learners at various levels. Previous studies suggest that computer simulations can improve the understanding of physics concepts [6]. Therefore, the present study investigates the use of computer simulations on the understanding as well as learning of acceleration and energy concepts under first year science and engineering students. The students already completed the theoretical work on acceleration, potential and kinetic energy, the work-energy theorem and the effect of friction on the energy of the system. A short online BlackBoard based pretest, an online computer based Simulation and a BlackBoard based post-test were administered to evaluate the impact of the simulation experiment on the understanding of the students. The Blackboard based pre-test and post-test consisted of basic multiple choice and short questions related to acceleration, various forms of energy, energy conversion and the impact of friction on a system. The simulation experiment was based on an existing PhET Interactive Simulation [7] that offered the opportunity to engage with a simulated controlled reality, as well as investigate concepts related to acceleration and energy. The experimental procedure and answer sheet was hosted on Leybold Didactic's Leydocs platform. A practical report based on the results of the simulation as well as graphs plotted using the data from the simulation were uploaded by the students at the end of the simulation. Detailed analyses of the student answers and the statistics for the various groups will be addressed. Results show that both science and engineering students gained a greater understanding of the concepts after completion of the computer simulation and accompanied report in an era of the fourth Industrial Revolution (4IR). **References** [1] Liu G. and Fang N., International Journal of Engineering Education Vol. 32, No. 1(A), pp. 19–29, 2016. [2] Taşar, M.F. What part of the concept of acceleration is difficult to understand: the mathematics, the physics, or both? ZDM Mathematics Education 42, 469–482, 2010. [3] A. Saglam-Arslan, M. A. Kurnaz. EEST Part B Social and Educational Studies 3. 109-118, 2011. [4] Sefton I. Understanding Energy, Proceedings of 11th Biennial Science Teachers' Workshop, The University of Sydney, 2004. [5] Kruger C. Some primary teachers' ideas about energy, Physics Educ. 25 :86-91, 1990 [6] Cândida Sarabandoa, José P. Cravinob, Armando A. Soares, Procedia Technology 13. 112-121, 2014. [7] University of Colorado. Energy Skate Park - Conservation of Energy | Kinetic Energy | Potential Energy - PhET Interactive Simulations. 2022. [Available via https://phet.colorado.edu/en/simulations/energy-skate-park]

Student award:

No

Level for award:

N/A

Astrophysics / **210**

Spatio-Spectral Modelling of the Pulsar Wind Nebula Kes 75

Authors: Christo Venter[1]; Anu Kundu[2]

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Kes 75 (G29.7-0.3) is a Galactic composite supernova remnant with an embedded pulsar, PSR J1846-0258, that was discovered via X-ray timing. This pulsar powers a pulsar wind nebula that was seen to have expanded rapidly over the past several years. The pulsar's inferred spin period and derivative thereof imply a canonical age of only 720 years and a very high spin-down luminosity of 8e36 erg/s. Later measurements revealed a braking index of n = 2.65 +/- 0.01. This value deviated from the canonical value of n = 3 for magneto-dipole braking radiation. A measurement of this quantity, subsequent to magnetar-like bursts plus a glitch that were detected in 2006, yielded an even lower value of n = 2.16 +/- 0.13. Significant gamma-ray emission was detected from Kes 75 by the H.E.S.S. Collaboration, although it was not possible to distinguish between shell and nebular emission. Taking into account the eventful history of this nebula during its short lifetime, we apply a multi-zone emission code to this source, finding reasonable joint fits to the broadband spectrum, X-ray surface brightness profile, expansion rate vs. time, and X-ray photon index vs. central radius.

Student award:

No

Level for award:

N/A

Physics for Development, Education and Outreach / **211**

Astronomy for development: past, present & future

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The Office of Astronomy for Development has now been part of the astronomy landscape for over a decade, and has recently undergone an external review. In this talk, we focus on the role that astronomy can play in socioeconomic development. This is particularly relevant as 2022 is the International Year of Basic Science for Sustainable Development, and astronomy is fundamentally linked to basic sciences. Using the sustainable development goals as a charter, we map out flagship projects of the Office for Astronomy for Development in the areas of astro-tourism, mental health and skills development. We also present the OAD's vision for a collaboration gateway, which is is intended to stimulate and nurture cross-disciplinary collaboration that can impact socioeconomic development.

Student award:

No

Level for award:

N/A

Nuclear, Particle and Radiation Physics / 212

Investigating the impact of neutrons on Cadmium Zinc Telluride Compton Camera system

Author: Josiah De Klerk[1]

Co-authors: Stephen Peterson [2]; Tanya Hutton [2]

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During proton therapy (PT), excited-nuclei decay via emission of characteristic prompt gamma rays along the beam path within the target. These gamma rays are detectable via a Compton camera and can be used for in vivo proton beam range verification using a technique called prompt gamma imaging (PGI). The detection efficiency of a PGI device can be negatively affected by additional secondary radiation (primarily neutrons) produced alongside the prompt gamma rays. The UCT Prompt gamma imaging system (Polaris) is a room temperature solid state Compton camera detector. The imaging device comprises of two independent detection platforms with each consisting of two Cadmium zinc telluride (CZT) crystals (20 x 20 x 10 mm^3) arranged side-by-side. The goal of the project is to better understand the impact of neutrons on the Polaris detectors during PT and compare its response to traditional gamma ray detectors such as NaI and $LaBr_3$. CZT is sensitive to thermal neutrons due to the high interaction cross-section, but due to the nature of the detector system it is not possible to distinguish between gamma rays and other secondary radiation. Another limitation of the Polaris detector system is the inability to detect high energy gamma rays. The traditional detectors act as means of calibration for expected gamma ray spectra in the Polaris detectors and to highlight any neutron impact on the CZT crystals. Preliminary results are presented from measurements conducted at the UCT n-lab MeASURe facility (neutrons up to 14 MeV) and at iThemba LABS (66 MeV proton beam).

Student award:

Yes

Level for award:

MSc

Physics of Condensed Matter and Materials / 213

Ground state phase stability simulation of Fe-X-Al alloys (X= Pd and Ag)

Author: Chrestinah Mkhonto[1]

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Transition-metal alloys, such as iron-aluminides are significant because of their impact on the industrial sector, such as excellent unique corrosion properties and resistance to high-temperature oxidation, which outperform Ni-based superalloys. Due to their extraordinary resistance to oxidation at high temperatures, Fe-Al based materials have recently received a lot of attention as a potential steel substitute. Previous research has shown that increasing the Al concentration reduces the density of materials and, as a result, improves the protective oxide layer at high temperatures. However, these systems are easily influenced by environmental effects and limited by their tendency for low-temperature fracture and decreased ductility. In this study, DFT was employed to investigate the thermodynamic ground state structural energies at varied concentrations for better yield strength of these materials to improve the application for stainless steel-IT superior protection with the addition of a third element Pd and Ag. The Universal Cluster Expansion (UNCLE) code was employed to predict new phases and stability of Fe-X-Al alloys. The ground state phase diagrams were predicted for Fe1-x-Pdx-Al and Fe1-x-Agx-Al systems. The Fe-Pt-Al indicated miscible constituent; in particular, the FePtAl2 and FeAgAl2 composition due to their lowest energy predicted by the enthalpy of formation. The enthalpy of formation (DHf) clearly indicates that Ag-doping with DHf of -0.222 eV/atom is the most stable system with the lowest energy, followed by Pd-doping with DHf of -0.110 eV/atom. Fe-Pd-Al and Fe-Ag-Al systems indicated miscible constituent behaviour due to negative enthalpy of formation, in particular the FePtAl2 and FeAgAl2 composition indicated thermodynamic stability. These results are in agreement with elastic properties, phonon dispersion curve and X-Ray diffraction pattern, implying a condition of stability.

Student award:

Yes

Level for award:

PhD

Poster Session / 215

Correlations of Ferroic Orders in Multiferroic TbMnO3 and TbMn2O5 Thin Films

Authors: Geoffrey Mwendwa[1]; Daniel Wamwangi[1]; Bhekumusa Mathe[1]; Lesias Kotane[1]; Erasmus Rudolph[1]; David Billing[2]; Adam Shnier[2]; Morgan Madhuku[3]

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Multiferroics are a class of materials exhibiting correlations in their ferroic orders (ferroelasticity, ferromagnetism, ferroelectricity, and ferrotorodicity). Light interaction with lattice vibrations is a powerful method to study the elastic properties of solids using surface Brillouin scattering (SBS). SBS is based on the inelastic scattering of photons by acoustic modes (phonons) to determine the elasticity of materials. In this work, ferroelastic, magnetic, and magnetoelctric properties of multiferroic rare-earth complex oxides TbMnO3 and TbMn2O5 are investigated in thin film format. The phonon velocities were measured at room temperature using a diode pumped solid-state laser (λ=532 nm) at an incidence angle of 60 degrees. The measured data was optimized and fitted with data simulated using surface elastodynamic Green's function for discrete phonon dispersion in the k||d range of 0–10. By the least-squares fitting approach, we obtain the uncertainties of measurement from Taylor series expansion of the phonon phase velocity dependence on the primary elastic constants (C11 and C44). On the other hand, the magnetic properties of the films have been studied by vibrating sample magnetometry (VSM), and magnetoelectric coupling using precision multiferroic tester.

Student award:

Yes

Level for award:

PhD

Theoretical and Computational Physics / 216

Modelling the infectiousness of viruses when exposed to ultraviolet germicidal system: A computational fluid dynamics approach

Authors: Emmanuel Igumbor[1]; Simon Connell[1]; Muaaz Bhamjee[1]; Mbolahasina Ralijaona[1]; Neil Martinson[2]; Kennedy Otwombe[3]

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Late 2019, the world started experiencing the advent of a new deadly disease (Coronavirus). Coronaviruses are widespread in humans and several other vertebrates and cause respiratory, enteric, hepatic, and neurologic diseases. There was relatively little information on the corona virus; consequently, the world was thrown into a state of pandemic as the virus spread across all continents with high morbidity and mortality. Due to the risk associated to coronavirus at the time, many studies have attempted to identify mitigation measures to reduce its infectiousness and understand its dynamics, evolution and control. Despite the numerous studies reported, there is limited modeling data that shows the decay process of the corona virus infectiousness in a confined environment, when subjected to ultra-violet germicidal irradiation (UVGI) system. Hence, in this study we report the results of a mathematical model that predicts the infectiousness of coronavirus while evolving using a computational fluid dynamic technique. Droplets containing coronavirus particles were injected into a fluid domain and allowed to move in the ambient flow, subject to illumination with UVGI in certain regions of the domain. Our modelling describes the viral concentration in the droplet and its reduction over time. The model can be used to predict infectiousness of the droplets when subjected to a UVGI system in different scenarios. Ultimately, the model will be used to inform and optimize the design of engineered interventions. This work will describe the details and benchmarking of the modelling.

Student award:

No

Level for award:

N/A

Poster Session / 217

Survey of Radiation Levels at Ithemba Labs using a Mobile Radiation Detection Unit Equipped with a LaBr3:Ce Detector

Authors: Ferdie van Niekerk[None]; Pete Jones[1]; Modisane Tiro[2]

[1] *PhD supervisor*

[2] *Co-researcher*

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A mobile radiation detection unit (MRDU) was developed to measure the radiation levels outside the iThemba LABS buildings, within the borders of the facility. The main attraction of this mobile unit is the fact that it is equipped with a LaBr3:Ce detector. This detector is superior to more conventional detectors (such as NaI:Tl) because of typically better spectral resolution, a high photon yield, and good detection efficiency [1, 2, 3]. It is known that the LaBr3:Ce detector has various sources of intrinsic activity of which the main cause is the presence of the radioactive 138La-isotope in the scintillation crystal [4]. One of the decay modes of 138La produces a gamma photon at 1435.8 keV which overlays with the 40K energy peak at 1460.8 keV when the detector resolution is taken into account. To quantify 40K activity this internal interference needs to be corrected. Additional to this, the influence of the radiation-source geometry also needs to be considered, especially during terrestrial surveys. This has a direct influence on detector efficiency which is a fundamental parameter for the accurate calculation of activity concentrations for the various radionuclides present in natural environments. Using the mobile radiation detection unit an assessment of radiation at the outside areas of the iThemba LABS facility was done. It was possible to elucidate the naturally occurring nuclides as well as 22Na from the gamma-ray spectra obtained. Due to the constant change in this geometry at the storage containers the 22Na, in particular, could only be estimated. Considering background radiation as well as the intrinsic radiation from the detector due to the presence of radioactive 138La, the activities of the nuclides were estimated to be 49.1 Bq/kg for 40K, 3.78 Bq/kg for 238U, 12.8 Bq/kg for 232Th and 72.5 kBq for 22Na. The effective dose rate of the NORM-nuclides was calculated as 0.0043 mSv/y. References [1] Zeng, M., Zeng, Z., Cang, J. et.al. (2014). A Prototype of LaBr3:Ce in situ Gamma-Ray Spectrometer for Marine Environmental Monitoring, Technology and Instrumentation in Particle Physics, 2-6 June 2014. [2] Quarati, F.G.A., Owens, A., Dorenbos, P. et.al. (2011). High energy gamma ray spectroscopy with LaBr3 scintillation detectors. Nuclear Instrumentation and Methods in Physics Research: Accelerators, Spectrometers, Detectors and Associated Equipment, vol. 629 (1), pp. 157-169. [3] Drescher, A., Yoho, M., Landsberger, S. et.al. (2017). Gamma-gamma coincidence performance of LaBr3:Ce scintillation detectors vs HPGe detectors in high count-rate scenarios. Applied Radiation and Isotopes, vol. 122, pp. 116-120. [4] Zenga, Z., Pana, X., Maa, H. et al. (2017). Optimization of an underwater in-situ LaBr3:Ce spectrometer with energy self-calibration and efficiency calibration, Applied Radiation and Isotopes, vol. 121, pp. 101-108.

Student award:

No

Level for award:

N/A

Poster Session / 218

The synthesis and characterization of metallic@semiconductor nanocomposite materials as active ingredients for solar and thermal energy harvesting applications

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The synthesis of various stable metallic nanoparticles is increasingly becoming the focus and source of interest, this is due to their key features such as surface plasmonic activity, catalytic activity, and stability, amongst others, these therefore indicate their potential uses for several promising applications. This study describes the synthesis of SnO_2-coated Gold nanostructures, including; nanospheres, nanoprisms, nanooctahedrals, and tip-blobbed nanooctahedrals (these are monometallic heteromorphic structures), with the aim to demonstrate the stabilizing effect of SnO_2 on the gold nanostructures. While our understanding of the reaction mechanisms initiated at the metal-semiconductor interface is complicated by a lot of factors including spatial non-uniformities. Herein we also study the various resulting metal-semicondctor systems which might have general relevance in broadenig our understanding of semiconductor stabilization and interaction at the surface of a metal. The wet chemistry approach used in this study has previously been successfully used to synthesize gold nanospheres stabilized with both SnO_2 and SiO_2. From an application perspective, the study intends to demonstrate the potential uses of the stable colloids of gold-semiconductor nanocomposite materials as heat transfer fluid additives, owing to the outstanding heat storage capabilities of the coating semiconductor material and the impeccable surface plasmonic resonance activities of the core metal structures. We also intend on emphesizing their uses in sensor devices and solar cells. The examinamination of the colloid stabilities using Ultraviolet-Visible spectroscopy (and Zeta potentiometer), demonstrates a clear stabilization by the coating material and absorption enhancement. Furthermore, the elemental analysis measurements carried out using TEM-EDS confirmedl the metal-semiconductor interaction which aided in our description of the proposed reaction mechanisms, from the analysis we also managed to search for other trace products. The structural morphologies of the metal nanomaterials before and after coating were conducted using transmission electron microscopy and secondary electron microscopy, the analysis of the morphologies gives some important insights for other potential future applications.

Student award:

Yes

Level for award:

MSc

Nuclear, Particle and Radiation Physics / 219

Higgs decay to dark vector bosons via an additional scalar

Author: Matthew Connell[1]

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Our group is conducting a search for physics beyond the Standard Model via non-standard decays of the Higgs boson at the ATLAS detector. A hidden or dark sector can be introduced with an additional U(1) gauge symmetry. These exotic decays are an attractive way to search for new physics as current measurements still allow for a significant branching ratio to exotic states, given even a small coupling to hidden sector particles. Further, hidden sector particles may preferentially couple to the Higgs boson, providing a promising portal to new physics. Previous studies have searched for Higgs decays via two dark vector bosons, each of which promptly decay to two leptons. Event display software for these decays indicates a significant amount of missing energy, which has not yet been incorporated into any dark boson searches. Missing energy can indicate the presence of exotic particles that are not visible over the timeframe of the detector. This presentation will discuss an ongoing search for a Higgs decaying to vector bosons via an additional intermediate scalar, S, ending in a four lepton plus missing energy final state. This scalar would represent a new dark sector scalar, such as the dark Higgs. We aim to explain the process of and demonstrate results for initial signal modelling for this decay. Currently there are no constraints on the dark Higgs mass, and if it is shown that the dark Higgs can be heavier than the Standard Model Higgs, allowing the dark vector bosons to be heavier, opening up further decay channels with potentially more dark sector states.

Student award:

Yes

Level for award:

PhD

Physics of Condensed Matter and Materials / 220

The phase stability, mechanical and electronic properties of CsCl-type intermetallic: TiTM (TM = Ni, Ru and Pd), a first-principles approach

Author: Bongani Ngobe[1]

Co-authors: Ramogohlo Diale [2]; Maje Phasha [3]; Mahlaga Molepo [4]

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Most Ti-based CsCl-type (Pm3m) compounds solidifies congruently to an ordered B2 phase of high symmetry at high temperature and transforms martensitically to lower symmetry phases upon cooling to room temperature. In this work, the phase stability, the mechanical and electronic properties of three CsCl-type intermetallic compounds TiTM (TM=Ni, Ru and Pd) were computed using density functional theory (DFT) based on first-principle technique are reported. The obtained lattice parameters are in good agreement with our experimental XRD results, which is a good indication that the computational parameters used in this work can be reliable to calculate other physical properties. Enthalpy of formations (ΔHF) and density of states (DOS), which are used to evaluate the thermodynamic stability of the compound, were calculated from the geometrically optimized crystal structures. A high negative heats of formation (-0.75 eV/atom) was obtained for TiRu phase, and its Fermi level found to coincide with the center of the pseudogap demonstrating the high stability and resistance to phase transition amongst the three investigated compounds. The primary elastic constants (C11, C12 and C44) and shear elastic coefficient (C') for cubic crystals were calculated. It was found that TiRu showed mechanically stability while TiPd and TiNi were not mechanically stable. Furthermore, the TiRu was found to exhibit only positive frequencies, while TiPd and TiNi exhibit both positive and negative frequencies signifying possible phase transition to low symmetry phases such as L10/B19/B19' at lower temperatures, in agreement with experimental data.

Keywords: First-principles calculations, Density functional theory (DFT), Elastic properties, Phase stability, Density of states, Phonon dispersion and Shape memory

Student award:

Yes

Level for award:

MSc

Space Science / 221

Development of the HARM model for aviation dosimetry

Authors: Moshe Godfrey Mosotho[1]; Du Toit Strauss[2]; Rendani Rejoyce Nndanganeni[3]

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Commercial aviation space is filled with intense particle radiation that poses a heath risk to the aviation industry. Measurements obtained using dosimetric instruments during commercial aircraft flights have shown that the radiation levels can exceed dosimetric health limits of ground level work places. However, most of these measurements are not conducted routinely and for specific flight routes. Therefore, to characterize and visualize the global radiation exposure of commercial aircraft passengers and flight personnel at aviation altitudes, the High Altitude Radiation Monitor (HARM) model was developed at the North-West University (NWU) ideally for dose accumulation assessment and the implication thereof. The model calculations are based on the temporal top-of-the-atmosphere galactic cosmic-ray spectra and ground-based neutron monitor observations, while a comparison to experimental latitudinal data survey measured with a tissue equivalent proportional counter (TEPC) onboard a commercial flight shows fairly good agreement between model and measurements. In this presentation, I will introduce the HARM model and briefly discuss its development stages and show its preliminary results.

Student award:

No

Level for award:

N/A

Astrophysics & Space Science / 222

Modelling compact stars: numerical solutions to the structure equations using Python

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The study of compact stars (CS) is a topic very valuable for the testing of modern physics in order to better understand the behaviour of cold dense nuclear matter. CS (white dwarfs or neutron stars) have no fusion processes occurring within them. The only way these stars are then capable of supporting themselves is through the degeneracy pressure of the fermions that constitute these objects. These stars can then be modelled as a degenerate Fermi gas of either electrons or neutrons. This study aimed to solve for the Newtonian and Tolman-Openheimer-Volkoff (TOV) structure equations through a numerical approach using Python in order to model the behaviour of these stars. White dwarfs were modelled as a fermi gas of electrons while the neutron star was modelled first as a pure neutron gas and then as a mix of neutrons,protons and electrons. A discussion on how realistic these results ensued. It was found that within certain limits, the results obtained particularly for the neutron stars, were relatively close to expected values for the mass of these objects in literature.the masses of white dwarfs in the non-relativistic and relativistic limits were 0.369 solar masses and 1.2469 solar masses respectively. The mass of a pure neutron star in which its constituent neutrons have arbitrary relativity were found for the TOV solution to be 0.771 solar masses and for the Newtonian structure equation to be 1.5312 solar masses. Lastly, the radius to mass ratios for the TOV solution was found to be 7.92442 and for the Newtonian, 9.6852 for a pure neutron star.

Key words: Compact stars (CS), Tolman-Oppenheimer-Volkoff structure equations (TOV), Newtonian structure equations.

Student award:

Yes

Level for award:

MSc

Nuclear, Particle and Radiation Physics / 223

A frequentist study of the false signals generated in the training of semi-supervised neural network classifiers using a WGAN as a data generator

Author: Benjamin Lieberman[1]

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In resonance searches for new physics, machine learning techniques are used to classify signal from background events. When using machine learning classifiers it is necessary to measure the amount of background events being incorrectly labelled as signal events. In this research the $Z\gamma \rightarrow (\ell^+\ell^-)\gamma$ final state dataset focusing around 150GeV centre of mass is used. A Wasserstein Generative Adversarial Network is used as a generative model and a semi-supervised DNN is used as a classifier. This study provides a methodology and the results of the measurement of false signals generated during the training of semi-supervised DNN classifiers.

Student award:

Yes

Level for award:

PhD

Theoretical and Computational Physics / 225

Statistical thermal models for particle reproduction in heavy ion collisions

Authors: Refiloe Innocencia Maphoto[1]; Boineelo Sekori[2]; Kudzai Sithole[3]; Vincent Masilela[4]; Thuthukile Khumalo[5]

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The quantity of various particles reported in relativistic heavy-ion collision research is consistent with the notion that they attain thermal equilibrium at temperatures substantially higher than those at which they kinetically freeze-out, which is a remarkable conclusion. This study attempts to explain this phenomenon by using statistical thermal models based on statistical mechanics theories to simulate the behavior, properties, and distribution of matter at extreme temperatures of microscopic matter. Additionally, the focus of the study is to apply statistical thermal models to determine how particle ratios and densities are influenced by temperature for particles produced in heavy-ion collisions. Statistical thermodynamics models are applied in the last stage of heavy ion collision which is hypothesized to be in thermal equilibrium. The reason for this is that, as the temperature rises beyond 200 MeV, the quark-gluon plasma begins to form, and after the quark-gluon plasma forms, hadronization occurs, resulting in the production of elementary particles. The ratios of these elementary particles, kaons, pions, antiprotons, and protons, were calculated and found to be in good agreement with the experimental results obtained from other studies. In conclusion, the study obtained the $\bar{p}/p$, K/π ratio, and u-quark and gluon densities plots as a function of temperature.

Student award:

Yes

Level for award:

MSc

Applied Physics / 226

Developing an Infectiousness model for droplet transmission

Authors: Mbolahasina Ralijaona[1]; Emmanuel Igumbor[1]; Muaaz Bhamjee[1]; Simon Connell[1]; Neil Martinson[2]; Kennedy Otwombe[2]; Hennie Grobler[1]

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Modelling of clinical public health data in clinical spaces guided by principles of physics can produce safer environments. Understanding airborne transmission of viruses is essential considering the recent worldwide SARS-CoV-2 pandemic. More understanding can help define better public health strategies to adopt and to design public spaces in such a way that humanity is no longer vulnerable to airborne transmission. Infectious saliva droplets are the principal factor of transmission and are associated with the magnitude of viral load. There is a need to consider the effects of local environmental factors on the evolution of droplet infectiousness. This work aims to develop a computational fluid dynamics model that incorporates heat and mass transfer to account for droplet evaporation. A computational fluid dynamics approach is applied to simulating droplet time evolution. An

Eulerian-Lagrangian approach was used to simulate air and particle flow. These flows were calculated using a two-way coupling method. Interactions between droplets are captured with coalescence and breakup models. Infectiousness is lowered by temperature, time and windspeed whereas humidity acts on infectiousness in such a way that it decreases less rapidly over time. Thus indoor spaces should be well ventilated. The results are benchmarked to measurement and other computational based methods and studies. The aim is to use the model to optimise the design of clinical and public spaces with optimal ventilation to minimise the risk of infection.

Student award:

No

Level for award:

N/A

Poster Session / **227**

Hyper-parameter optimization in the search for new resonances using weak supervised learning

Author: Edward Nkadimeng[1]

Co-authors: Nalamotse Joshua Choma [2]; Salah-Eddine Dahbi [1]; Bruce Mellado [1]

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We present an approach to search for heavy resonances. We focus particularly on the heavy resonances decaying into Zγ. The search is carried out in the di-lepton channel with two electrons~(muons) in the final state. This study is based on data from the ATLAS experiment gathered during the LHC Run-2, which corresponds to an integrated luminosity of 139 fb^{-1}. The goal is to set up a Deep Neural Network (DNN) based on weakly supervised learning to search for heavy resonances. DNN's can learn from large volumes of complex data and find non-linear feature combinations which as a result, are a useful tool for exploring large amounts of data in High Energy Physics. Hyper-parameters in combination with deep neural networks are used to search for resonances in the Z final state.

Student award:

Yes

Level for award:

PhD

Space Science / **228**

The Vacuum Arc Ion Thruster for Space Science Applications

Authors: Paul Stansell[1]; phil ferrer[2]

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The Vacuum Arc Thruster (VAT) is a simple electric propulsion system utilising pulsed arc discharges. Due to its low mass and power requirements, it is a candidate for small satellite space science missions. However, its thrust to power ratio, fuel efficiency and total impulse are much lower than larger, more traditional systems such as Hall effect and gridded ion thrusters. In this work the VAT is investigated as a plasma source for a high performance gridded ion thruster, a so-called Vacuum Arc Ion Thruster. This device seeks to combine the low mass and power advantages of the VAT with the high performance of a gridded ion thruster.

Several vacuum arc thrusters, as well as the pulsed power circuits that drive them, were built and characterised. Attention was given to their performance as thrusters themselves, as well as as plasma sources for the ion thruster. Different arc current pulse shapes and different cathode materials were experimented with. Total ion currents were measured for planar and coaxial thruster designs and a ballistic pendulum was constructed to provide individual impulse bit thrust measurements. The grid setup used to extract the ions into a beam as well as the extractor power supply design are presented. Attention was also given to beam neutralisation to ensure that beam ions do not return and coat sensitive spacecraft components.

Finally, the overall performance of the vacuum arc ion thruster is reviewed in the context of its application to a variety of space science missions.

Student award:

Yes

Level for award:

MSc

Physics of Condensed Matter and Materials / **229**

Magnetic Phase Transitions in Ce^{3+} Substituted $CoCr_2O_4$ Nanoparticles

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Broken inversion symmetry is observed in compounds with a spiral ordering, leading to ferroelectricity has attracted recent attention [1]. $CoCr_2O_4$ is a compound with a complex conical-spiral spin ordering of ferrimagnetic nature that has a spontaneous magnetization [2]. This observed spiral ordering has induced ferroelectric polarization [3]. The crystal structure of $CoCr_2O_4$ is cubic spinel, where tetrahedral *A* sites are occupied by Co^{2+} and the octahedral *B* sites by Cr^{3+} [2, 3]. Isotropic antiferromagnetic *A- B* and *B- B* exchange interactions (J_{AB} and J_{BB}) among the nearest neighbours with $J_{BB}/J_{AB} > 2/3$, give the solution for the ferrimagnetic spiral ground state having the spins located on the conical surfaces [4, 5]. The basic ordering of spins in the compound is AFM with unequal magnitudes that lead to a net FM order in the case of ferrimagnetic materials [6]. The present work investigates the role of Ce^{3+} substitution at the Cr^{3+} site on spiral ordering and other magnetic transitions in $Co(Cr_{0.95}Ce_{0.05})_2O_4$ nanoparticles. X-ray diffraction (XRD) studies of the sample calcined at 600 ℃ revealed phase purity and broadened diffraction peaks, which are signatures of the size effect. The crystallite size (D) estimated from the XRD was 6.3 ± 0.6 nm. The average particle size calculated from the transmission electron microscopy (TEM) data was found to be D_{TEM} = 8.4 ± 0.5 nm, corroborating the XRD results. Electron diffraction patterns confirm the crystalline nature of the nanoparticles having a bi-pyramidal shape. Magnetization as a function applied field shows an increase in coercivity as the temperature was decreased below the Curie temperature, T_C. Magnetization measured as a function of temperature indicated the ferrimagnetic behaviour, with T_C = 92.5 ± 0.5 K (using the "knee-point method"). However, the lock-in temperature observed for the $Co(Cr_{0.95}Ce_{0.05})_2O_4$ nanoparticles, T_L = 15 ± 2 K, is in agreement with that previously reported for pure $CoCr_2O_4$. Interestingly the spiral ordering was smeared by substituting Ce^{3+} at the Cr^{3+} site. The present work describes the impact of rare-earth Ce^{3+} ion substitution at the *B* site that can alter the exchange interaction in such a way that causes suppression of the spin spiral modulation.
References: [1] D.I. Khomskii, *J. Magn. Magn. Mat.* **306** (2006) 1. [2] Y.J. Choi, J. Okamoto, D.J. Huang, K.S. Chao, H.J. Lin, C.T. Chen, M. van Veenendaal, T.A. Kaplan, S-W. Cheong, *Phys. Rev. Lett.*

102 (2009) 067601. [3] Y. Yamasaki, S. Miyasaka, Y. Kaneko, J.-P. He,T. Arima, Y. Tokura, *Phys. Rev. Lett.* **96** (2006) 207204. [4] D.H. Lyons T. A. Kaplan, K. Dwight, N. Menyuk., Phys. Rev. **126** (1962) 540. [5] A review: N. Menyuk, in *Modern Aspects of Solid State Chemistry*, edited by C.N.R. Rao (Plenum, New York,1970), p. 1. [6] K. Majumdar, S.D. Mahanti, *J. Phys.: Condens. Matter* **33** (2021) 125801.

Student award:

No

Level for award:

N/A

Poster Session / **230**

Topic: Computational analyses of graphene quantum dots as anode material for lithium-ion batteries

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Many renewable energy technologies are underperforming due to optimal energy collection and storage. Renewable energy generation is not available all the time, it happens when the wind blows or the sun shines, storage is an essential part. Lithium-ion (LI) batteries are dominating the market as storage devices with recent advances towards the electric vehicles and renewable energy storage. Exploiting high capacity anode materials is one of the most effective ways to construct high energy density LI batteries. Energy, power, charge-discharge rate, cost, cycle life, safety and environmental impact are some of the parameters that need to be considered in adopting optimal LI batteries. As the recent development of batteries is mostly towards solid state batteries, small and high energy density materials are required. Graphene quantum dots (GQDs) have broad prospects in energy storage and conversion. First principle calculations are used to analyze optical properties of GQDs. The UV-vis spectra shows the maximum absorption peak at 750 nm within the edge of the visible region of the solar spectrum, thus favorable for renewable energy storage. Computational analyses strongly suggest the future development trend of GQDs research and its opportunities in energy storage devices.

Student award:

Yes

Level for award:

PhD

Physics of Condensed Matter and Materials / **231**

Impact of Cr substitution on magnetic properties of cobalt-doped ZnO nanoparticles

Author: Lokesha Handalagere Shankarappa[1]

Co-authors: Aletta Prinsloo [1]; Pankaj Mohanty [1]; Charles Sheppard [2]

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This study focuses on the magnetic properties of $Zn_{1-x}Co_xO$, with x = 0.01, 0.03, and $Zn_{0.96}Co_{0.01}Cr_{0.03}O$, synthesized by solution combustion method. X-ray diffraction (XRD) revealed samples are in a hexagonal wurtzite structure. Rietveld refinement gives lattice parameters, a = b = 3.246 Å, and c = 5.201 Å, for $Zn_{0.99}Co_{0.01}O$; matching standard data (PDF#36-1451), and marginally increased in $Zn_{0.96}Co_{0.01}Cr_{0.03}O$, attributed to defects near dopants sites [1]. The particle size determined using transmission electron microscope images was found to be 48±2, and 39±3 nm for $Zn_{1-x}Co_xO$ (x = 0.01, 0.03), respectively, and 15±2 nm for $Zn_{0.96}Co_{0.01}Cr_{0.03}O$. Diffuse reflectance spectra show the absorption bands in all samples at 569 nm $({}^4A_2(F) \rightarrow {}^4A_1(G))$, 610 nm $({}^4A_2(F) \rightarrow {}^4T_1(P))$ and 660nm $({}^4A_2(F) \rightarrow {}^2E(G))$ are transitions of Co^{2+} ions replacing Zn^{2+} sites [3]. In Co-Cr doped ZnO, an absorption band at 541 nm $({}^4A_2(F) \rightarrow {}^4T_{2g}(F))$ reflects the transition of Cr^{3+} ions [2] in the lattice. Band-gap values found are 3.306±0.003, and 3.289±0.004 eV for $Zn_{1-x}Co_xO$ (x = 0.01, 0.03, respectively) and 3.285±0.003 eV for $Zn_{0.96}Co_{0.01}Cr_{0.03}O$. Magnetization as a function of field curves, $M(\mu_0 H)$, measured at room temperature (RT) using a vibrating sample magnetometer, of $Zn_{0.96}Co_{0.01}Cr_{0.03}O$ and $Zn_{0.97}Co_{0.03}O$ samples are hysteretic, signifying RT ferromagnetism (FM). Cobalt-doped ZnO shows diamagnetism for x = 0.01, while RTFM is seen for the x = 0.03 sample. The observed RTFM are explained based on bound magnetic polaron (BMP) mechanism. The number of BMPs created in $Zn_{0.97}Co_{0.03}O$ was found to be $2.5 \times 10^{14} cm^{-3}$. It is suggested that the exchange interaction of Co^{2+} and/or Cr^{3+} dopants mediated BMPs is ordering RTFM. Keywords: ZnO, Combustion synthesis, Ferromagnetism, TEM.

References

1. M. Ashokkumar, S. Muthukumaran, Enhanced room temperature ferromagnetism and photoluminescence behavior of Cu-doped ZnO co-doped with Mn, Phy. E 69 (2015) 354–359. https://doi.org/10.1016/j.physe.2015.02.010.
2. J.J. Beltrán, C.A. Barrero, A. Punnoose, Combination of Defects Plus Mixed Valence of Transition Metals: A Strong Strategy for Ferromagnetic Enhancement in ZnO Nanoparticles, J. Phys. Chem. C 120 (2016) 8969–8978. https://doi.org/10.1021/acs.jpcc.6b00743.

Student award:

No

Level for award:

N/A

Applied Physics / **232**

Forecasting Short-term Power Consumption Using Deep Learning and Boosting Machine Learning Techniques

Authors: Makhamisa Senekane[3]; Lerato Lerato [1]; Sebota Mokeke[1]; MHLAMBULULI MAFU[2]; Naleli Matjelo[1]

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Short-term power consumption forecasting is increasingly playing a crucial role in ensuring the optimal management of power systems. One approach that can be utilized for forecasting short-term power consumption involves using Machine Learning (ML) models. In this paper, we report the use of Machine Learning models to forecast one hour-ahead power consumption. Machine Learning models used include those based on Artificial Neural Networks (ANN) and those based on boosting. We then compared the performance results for both ANN-based and boosting-based techniques. The results obtained from the study reported in this paper underline the importance of using Machine Learning models for short-term power consumption.

Student award:

No

Level for award:

N/A

Physics for Development, Education and Outreach / 233

Water Quality Assessment Using Graph Convolutional Neural Networks

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Water-borne diseases such as typhoid fever do pose a threat to communities, especially those communities in the Global South. This threat can be addressed by assessing the quality of water that is being consumed by the said communities. One approach that can be adopted in this assessment of water quality involves the use of Machine Learning (ML) techniques. ML is a branch of Artificial Intelligence (AI) that enables computers to learn from data without being explicitly programmed. In this paper, we present water quality assessment using convolutional Graph Neural Networks (GNNs). The performance results obtained from the study reported in this paper underline the importance of the use of convolutional GNNs to assess water quality.

Student award:

No

Level for award:

N/A

Poster Session / 234

Structure, optical and magnetic properties of combustion synthesized Ni-Cr doped ZnO

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Structural, optical and magnetic properties of combustion synthesized $Zn_{0.96}Ni_{0.01}Cr_{0.03}O$ and $Zn_{0.90}Ni_{0.05}Cr_{0.05}O$ have been investigated. X-ray diffraction (XRD) analyses confirm that samples are in the hexagonal wurtzite structure. No impurity peaks where detected in $Zn_{0.96}Ni_{0.01}Cr_{0.03}O$, while a weak secondary spike $ZnCr_2O_4$ phase ($2\Theta = 43^o$) was identified in $Zn_{0.90}Ni_{0.05}Cr_{0.05}O$. Lattice parameters, obtained from Rietveld refinement, were found to be a=b=3.2535±0.0002 Å for both the samples, while c=5.2132±0.0003 Å for $Zn_{0.96}Ni_{0.01}Cr_{0.03}O$ decreasing to 5.2129±0.0002 Å for $Zn_{0.90}Ni_{0.05}Cr_{0.05}O$. These values are comparable with the standard data (PDF#36-1451). Diffuse reflectance spectra show weak absorption bands at 422, 610 and 660 nm, characteristic of tetrahedral Ni^{2+} ions in the ZnO lattice [1]. Bandgap values, calculated using the Kubelka–Munk function [2], was found to be 3.287±0.003 and 3.272±0.003 eV for $Zn_{0.96}Ni_{0.01}Cr_{0.03}O$ and $Zn_{0.90}Ni_{0.05}Cr_{0.05}O$, respectively. Magnetization as a function of field measurements, $M(\mu_0 H)$, was performed at room temperature using a vibrating sample magnetometer. The $Zn_{0.96}Ni_{0.01}Cr_{0.03}O$ and $Zn_{0.90}Ni_{0.05}Cr_{0.05}O$ samples show ferromagnetic (FM) and antiferromagnetic (AFM) behaviour, respectively. Point defects are the source for the obtained FM in $Zn_{0.96}Ni_{0.01}Cr_{0.03}O$. The exchange interaction between Ni^{2+} and/or Cr^{3+} dopants and formation of a $ZnCr_2O_4$ phase is responsible for AFM behaviour in $Zn_{0.90}Ni_{0.05}Cr_{0.05}O$. This study reveals that the Ni^{2+} and Cr^{3+} ions successfully substituted into Zn^{2+} sites at lower concentrations of Cr^{3+} ions, while at higher concentrations some of the Cr ions are in an octahedral rather than tetrahedral coordination causing the formation of secondary phase. Interestingly, in Ni-Cr doped ZnO, the weak FM behaviour is transformed to AFM behaviour depending on the Cr content.

Keywords: ZnO, Combustion synthesis, Rietveld refinement, Magnetic properties

References

1. J.J. Beltrán, C.A. Barrero and A. Punnoose, The Journal of Physical Chemistry C., Vol. 120, p.8969–8978(2016).
2. N. Srinatha, K.G.M. Nair and Basavaraj Angadi, Physica B., Vol. 474, p.97–104 (2015).

Student award:

No

Level for award:

N/A

Photonics / 235

Simulating a deformable mirror with a spatial light modulator

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Co-authors: Angela Dudley [2]; Andrew Forbes [3]

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Deformable Mirrors are highly topical due to their ability to compensate for phase distortions caused by atmospheric turbulence. Since these devices can handle optical powers in the order of kilowatts, they are well suited for high-power applications ranging from high bandwidth optical communication to spatial profile control in additive manufacturing and other applications that involve high thermal aberration corrections. The number of mirror segments and their geometric structures are vital for beam shaping. Here we use a Liquid Crystal on Silicon Spatial Light Modulator to mimic the mechanical design of a deformable mirror and comparatively analyse the effect of mirror segment number and geometry on structured modes.

Student award:

Yes

Level for award:

MSc

Poster Session / 237

Binarised phase masks

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Spatial Light Modulators have received a great deal of attention due to their ability to tailor the amplitude, phase and (in some cases) the polarisation of light. They are ubiquitous to applications that include free-space optics, optical fibre, underwater communication and metrology to name a few. Binarising a phase mask (or hologram) involves segmenting a 'continuous' 2π phase-shift into N-discrete levels (or bands). Here, we used a Spatial Light Modulator to generate a series of discrete multi-levelled phase masks to investigate the fidelity of a variety of segmented structured modes by comparing them with modes generated with 'continuous' phase masks.

Student award:

Yes

Level for award:

MSc

Physics of Condensed Matter and Materials / **238**

Machine Learned Buckingham Interatomic Potentials for Co-doped Li-Mn-O spinel

Authors: DONALD HLUNGWANI[1]; Raesibe Sylvia Ledwaba[2]; Phuti Ngoepe[2]

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The current operational materials for lithium-ion batteries require improvement to sufficiently support large-scale systems such as the revolutionary electric vehicles and the storage of the sporadic energy garnered from renewable energy sources. Spinel LiMn2O4 is one of the safest and economically viable cathode materials that can provide adequate energy densities. However, LiMn2O4 suffers capacity fading during prolonged charge/discharge cycles. First-principles studies have shown that cation doping is one of the most effective ways of improving material performance. The effect of doping spinel LiMn2O4 at both electronic and atomic-level is not yet fully understood, particularly with Co, Ni, Cr, and Zr. The atomic-level exploration of such doping of LiMn2O4 to yield insights on how to suppress the reported capacity fading is hindered by the lack of accurate interatomic potentials. Hence, in this study we employ machine learning technique and the General Utility Lattice Program (GULP) to develop accurate Co – Co, Co - O and Co – Mn Buckingham interatomic potentials to be incorporated in a Co-doped Li-Mn-O spinel. The Buckingham potentials for Co – Co and Co – O interactions have been developed successfully and used to perform the molecular dynamics (MD) technique Amorphisation and Recrystallisation (A&R). The Co – Co and Co – O potentials have been tested on LiCo2O4 which successfully amorphised at 1900 K and recrystallised at 1900 K. The generated potentials will enable the exploration of the effect of doping nanostructured Li-Mn-O spinel with cobalt on the operating voltage which directly affects the energy density of battery.

Student award:

yes

Level for award:

PhD

Poster Session / **239**

Effect of annealing temperature and time on α-hematite thin films prepared via dip coating method for photoelectrochemical water splitting applications

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In this study, four layers of hematite (α-Fe2O3) thin films were prepared layer-by-layer on fluorine-doped tin oxide (FTO) using the dip coating method at withdrawal speed of 60 mm/min, annealed at 400-700oC for 2 hours, 30 minutes each layer. Following similar procedure additional samples were prepared and annealed at 700oC but different time intervals of 5,10 and 20 minutes for each of the four layers. The prepared α-Fe2O3 thin films were used as photoanodes in a three-electrode photoelectrochemical (PEC) system for water splitting. X-ray diffraction (XRD) and Raman spectroscopy studies confirmed the preparation of highly crystalline hematite thin films of good purity. The α-Fe2O3 films showed good optical absorption in the visible region because of their bandgap which was estimated to be 2.06-2.10 eV. The highest photocurrent density of 60μA/cm2 at 1.5 V vs reversible hydrogen electrode (RHE) was obtained for films annealed at 700oC for 30 mins for each layer. Electrochemical Impedance Spectroscopy (EIS) showed the reduced charge transfer resistance and increased capacitance of the α-Fe2O3 photoanodes annealed at 700oC for 30 mins for each layer, which has been related to improved photocurrent density obtained for the films. This study affirmed that the annealing of α-Fe2O3 films at higher temperatures and for prolonged time can enhanced their PEC properties for water splitting. Keywords: Hematite photoanode, dip coating, water splitting, annealing temperature, annealing time

Student award:

Yes

Level for award:

MSc

Poster Session / **241**

Enhancement of Li and graphane interaction through extended H vacancy pathways for Li-ion batteries: Ab initio study

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First-principles density functional theory calculations were performed to study the energetic stability, electronic and electrochemical properties of Li atoms on the H vacancies (VH) following a Line pathway as well as the zigzag pathway on a graphane sheet for LIBs. The results of Li on a single H vacancy VH1(L) revealed that it successfully induced interaction based on the improved binding energies, charge transfer and significantly shortened Li height, as compared to those of pristine graphane. An increase in H vacancies along the line pathway from one VH1(L) to five VH5(L) leaves behind localized electrons ready to interact with the Li atom resulting in high binding energies ranging from 1.82eV to 2.92eV. While creation of H vacancies along the zigzag pathway from one VH1(Z) to five VH5(Z) leaves behind electrons that pair and repel Li atom away yielding undesired low binding energies which become a setback for LIBs. For the increment of Li content following a line VH pathway, the binding energies of Li on configurations VH1(L) to VH5(L) tend to reduce in order, endearingly are still higher than the minimum Li standard bulk cohesive energy of 1.63 eV, suggesting a possible uniform dispersion of Li atoms with less clustering on the graphane sheet. A transition from insulator to metallic behaviour was observed with induced new Li states at the vicinity of the fermi level, which will enhance electron transmission in the graphane sheet. At five Li content adsorbed along the line configurations, a relatively high storage capacity of 207.49 mAh/g with its corresponding lithiation potential of 1.48 V are achieved and are comparable to the other previously studied 2-dimensional anode materials with high Li concentration.

Keywords: graphane, Li-ions batteries, adsorption, binding energy. 2-D anode materials, LIBs

Student award:

Yes

Level for award:

MSc

Theoretical and Computational Physics / 242

First principle' study of the properties of the Titanium based alloys (Ti doped with Mo, Mg, Zr, Ta and Si) for biomedical applications

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Introduction: Ti alloys presented excellent human implantation properties from research over the past 7 decades. Aim: The aim of the study is to investigate the three main selected properties of Ti-based alloys, which include the structural stability, mechanical and elastic properties doping with Mg, Mo, Zr, Ta and Si for biomedical applications using the First Principle' Approach. Method: The investigation was performed with the use of a computer simulation software, CASTEP code which contains the virtual crystal approximation (VCA) that applies the ab-initio total energy calculations belonging to the density functional theory (DFT) via the route of plane wave pseudopotential calculations for Kohn-Sham equations, with the help of Perdew-Burke-Ernzerhof (PBE) of the generalized gradient approximation (GGA). Results: The fermi level of the PDOS of Ti-Si alloy is located slightly on the edge of the d-orbital. A pseudo gap appears near the fermi level in the PDOS graph of Ti-Mo alloy indicating a stabilized covalent bond. For the PDOS of Ti-Ta alloy, weaker bonds are shown which elaborates less stability. The fermi level is at the far edge of the d-orbital therefore showing weaker stability. Conclusion: The results with the experimental values thus indicating that the investigation wasindeed successful.

Student award:

Yes

Level for award:

MSc

Poster Session / 246

Synthesis and Characterization of Graphene Oxide Nanocomposite for Application in Hybrid Supercapacitors

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Energy storage is one major challenge in the development of viable storage devices to sustain many electronic devices. Hybrid supercapacitors combine the underlying structures of both batteries and supercapacitors in one physical unit. Graphene oxide (GO) has been suggested as a promising material for improved energy density in storage devices. In this study, GO was prepared by modified Hammers method using graphite, KMnO4, H2SO4 and H3PO4. Fourier-transform infrared (FTIR) and Ultraviolet-Visible (UV-vis) spectroscopy were used to characterize the synthesized GO. From FTIR analysis, the transmittance broad band between 3100 to 3300 cm-1 (O-H) and spectral troughs at 1730 cm-1 and 1018 cm-1 which are attributable to C-O indicate the successful oxidation of graphite. UV-vis spectra support this success with the highest absorption peak at 800 nm.

Student award:

Yes

Level for award:

MSc

Nuclear, Particle and Radiation Physics / 247

Characterization of UF4 waste using gamma spectroscopy

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The Republic of South Africa in 1991 signed the non-proliferation treaty (NPT) which regulates nuclear states in terms of usage of nuclear technology and materials. However, the implementation of nuclear safeguards requires nuclear material accounting and control (NMAC). These safeguarded nuclear material include uranium, thorium and plutonium. There are nuclear material of unreacted waste, packed in approximately 350 polystyrene overpack drums (210 L in volume) collected from the extraction end of the research reactor as a result of earlier nuclear activities prior to 1991. This waste is under the South African Nuclear Energy Corporation (Necsa). The aim of this research was to characterize this radioactivity of the unburnt UF4 waste drums using gamma spectrometry technique. A Canberra BEGe detector with a Genie 2000 software was employed in this study to collect data. For each drum, activity was measured from the outside in three locations (top, middle and bottom), to identify the radionuclde therefrom. The results show that most in all the seven drums investigated, 235U and 234Pa were detected with activities of 1.18 ± 0.12 Bq/kg and 0.017 ± 0.002 Bq/kg, respectively. 228Ac & 212Pb activities were not detected outside the drums confirming that the concrete encapsulation was effective in immobilizing these radionuclide.

Student award:

Yes

Level for award:

PhD

Poster Session / 248

structural and electronic properties of TiNOs (N = 1- 15) clusters:A density functional theory study

Author: Ramalebana Moeti[None]

Co-authors: Hasani Chauke ; Phuti Ngoepe ; Tshegofatso Phaahla

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Doped transition metal nanoclusters have attracted significant interest for essential scientific research and various application purposes such as heterogeneous catalysts, electrochemistry and alloy designs. However, the current understanding of titanium bearing bimetallic nanoclusters is far from satisfactory. This is due to the complexity of the almost empty d band. The concept of metal doping of nanoclusters provides an opportunity to tune their activity and selectivity. In this study, structural and electronic properties of TiN-1Os (n = 2 –16) clusters have been investigated using density functional theory. The calculations showed that Osmium impurity prefers to be encapsulated and mostly occupies the face and surface of titanium nanoclusters. The Ti6Os and Ti12Os nanoclusters are found to be more stable. Interestingly, Osmium dopant converted N = 13 as the magic cluster. The HOMO-LUMO gave the lowest energy gap at Ti12Os (N = 13), which correlates well with the predicted binding energy, relative stability and dissociation energy

Student award:

Yes

Level for award:

Hons

Physics for Development, Education and Outreach / 249

Students' understanding of physical components of electrical circuits.

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In many cases, the teaching of electricity starts from the basic use of ohms law and its mathematical interpretations. Less is done in terms of defining and explaining qualitatively the role of the electric circuit elements like a resistor, a conductor, a switch and lastly a battery. Since the learning of electricity is predominantly conceptual, it is perceived as difficult because it cannot be physically touched or seen and those physical components are less dealt with qualitatively. The physical components are used during representations to explain the conceptual interactions of what takes place in each component in terms of current, resistance and potential difference. This research is aimed at determining how students define and explain the role of some basic electric circuit elements, that is, resistors, conductors, batteries and a switch. In addition, this work aims to determine how the knowledge of these physical components can enhance the understanding of electricity as a whole.

Student award:

No

Level for award:

N/A

Physics of Condensed Matter and Materials / 250

Evaluating the small Ti7 cluster in α-TiCl3 medium

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The Kroll process is a widely used technique in the commercial production of titanium. This process involves a magnesiothermic reduction of titanium tetrachloride (TiCl4). Although this process has several advantages, it is, however, not suitable for the development of a continuous reduction process. Recent studies have introduced a magnesiothermic reduction of other transition metal halides such as titanium trichloride (TiCl3) or titanium dichloride (TiCl2). This is in an attempt to develop a high-speed (semi-)continuous reduction process. In this study, classical molecular dynamic calculations were performed to understand the influence of temperature on the Ti7/TiCl3 (α-TiCl3) system. The DL_POLY code was used to evaluate the temperature dependence of the structure. It was found that the cluster maintains its pentagonal bipyramid geometry. The entropy and Gibbs free energy were used to deduce the behaviour of atoms and the spontaneity of the structure. It was observed that the entropy graph shows the system to be well arranged (ordered) at the temperature range of 50 K – 2000 K. Furthermore, it was also observed that the system is spontaneous (favourable) at 50 K. The results of this study give us more insight into the TiCl3 medium as a potential medium for evaluating titanium.

Student award:

Yes

Level for award:

PhD

Poster Session / 251

layered organic-inorganic perovskite films in solar cells

Author: Sandile Thubane[None]

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Perovskites of cesium lead halide (CsPbX3, X = Cl, Br, I) have received a lot of attention due to their relative stability in comparison to their organic-inorganic counterparts. This study synthesized a thin film of cesium lead tribromide (CsPbBr3) by spin coating followed by dip coating and characterized it through a scanning electron microscope (SEM), ultraviolet-visible (UV- Vis) spectrometer, and X-ray diffraction (XRD) in order to observe its morphological, optical and structural characteristics. SEM micrographs revealed pinholes within the perovskite film that significantly impacted device performance. To address this issue, we show that spin-coating phenethylammonium bromide (PEABr) on CsPbBr3 thin films improves morphology and surface coverage. The optical study of CsPbBr3 thin film showed a broad UV-Vis absorption with an onset at 530 nm and an excitonic peak at 515 nm. However, CsPbBr3/PEABr preserves the optical properties of CsPbBr3. Additionally, two excitonic peaks appear at 405 and 436 nm which are attributed to a 2D perovskite PEA2Csn-1PbnBr3n+1 with n = 1 and n = 2 phase. The viscosity of PEABr was also suggested to play a role in the decrease followed by an increase in absorption of CsPbBr3/PEABr films. XRD results of CsPbBr3 film showed the impurity phase of CsPb2Br5 and a cubic CsPbBr3 structure with the Pm-3m space group. Furthermore, PEABr had no effect on the intrinsic crystal structure of CsPbBr3. The CsPbBr3 solar cell produced a low open-circuit voltage (Voc) of 0.3 eV and a fill factor (FF) of 30.89%, which may due to the loss of charge-carriers in the area with pinholes. This could also explain the device's low power conversion efficiency (PCE) of 0.9%. A mixed-cation solar cell based on CsMAFAPb(IBr)3 was also designed and fabricated. This solar cell showed a photoluminescence emission at 766 nm with a charge carrier lifetime of 24 ns, which indicates that it is less prone to degradation. Current density-voltage (J-V) characteristics of CsMAFAPb(IBr)3 show a Voc and a FF of 1.14 eV and 57.32%, respectively. With this device, PCE of 13.89% was also achieved, with a short-circuit current of 23 mA/cm2. We conclude that these results may be related to the low hysteresis experienced at low voltage scan speeds of 10 mV/s. All things considered, the addition of an organic spacer to a 3D perovskite improves the morphological, optical, and structural characteristics of the as-prepared 3D perovskite film.

Student award:

Yes

Level for award:

MSc

Physics of Condensed Matter and Materials / 252

The effects carbon and boron on the T-MnAl alloy properties employing the first principle approach

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The development of permanent magnets without rare-earth elements has gained a lot of attension. The T-phase MnAl alloy has gained particular attention due to the low cost of materials required. The density functional theory (DFT) within the generalized gradient approximation (GGA) was used to perform first-principle calculations, to study the T-MnAl alloy. The effects of carbon and

boron on the electronic and magnetic properties of T-MnAl alloy were studied. The spin Orbital magnetic moments of Mn, C, and B ions were found to be opposite to each other, which is in agreement with Hund's rule. The total spin magnetic moments were found to be lower than that of the total orbital magnetic moment.

Student award:

Yes

Level for award:

MSc

Theoretical and Computational Physics / **253**

Quantum key distribution protocol implemented with biphotons

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High-dimensional quantum key distribution has become a viable alternative towards bringing the quantum key distribution (QKD) technology closer to its wide adoption owing to its capability of tolerating high error rate and high photon information capacity. In this work, we propose of measurement device independent QKD protocol which exploits the polarization state of a biphoton to encode information on a three level quantum system - a qutrit. Also, we investigate the performance of the proposed protocol by simulating the secret key rate as function of transmission distance in the finite regime. The simulation results demonstrate that the protocol can achieve a significant secret key rate at reasonable transmission distances of about 90 km with 10^{16} signals. Furthermore, our results indicate that reasonable key rates are achieved with minimum data size of about 10^{14} signals which are realizable with the current technology.

Student award:

No

Level for award:

N/A

Poster Session / **255**

Carbon Ion implanted ZnO Nanorods-Structural and Optical analysis

Authors: Kebadiretse Lefatshe[1]; Cosmas Muiva[None]; Morgan Madhuku[None]

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Incorporation of either metallic or non-metallic ions through implantation persuades structural imperfections which alters the electronic structure and possibly the optical properties of the implanted materials. 50 keV carbon ions were implanted into ZnO-NRs with varying fluences up to 3.0 × 1016 ions/cm2. The successful assimilation of carbon ions into the ZnO is primarily noted by a variation of the full width at half maximum (FWHM), the peak intensity and the reduction in crystallite sizes which is relative to the fluence of the ions. The bombardment of C+ ions into the ZnO lattice did not result in formation of secondary phase or carbon related reflections. At lower fluence, substitution and interstitial preference is observed, whereas increasing the fluence of carbon ions results in interstitial occupancy. The 1D nanorod morphology is retained, however AFM statistical analysis indicates a variation of morphological parameters. A significant increase in the surface roughness is noted and associated to the sensitivity of the intersection angle between neighbouring grains. The variation in the optical absorption and extinction coefficients reveal that the carbon ions are definitely incorporated into the ZnO lattice thus modifying its crystal and electronic structures. Values of 3. 20, 3.22, 3.25, 3.17 and 2.97 eV where estimated as the optical band gaps of C+ implanted with carbon ions of fluence of 1 x1015, 2 x1015, 3 x1015, 1 x1016 and 3 x1016 ions/cm2 respectively. A possible explanation for the reduction of the band gap is that the substitution of carbon species into the ZnO lattice introduces isolated impurity bands of C (2p) between the conduction and valence bands, which often appear above the Fermi level. These states serve as freeway for electrons to swiftly transfer into the CB upon photoexcitation

Student award:

Yes

Level for award:

MSc

Applied Physics / **256**

Density functional theory study of Nax (TiyZnzMnw)O2 as a 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*

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Rechargeable sodium-ion batteries 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 has recently attracted tremendous research interest. In this study, density functional theory was used to investigate structural and electronic properties NaMnO2 doped with Ti and Zn. expansion of volumes is induced by the dopants, The partial density of states underlines that these states nearby the Fermi level are contributed from the d-orbital of Ti and Zn. The magnetism is attributed from the hybridisation of d-orbitals of dopant and Mn atom with O-p states, namely p-d exchange hybridisation. The lowest conduction band and highest valence band are mostly contributed from Mn atom, Ti and Zn dopants which are responsible for the electronic conductivity. Na(Mn,Ti)O2 and Na(Mn,Zn)O2 and are all semiconductors with reduced band gaps, while Na(Mn,Ti,Zn)O2 displays half-metallic ferromagnetic behavior.

Student award:

Yes

Level for award:

PhD

Poster Session / 257

Li adsorption on a self-healed graphane for the next generation ion batteries

Authors: Edwin Mapasha[1]; Sentserere Kgalema[None]

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Density functional theory calculations where performed to study the behaviour of Li atom on self-healed graphane, focusing on the reconstructed region. The energetic stability, structural and electronic properties of different Li configurations where examined. Li atoms prefers to strongly bind at the octagon site transferring almost of its electronic charge towards its surrounding carbon atoms based on Barder charge analysis criterion, unlike in the case of pristine. Li atom enables semiconducting-metallic transition with an induced Li states at the vicinity of Fermi level, suggesting an introduction of electronic conductivity which will enhance electron transmission in the graphane sheet. The self-healed graphane promises to be a high performance electrode material by exhibiting lithiation voltage of 1.89 V. Lastly, we found that self-healed graphane monolayer can specifically be suitable for anode material due to its calculated relative high storage capacities and high rate performance for next generation ion batteries.

Student award:

No

Level for award:

N/A

Physics for Development, Education and Outreach / 258

The effects of monitored peer teaching and learning on the understanding of basic Physics concepts

Authors: Buyi Sondezi[1]; Mphiriseni Khwanda[2]; Paul Molefe[1]

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Learners and students alike are always seeking alternative ways of learning and understanding the concepts of most Science, Technology, Engineering and Mathematics (STEM) courses. Among these clusters of STEM courses, a sub-branch of Physics has been the most challenging one for both learners at the school level as well as for students at the university level. The challenge is particularly prominent in the first few years of their university experience. In an endeavour to deal with this challenge, lecturers are forever seeking ways and strategies of effective methods that could be used to make the delivery of this course easy and manageable for students. Peer teaching has been adopted as one of the methods to be explored in teaching a specific topic to a specific group of first-year students, to enhance their involvement, understanding and ownership of their learning. This work reports on the findings of this method as investigated on to first-year students at the University of Johannesburg. Conclusions were drawn from well-analysed data obtained from interviews and questionnaires from students.

Student award:

No

Level for award:

N/A

Physics of Condensed Matter and Materials / 259

Investigating sodium incorporated Li2MnO3 nanostructured cathodes for lithium-ion batteries

Authors: Phuti Ngoepe[1]; Raesibe Sylvia Ledwaba[1]; Tshidi Mogashoa[2]

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[2] *UL*

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Capacity degradation and voltage fade of Li2MnO3 during cycling are the limiting factors for its practical use as a high capacity lithium-ion battery cathode. The incorporation of sodium ions in the lithium sites can mitigate voltage decay by limiting transition metal migration, impeding the oxygen loss and also improving lithium diffusion of Li-rich layered host materials. In this work, nanostructured Li2MnO3 models have been generated via the simulated amorphisation and recrystallisation (A+R) technique employing the DL_POLY code. Accordingly, sodium was partially introduced into the Li2MnO3 lattice resulting in a series of Li2-xNaxMnO3 ($0 \leq x \leq 2$) models of different lithium and sodium content. The generated models were subjected to various temperatures to determine the temperatures at which amorphisation and recrystallisation materialised. All the molecular dynamics calculations were carried out at temperatures between 1600-1800 K. Lithium-ion diffusion has been significantly increased in models with low sodium content. Particularly, Li1.975Na0.025MnO3 consisting of the lowest sodium content displayed a high diffusion rate. Characterisation of the x-ray diffraction patterns revealed peak broadening along with the shifting of peaks at 2Θ~38 to the right due to the enlarged lithium layers occupied by sodium ions to facilitate lithium diffusion. These findings shed insights on the role of sodium substitution on the nanostructured Li2MnO3 cathodes and will help guide the enhancement of high-capacity energy storage.

Student award:

Yes

Level for award:

PhD

Applied Physics / 260

Developing a Nuclear Orientation Thermometer for the UCT Dilution Refrigerator

Author: Yanga Ntolosi[1]

Co-authors: Steve Peterson [2]; Mark Blumenthal [3]; Dominique Gouveia [3]

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[3] *2. Department of Physics, University of Cape Town*

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A significant challenge in low temperature thermometry is the accurate measurement of temperatures below 1 k. Nuclear Orientation (NO) is a non-electronic technique to measure ultra-low temperature accurately as opposed to traditional resistive thermometers. The NO method relies on the measurement of the alignment of the nuclear spin in a radioactive nucleus, where the temperature can be derived from the Boltzmann distribution. The aim is to develop a NO thermometry system using the recently procured gamma-ray anisotropy thermometer (60CoCo(hcp)) source for use in the University of Cape Town Department of Physics dilution refrigerator. The UCT dilution refrigerator is able to achieve these ultra-low temperatures (down to 8 mK) by taking advantage of the properties of both 3He and 4He gas.

The 60CoCo(hcp) radiation source, irradiated using the SAFARI-1 research reactor at NECSA, is incorporated into the dilution fridge by thermally mounting it onto the plate in which the mixing chamber is positioned. The data acquisition system, a Sodium Iodide (NaI) scintillation detector, is placed in line with the source allowing it to detect the radiation as accurately as possible. The ratio of the detected radiation at various temperatures provides the measurement of nuclear spin alignment and thus the absolute temperature of the system. The preliminary measurements are promising, but more work needs to be done in order to develop a fully-functioning NO temperature measurement system.

Student award:

Yes

Level for award:

MSc

Poster Session / **261**

Modelling Weather Patterns and Solar PV systems for the Sizing of Standalone PV Battery Charging System

Author: Happy Ndlovu[None]

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The department of physics and Engineering at the University of Zululand (UNIZULU) is located in the middle of rural Zululand with communities that need to supplement the national energy grid with alternative energy sources. Most of these communities are rural or semi-rural who mostly harness solar energy by using standalone Photovoltaic (PV) battery charging systems. The University in its endeavour to support the surrounding communities carries out research with the purpose to ease the financial burden of these communities by tapping into the intellect of the postgraduate students. Zululand boasts a subtropical climate with sufficient solar radiation available for more than nine months of the year. The focus of this project is twofold: to predict the seasonal solar radiation in Norther KwaZulu Natal especially in non-monitored areas, and to model solar PV arrays for the sizing of standalone battery charging systems with the focus on hot climate regions. Recently an Electronics research laboratory that hosts state of the art equipment was inaugurated at the institution. This lab supports the use of 4th Industrial Revolution (4IR) techniques such as artificial intelligence approaches to provide soft means of modelling the weather patterns and the PV systems. The study involves the understanding of the processes/ principles involved in the generation of electrical energy from Solar cells. It will then require the translation of this understanding into models that can be used to captured the essence of the weather patterns and their interaction with the PV systems. Putting together a soft model and finally a prototype will be a major part of the suggested study. The developed prototype instrument will then be tested for recommendation on performance and possible adoption.

Student award:

Yes

Level for award:

MSc

Physics of Condensed Matter and Materials / **262**

Effect of Mn addition on the ductility of FeCo soft magnetic alloy

Authors: Tebogo Ledwaba[1]; Ramogohlo Diale[2]; Phuti Ngoepe[1]; Hasani Chauke[2]

[1] *University of Limpopo*

[2] *UL*

Corresponding Author: ledwaba.tebogo81@gmail.com

FeCo alloy plays an important role in soft magnetic materials with a wide range of technological applications due to its high saturation magnetization and Curie temperature. However, this alloy shows low levels of ductility at room temperature. The ductility of this alloy can be improved by the ternary addition of Manganese (Mn). In this study, a supercell approach was used to generate B2 Fe50Co50-XMnX structures (0≤X≤50), and different properties were evaluated to determine their ductility and stability at room temperature. Both binary and ternary structures were fully optimized to obtain better equilibrium ground-state properties such as lattice parameters and thermodynamic properties. The results obtained from the FeCo system gave equilibrium lattice parameter and heats of formation which are in good agreement with the experimental findings to within 1%. The ductility and brittleness behavior of the B2 Fe50Co50-xMnx alloys was evaluated through the three quantities: Poisson's ratio, the B/G ratio, and the Cauchy pressure at different compositions. The findings confirm that alloying with Mn effectively improved the ductility. It was also found that the ternary addition of Mn to the FeCo system resulted in enhanced magnetic properties. The findings reveal that Fe50Co50-xMnx alloys can be used in the future development of magnets.

Keywords: FeCo soft magnetic alloys, Supercell approach, Magnetic properties, Ductility

Student award:

Yes

Level for award:

MSc

Poster Session / **264**

Electronic, Magnetic and Mechanical Properties Of Nd2Fe14B Permanent Magnets: Ab Initio Study

Authors: MPHAMELA ENOS BALOYI[1]; Phuti Ngoepe[2]; Hasani Chauke[2]

[1] *applicant*

[2] *University of Limpopo*

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Neodymium-based permanent magnets (Nd2Fe14B) are the potential permanent magnets for use in various applications due to their high magnetic field strength and resistance to demagnetisation. These magnets have various applications in highly efficient energy conversion machines and devices such as wind turbines and electric vehicles due to their exceptional magnetic properties. However, they suffer from low operating temperatures below 585 K. In this study, we investigate the electronic, magnetic and mechanical properties of Neodymium magnets using the first principle density functional theory approach. Nd2Fe14B was found to be thermodynamically stable since the heats of formation are found to be negative. However, it was found that Nd2Fe14B fails to meet the tetragonal stability criteria, which is ascribed to the mechanical instability of the material. Moreover, the density of states was calculated to predict the electronic stability of the permanent magnets which is in agreement with the calculated heats of formation. The phonon dispersion curves were also calculated and Nd2Fe14B is found to be vibrationally unstable due to the presence of soft modes. The calculated magnetic moment compares well to the experimental findings. The substitution of Nd with available rare earth elements is suggested to enhance the stability and magnetic properties of the magnets.

Student award:

Yes

Level for award:

PhD

Poster Session / 265

Photoluminescence characteristics of bulk hydrogenated anatase TiO2

Authors: Assane TALLA[1]; Z. N Urgessa[1]; S.V. Motloung[2]; J.R Botha[1]

[1] *Nelson Mandela University*

[2] *Walter Sisulu University*

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This study investigates the optical characteristics of hydrogenated crystalline bulk anatase Titanium dioxide (TiO2) using temperature-dependent photoluminescence (PL). The incorporation of deuterium (D2) is achieved by annealing in D2 atmosphere at a temperature of 300 oC. Temperature-dependent PL measurements are performed under continuous wave-laser excitation from 5.5 K to room temperature. The low-temperature PL measurement reveals that the spectra are dominated by exciton emission at 3.368 eV, accompanied by several phonon replica. As the PL spectra of TiO2 often show a significant Stokes shift with a broad emission band centered in the visible spectral range, such sharp PL features for TiO2 are rare in literature. As these samples are hydrogenated and other vibrational spectroscopy studies have already been performed on a similar sample, the lines observed at 3.368 eV are tentatively assigned to an exciton bound to hydrogen at oxygen vacancies (HO). The line observed at 3.305 eV is stable up to a measurement temperature of 200 K and accompanied by a persistent set of phonon replica. It is tempting to associate this line with defect-related emission. The corresponding exciton binding energies are calculated from the temperature-dependent PL and will be discussed in detail.

Student award:

Yes

Level for award:

PhD

Astrophysics & Space Science / 266

The development of Radio Astronomy in South Africa

Author: Sharmila Goedhart[1]

[1] *SARAO*

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South Africa is one of the host countries to the Square Kilometer Array (SKA) and has built the 64-antenna MeerKAT Telescope as a pathfinder and precursor to the SKA. Prior to the creation of the SKA South Africa project, the sole radio astronomy facility in South Africa was the 26m dish at Hartebeesthoek Radio Astronomy Observatory (HartRAO).

In this talk I'll give an overview of the history of radio astronomy in South Africa, the development of MeerKAT through the bid to host the SKA and highlight some of the recent scientific discoveries since the inauguration of MeerKAT in 2018.

Student award:

No

Level for award:

N/A

Applied Physics / 267

Measurement of fast neutron removal cross sections for the elemental analysis of concrete

Author: Nalesi Segale[1]

Co-authors: Tanya Hutton [1]; Sizwe Mhlongo [1]; Andy Buffler [1]

[1] *University of Cape Town*

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In nuclear power plants, concrete structures are exposed to high stresses, prolonged high temperatures, moisture and high levels of neutron and gamma-ray radiation. These conditions often cause the concrete to degrade and change in composition over time, particularly with respect to water content [1]. The shielding properties, and subsequent elemental composition, of existing concrete need to be non-destructively determined to ensure compliance with the nuclear regulations. Previous work at the University of Cape Town has successfully demonstrated the use of fast neutron transmission spectroscopy to determine the composition of a concrete sample with respect to the base ingredients [2], but there are many instances where a more generalised approach is required [3]. Sand is one of the main components of any concrete and is comprised of variable proportions of silicon dioxide (SiO2) and calcium carbonate (CaCO3). In this work we present the results of neutron transmission measurements made with a collimated 241Am-9Be radioisotopic source, incident on samples of sand, SiO2 and CaCO3, and measured with an EJ301 organic liquid scintillator. Spectrum unfolding was used to determine the energy dependent effective removal cross sections for these samples. Future work will include measurements of elemental removal cross sections for carbon and silicon which will be used to infer the elemental composition of sand, and eventually concrete.

Student award:

Yes

Level for award:

Hons

Astrophysics / 268

African Astronomical Society (AfAS): the voice of astronomy in Africa

Author: Charles Takalana[1]

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The African Astronomical Society (AfAS) is a Pan-African Professional Society of Astronomers registered in South Africa as a non-profit, voluntary society. Our vision is to create and support a globally competitive and collaborative astronomy community in Africa. Our mission is to be the voice of astronomy in Africa and to contribute to addressing the challenges faced by Africa through the promotion and advancement of astronomy. AfAS's key objective is to develop Astronomy and Human Capacity throughout the continent of Africa through a vibrant and active AfAS. South Africa currently hosts the Secretariat of AfAS through the Department of Science and Innovation (DSI), and our office is located at the South African Astronomical Observatory (SAAO) in Cape Town.

This talk will focus on the progress made by AfAS in contributing to science, outreach, communication, and education activities emanating from Astronomy in Africa since its relaunch in March 2019 and how AfAS is further enhancing collaboration among countries in Africa and institutions outside of the continent. Various AfAS led flagship projects have also been initiated to strengthen astronomy activities in the continent further. The

talk will also talk about the efforts of the African Network of Women in Astronomy. This initiative aims to connect women working in astronomy and related fields in Africa. Finally, the talk will give an update on AfAS membership and past and upcoming calls.

Student award:

No

Level for award:

N/A

Applied Physics / **269**

Physics-Informed Neural Networks

Author: Alan Matthews[1]

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A Physics-Informed Neural Network (PINN) is a neural network that is constrained by laws of physics. The best-known type of PINN is a feed-forward, fully connected neural network, or multi-layer perceptron, with a loss function that has a data term plus a term for the PDE that governs the physical system. Including physics knowledge that is additional to data reduces the solution space, which allows for finding a solution when limited data is available. A PINN is not necessarily a replacement for analytical or numerical methods; rather it is useful in cases where solutions are difficult to find with conventional methods. A PINN may also have a modified architecture of connections between neurons, but that is more difficult to do than informing the loss function. A PINN may be applied to finding a future state of a system given initial conditions, as is done in time-evolution simulations, and also for inverse problems in which the final state is known but the parameter values need to be determined. Examples will be presented.

Student award:

No

Level for award:

N/A

Poster Session / **270**

Nuclear Structure of Neutron-Rich 128In Using Beta-decay Spectroscopy

Author: Nikita Bernier[None]

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Neutron-rich indium isotopes ($Z = 49$) near the well-known magic numbers at $Z = 50$ and $N = 82$ are prime candidates to study the evolving shell structure observed in exotic nuclei. Additionally, the properties of nuclei around the doubly magic ^{132}Sn have direct implications for astrophysical models, leading to the corresponding neutron-shell closure nuclei around $N = 82$ and the second r-process abundance peak at $A \approx 130$. The β decay of ^{128}Cd into ^{128}In was investigated using the GRIFFIN spectrometer at TRIUMF. In addition to the four previously observed excited states, 32 new transitions and 11 new states have been observed. These new results are compared with recent phenomenological shell model calculations as well as ab initio predictions from the valence-space in-medium similarity renormalization group (IMSRG), based on two- and three-nucleon forces derived from chiral effective field theory. This new experimental information highlights the challenges for both phenomenological and ab initio calculations to reproduce the full complexity of heavy nuclei four nucleon-holes away from the doubly magic ^{132}Sn.

Student award:

No

Level for award:

N/A

Space Science / **271**

A behavior of EIA during geomagnetic storms

Author: Avuyile Bulala[1]

Co-authors: John Habarulema [2]; Tshimangadzo Matamba [2]

[1] *iThemaba LABS*

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This research study aims to establish the behavior of Equatorial Ionization Anomaly (EIA) during geomagnetic storms. To identify geomagnetic storms, criteria of Dst ≤ -30 nT, and where Kp ≥ 4 indices will be used. The dynamics of the EIA will be studied based on total electron content (TEC) data for the period of five years (2008 to 2013), TEC is derived from Global Navigation Satellite Systems, over the middle, low, and equatorial latitudes will be used for this analysis. This work will focus on establishing the range of electrodynamics magnitudes (vertical E × B drift magnitude) likely to be reached for EIA to expand beyond the crest of ± 20° towards mid-latitudes.

Student award:

Yes

Level for award:

PhD

Poster Session / **273**

Effects of changing operational voltage on Thermal and Current-Voltage measurements of poly-crystalline Photovoltaic module and individual cells

Author: Monphias Vumbugwa[1]

Co-authors: Jacqueline Crozier McCleland [1]; Frederik Vorster [1]; Earnest van Dyk [1]

[1] *Nelson Mandela University*

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Photovoltaic (PV) cells operating in the field generally have a degree of cell mismatch caused by; a) inherent mismatch from manufacturing shortcomings and b) different operational conditions, cell mismatch caused by external environmental factors such as partial shading or soiling and potential induced degradation (PID). This study focuses on the analysis of current-voltage (I-V) characteristics based on voltage measurements of individual cells and module current of a poly-crystalline PV module recorded concurrently with thermal images. This facilitates the understanding of the behaviour of abnormal thermal signatures at different operational I-V points, which were achieved by varying a resistive load. The change in load conditions influenced the module's current, voltage operational points and temperature distribution such that the mismatched cells behave differently. Mismatched cells are likely to operate in reverse bias and cause abnormal thermal signatures when the module's operational voltage is less than its maximum power voltage (VMP) of 28 V. Cell mismatch is unlikely to occur, hence no abnormal hot cells on TIR images, when the operational voltage of the module is greater than VMP. The dynamics of the abnormal thermal signatures can mislead decisions during TIR imaging inspections when bad cells do not show their abnormal thermal signature on TIR images. It is beneficial to optimise power output with the operational voltage higher and not less than VMP, since the bad cells will not become abnormally hot to cause detrimental effects. This study shows additional insights which can improve the operation, TIR imaging inspections, reliability and performance of poly-crystalline PV modules. Keywords: poly-crystalline cells, hot cells, different load conditions

Student award:

Yes

Level for award:

PhD

Nuclear, Particle and Radiation Physics / 274

Dipole polarizability effect on the quadrupole moment of the first 2+ state in 12C

Authors: Cebo Ngwetsheni[1]; Nico Orce[1]

[1] *University of the Western Cape*

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A high-statistics Coulomb-excitation study of 12C has been carried out using the 208Pb(12C,12C)*208Pb* Coulomb-excitation reaction at 56 MeV using the Q3D spectrometer at the Maier-Leibnitz Laboratory (MLL) in Munich (Germany). Beam currents of approximately 10^11 pps allowed the determination of the spectroscopic quadrupole moment of the first 2+ state at 4.439 MeV with unprecedented accuracy.

Furthermore, the effect of the nuclear dipole polarizability on E2 collective properties was investigated using large-scale shell-model calculations. The dipole polarizability parameter k accounts for deviations of the hydrodynamic model prediction with respect to the actual effects from the Giant Dipole Resonance (GDR). Away from shell closures and light nuclei, k values for ground states are observed to follow a smooth trend consistent with k=1. However, for light nuclei, values of k>1 are determined and recently, it has been shown that k values actually increase for excited states with respect to ground state values [1,2,3].

A no-core shell model (NCSM) calculation predicts $\kappa(2+) = 2.1(2)$ and ground state $\kappa(g.s.) = 1.5(2)$ in agreement with photo-absorption measurements $\kappa(g.s.) = 1.6(2)$. The phenomenological WBP shell model interaction predicts a smaller $\kappa(2+) = 0.9$ and $\kappa(g.s.) = 1.4$. Assumingi k(2+)NCSM=2.1(2) and k(2+)WBP=0.9 yield QS(2+)=+0.12(3) eb and QS((2+)=+0.07(3) eb, respectively, confirming the oblate deformation for the 2+ state.

Such a discrepancy in k values is associated with the binding energy predictions by these models. The WBP interaction predicts a larger g.s. binding energy compared to experiment data hence the reduced κ value. Previous studies show highly bound nuclear systems e.g. magic nuclei present reduced κ values. This work proves sensitivity of polarizability to change in binding energies, a 5% decrease of binding energy results a significant change in polarizability. Therefore establishing the nuclear dipole polarizability as a probe for investigating long-range correlations of the nuclear force such as nuclear collectivity and shell effects.

[1] M. K. Raju, J.N.Orce, P.Navrátil, G.C.Ball, T.E.Drake et al., Phys. Lett. B. 777, 250 (2018). [2] J. N. Orce, E. J. Martini, K. J. Abrahams, C. Ngwetsheni, et al., Phys. Rev. C 104, L061305 (2021). [3] C. Mehl, J. N. Orce, C. Ngwetsheni et al., Under review for publication.

Student award:

Yes

Level for award:

PhD

Physics of Condensed Matter and Materials / 275

Ab-initio study of hydrofluoric acid and ethylene carbonate adsorption on the Nb-doped on the LiMn2O4 surfaces

Author: Brian Ramogayana[1]

Co-authors: Khomotjo Maenetja ; Kemeridge Malatji ; David Santos-Carballal [2]; Nora H. de Leeuw [2]; Phuti Ngoepe [1]

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Surface cationic doping has been deemed one of the most effective methods of reducing the number of trivalent manganese (Mn^{3+}) ions that undergo a disproportionation reaction in lithium manganese oxide-based (LiMn2O4) lithium-ion batteries. However, the effect of surface doping on the major LiMn2O4 surfaces and their interactions with the electrolyte components is not yet fully understood. In this work, we present the effect of surface Nb doping and the adsorption of electrolyte components (ethylene carbonate and hydrofluoric acid) on the major LiMn2O4 (001),(011), and (111) surfaces using the spin-polarized density functional theory-based calculations [DFT+U-D3 (BJ)]. During Nb $^{5+}$ substitution on the top (Nb_t) and sub-surface layers (Nb_s), it was found that the stability of the (111) surface plane greatly improves for Nb_s, causing it to dominate the morphology. This is an interesting, since it has previously been suggested that exposing the (111) surface promotes the formation of a stable solid electrolyte interphase (SEI), which could significantly reduce Mn dissolution. Moreover, both EC and HF greatly preferred binding with the surfaces through the Nb instead of Mn atoms, and the largest adsorption energy was calculated for EC on Nb_b (Nb-doped on both Nb_t and Nb_s) of (001) and HF on Nb_t (111) surfaces. Furthermore, the EC/HF adsorptions further enhance the stability of the Nb_s (111) surface plane. However, minimal charge transfer was calculated for both HF and EC interacting with the pure and Nb-doped surfaces.

Keywords: Doping, adsorption, Density functional theory, Li-ion batteries, Surface chemistry

Student award:

Yes

Level for award:

PhD

Space Science / 276

The effects of ion beams on slow and fast ion-acoustic solitons in plasmas with two-temperature electrons

Authors: M. Maxengana[1]; S.K. Maharaj[1]; R. Bharuthram[2]

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[2] *University of the Western Cape*

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The Sagdeev pseudopotential formalism is used to investigate beam effects associated with drifting ions on the acoustic modes in a plasma which is composed of two warm (adiabatic) ion components and one or two-electron components (of different temperatures). One or both ion species are treated as drifting (beam) component(s). The primary objective of the study is to investigate the effect of the speed of the beam(s) on linear and nonlinear waves which are supported in the plasma system. Above a critical value for the beam speed, slow ion-acoustic solitons having unusual characteristics are supported which can propagate for speeds that are below the critical acoustic speed. For the case of symmetric beams (the oppositely directed beams have equal density and speed), both backward and forward propagating slow and fast ion-acoustic solitons occur for which propagation is symmetric with respect to negative and positive values of the Mach number (normalised soliton speed). For beams which are asymmetric (the counter-streaming beams have unequal density and speed), the symmetry breaks and the slow solitons can propagate only in the forward direction for Mach numbers which are between the lower and higher valued critical acoustic speeds. The fast ion-acoustic solitons are less sensitive to beam speed, although the Mach numbers shift to higher values for higher beam speeds.

Student award:

Yes

Level for award:

MSc

Physics of Condensed Matter and Materials / 277

Synthesis of copper nanowires for application as flexible transparent conducting electrodes

Author: Nicholas Hoy[1]

Co-author: Pontsho Mbule [1]

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Copper nanowires (CuNWs) are a promising material for flexible transparent conductive electrodes due to their outstanding transparency and conductivity properties. Long and smooth CuNWs were successfully synthesized via a hydrothermal method and partially cleaned by n-hexane and water separation routine. The synthesized CuNWs were then deposited on a polycarbonate substrate to make a flexible transparent conducting electrode. X-ray diffraction (XRD) results revealed three diffraction peaks indexed to the face centered cubic (fcc) crystalline Cu. Scanning electron spectroscopy (SEM) showed long and smooth nanowires and energy dispersive X-ray spectroscopy (EDS) confirmed the formation of the element copper and some degree of oxygen and carbon elements were also detected. Atomic Force Microscopy (AFM) confirmed the smoothness of the CuNWs. Furthermore, aluminum (2 mol%) doped zinc oxide (AZO) layer was coated onto CuNWs to prevent a possible oxidation in air environments and the MicroTester system was used to test the flexibility and stretchability of the fabricated Cu NWs based electrodes. The yield strength, strain hardening, fracture and the young modulus of the prepared electrodes are evaluated in detail for possible application as flexible transparent electrodes

Student award:

Yes

Level for award:

MSc

Physics of Condensed Matter and Materials / 278

Electrochemical Synthesis and Characterization of PANI/Graphene-foam Composite Films

Authors: Daniel Chilukusha[1]; Mandla Msimanga[2]; Ncholu Manyala[3]

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Intrinsically Conducting Polymers (ICPs) hold promise for future electronics due to their low cost, light weight and easy processability. Among them, Polyaniline (PANI) is the most widely studied because it is environmentally stable and possesses interesting redox properties which gives it a high level of tunability in electronic structure. However, since PANI can exist in a multiplicity of oxidation/protonation states, it is still a challenge to prepare it in a specific predetermined state with reasonable precision. Voltammetric scanning provides a clean and facile way of electrodepositing PANI films while monitoring, in real time, their oxidation/protonation state. Further, the method is suitable for producing thin films that are not only homogeneous and well-adherent but also with controllable thicknesses. This technique has not been fully exploited to incorporate hybrid nano-fillers such as graphene into the PANI matrix to afford functional materials with high dielectric constant, as required for electronic devices. This study reports, for the first time, the synthesis of composite films of PANI and graphene-foam using cyclic voltammetry. The results of UV-Vis, X-ray Diffraction and Raman Spectroscopy are presented herein.

Student award:

Yes

Level for award:

PhD

Nuclear, Particle and Radiation Physics / 279

Nuclear forensic analysis of natural uranium mined from northern Nigeria

Authors: Iyabo Usman[1]; Samuel Ogana John [2]

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Nuclear forensic science seeks to to aid attribution process of nuclear or radioactive materials found outside regulatory control. It is progressively seen as fundamental part of a strong nuclear security program. Having abundant deposits of uranium ore in Africa portends potential nuclear insecurity thereby the need to generate fingerprints becomes inevitable task. Isotopic ratios such as uranium, lead and thorium concentration, rare-earth elements patterns, trace impurities elements and age were determined. These analyses provide specific information on the origin and production process of uranium bearing materials. This study investigated these fingerprints and their applications in four selected uranium mines from northern parts of Nigeria (Riruwai, Mika-I, Mika-II and Michika), using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) analytical technique. In the results obtained, isotope system of 206Pb/238U, 207Pb/235U chronometry and Pb-Pb isochron as applied to the samples, yielded variable average age range of 29.4±0.009 Ma to 4280 ± 0.046 Ma comparable with the age of the Earth (4543 Ma), respectively.

Student award:

No

Level for award:

N/A

Physics for Development, Education and Outreach / 281

Teach electronics to applied physics students. Prototyping, design and research on a printed circuit board

Author: Marco Mariola[1]

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The applied physics curriculum often includes digital or analog electronics courses, including laboratory activities to understand the theory better and develop practical skills. During the laboratory time, the students generally assemble the electronic circuits on a breadboard or more simplified tools during the practical activity. The classical approach helps test a given circuit but does not train the students to work on a realistic electronic system due to the limited time. This work shows a new training platform built on a printed circuit board to perform experiments based on filters, diode and operational amplifiers. The most critical section of the board is the universal operational amplifier subcircuit. The operational amplifier circuit can be reconfigured by the student by following the board schematic. Using this approach, the students will learn how to modify an existing board or how to change a first designed circuit before sending the board to production.

Student award:

No

Level for award:

N/A

Applied Physics / 282

Optimised mathematical library for Atmel microcontrollers

Author: Marco Mariola[1]

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Microcontroller units often are essential parts for experimental setups and automatic control. Since the simplifications of the programming platforms, the microcontrollers have become accessible to a large spectrum of researchers, also with limited knowledge of the microcontroller systems. Over a plug and play philosophy, the simplification pertains to the software realisation since many functions are available. The users often consider the software library a black-box object, and sometimes improper use of the library can result in a failed system. Some of the available libraries for mathematical calculation are not well optimised in terms of algorithm and memory management. In this work, a well-optimised library for the Atmel microcontroller is presented. The library presented is optimised for matrix calculation and memory optimisation.

Student award:

No

Level for award:

N/A

Poster Session / 283

Coulomb Excitation of 66Ge

Authors: Kenzo Abrahams[1]; Nico Orce[1]

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The Coulomb excitation of ^{66}Ge has been performed for the first time using "safe" bombarding energies at the HIE-ISOLDE facility at CERN in July 2017. A particle-γ coincidence experiment using the MINIBALL array and double-sided silicon detectors has allowed the determination of transitional and diagonal matrix elements in ^{66}Ge, yielding new measurements of the reduced transition probability connecting the ground state, 0_1^+, and the first excited state, 2_1^+, or $B(E2;2_1^+ \rightarrow 0_1^+)$ value, and the spectroscopic quadrupole moment of the 2_1^+ state, $Q_s(2_1^+)$. A relatively large $B(E2) = 29.4(30)$~W.u. has been extracted using beam-gated data at forward angles – less sensitive to second-order effects – as compared with the adopted value of 16.9(7) W.u., but in closer agreement with modern large-scale shell-model calculations using a variety of effective interactions and beyond-mean field calculations. A spectroscopic quadrupole moment of $Q_s(2_1^+) = +0.41(12)$ eb has been determined using the reorientation effect from the target-gated data at projectile backward angles – more sensitive to the reorientation effect. Such an oblate shape is in agreement with the corresponding collective wave-function calculated using beyond mean-field calculations and its magnitude agrees with the rotational model, assuming $B(E2) = 29.4(30)$ W.u. This work solves a long-standing puzzle regarding the loss of quadrupole collectivity in ^{66}Ge and provides a deeper insight into how oblate nuclei rotate.

Student award:

Yes

Level for award:

N/A

Poster Session / 284

Electrochemical Impedance Spectroscopy. Case of study and software implementation

Author: SENZO HLONGWANE[1]

Co-authors: Francesco Petruccione [1]; Marco Mariola [1]

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Any substance subjected to a variable electrical signal responds like a passive electrical circuit. The electrochemical impedance spectroscopy aims to characterise the equivalent circuit of a given substance. The characterization of the equivalent circuit is essential when the material should be used for battery or to determine any other application. In this work, the methodologies and optimisation used to characterize the electrical property of the substance are presented.

Student award:

Yes

Level for award:

PhD

Nuclear, Particle and Radiation Physics / 285

CFD humidity and temperature modelling in the ATLAS ITK Strip

Authors: Pedro Mafa Takisa[1]; M Bhamjee[2]; SH Connell[3]; L.L Leeuw[4]; M.S.W. Potgieter[3]; M Oriunno[5]

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CERN has planned a series of upgrades for its Large Hadron Collider (LHC). Rearmost in this current series of planned upgrades is named the High Luminosity LHC (HL-LHC) and as the name suggests will bring the instantaneous Luminosity up to 21×10^{34} \mbox{cm}$^{-2}$\mbox{S}$^{-2}$. The ATLAS detector will be substantially changed to meet the challenges of this upgrade (termed the "Phase II" upgrade). Many systems and subsystems require the most radical changes. The ATLAS Inner Tracker (ITk) is being completely rebuilt for Phase II. The changes to the pixel detector system, and the barrel and end-cap strip detector systems need global monitoring of the temperature, humidity and dew point inside the detector volume with a goal of keeping the ATLAS ITK dry. Hence, it is important to have a simulation of multi-species fluid flow in the ATLAS ITk. We use CFD simulation to develop a quantitative understanding of the fluid flow within the ITk as a result of the dry nitrogen purge, the temperature environment, the humidity under normal conditions, and operating conditions.

Student award:

No

Level for award:

N/A

Poster Session / 286

Deposition and characterisation of a Zinc Oxide thin film on p-type Silicon prepared by thermal spray pyrolysis

Author: Zahlia Stacey[None]

Corresponding Author: zahlia@fastrak.co.za

Transparent conducting oxides are of great interest in recent studies. Zinc Oxide thin films with different thicknesses were synthesized using thermal spray pyrolysis on p-type Silicon as the substrate. The prepared material was then annealed at 500 ℃ for 60 minutes. X-ray diffraction (XRD) was used to show what the preferred crystal orientation for the sample is, the grain size, the dislocation density, the micro strain and the lattice constants. Schottky diodes were then fabricated on the material. The diodes were characterized at room temperature by the use of current-voltage (I-V) and capacitance-voltage (C-V) measurements to investigate the effects on the deposited Zinc Oxide thickness on the electrical properties of the diode. The results showed how the ideality factor, series resistance, carrier density and built in voltage changes with an increase in the Zinc Oxide layer's thickness.

Student award:

No

Level for award:

N/A

Physics of Condensed Matter and Materials / 287

Lattice expansion studies of the crystal structure transformation in intermediate valent Ce_2Rh_2Ga

Authors: Sindisiwe Xhakaza[1]; Andre Strydom[2]

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The ternary intermetallic compound Ce_2Rh_2Ga exhibits an unusual crystal structure transformation at 128.5 K [1] together with temperature-driven intermediate valence of the nominally trivalent cerium ions below room temperature [2]. Although the two phenomena may have a causal relationship, the origin of the structure transformation remains to be understood. Strongly correlated cerium compounds are renowned for valence instabilities, but structure transformations in cerium compounds are uncommon by comparison. In this study we report on the synthesis and characterization of two doped variants, namely $Ce_{2-x}T_xRh_2Ga$. Here T is the element Y and La respectively in which 10% of the cerium sublattice has been replaced by two elements to achieve positive (Y) and negative (La) chemical pressure respectively. We demonstrate that the parent compound Ce_2Rh_2Ga is amenable to chemical substitution, and both doped variants were confirmed to form in the same orthorhombic ordered version of the La_2Ni_3-structure type at room temperature (space group Cmce) of the undoped Ce_2Rh_2Ga compound. As a single experimental probe of both the cerium valence and the crystal structure transition in the doped compounds we made use of the temperature dependence of dc-magnetic susceptibility. With the results of this study we report on the variations in the paramagnetic Weiss temperature (which is a measure of the magnetic exchange) and the effective magnetic moment values of the cerium ions in the two doped compounds as calculated from the magnetic susceptibility data, and we illustrate the interesting opposing effects obtained by means of control over the crystallographic unit cell volume.

1. S. Nesterenko, A. Tursina, M. Pasturel, S. Xhakaza, and A. Strydom, J. Alloys Compd., 844, (2020) 155570/1-11.
2. H. Sato, T. Matsumoto, N. Kawamura, K. Maeda, T. Takabatake, and A.M. Strydom, Phys. Rev. B 105 (2022) 035113/1-7.

Student award:

Yes

Level for award:

PhD

Poster Session / 288

First Principles Study of Nitrogen Dopant-Vacancy Complexes in Graphane

Authors: Hezekia Mapingire [1]; R. E Mapasha [1]

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We use first principles calculations to characterize four types of dopant-vacancy point defects in the two dimensional material graphane for the purpose of quantum computing. The point defects we consider in this contribution are NcHv, NcCHv, NchHv, NchCHv and their various charge states. We derived the formation energies and other electronic properties of these point defects. Analysis of the defect level diagrams shows that NcHv is a deep point defect that can be potentially utilised as a qubit like the prototype NV centre in diamond.

Student award:

Yes

Level for award:

PhD

Theoretical and Computational Physics / 289

Anomaly Detection on the high throughput network of the ATLAS TDAQ system

Author: Mitchell Phiri[1]

Co-author: Simon Connell [1]

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As the volume of data recorded from systems increases, there is a need to effectively analyse this data to gain insights about the system. One such analysis requirement is anomaly detection. Data-driven approaches such as machine learning, are by construction, able to *learn* (to some degree) the underlying representations in the data and consequently identify a hyperplane which separates the normal point states from the anomalous ones. In most cases the data is not linear in the parameter space, does not possess apparent trends or periodic seasonality and is noisy. In this work, we develop models for anomaly detection analysing data obtained from the networking devices of the ATLAS Trigger and Data Acquisition System (comprising approximately 10 000 interfaces polled at 30 seconds intervals). The selection of algorithms was based on robustness and interpretability of the models. Ultimately, the deep learning architectures as well as those inspired by biological networks and those that employ transformations that linearise the measurement space were chosen. Preliminary results indicate that we are able to model the system to some degree and the anomaly detection solution is generic for a multiple parallel suite of time series data, somewhat independent of its origin. As such these concepts and results are also applicable to the energy space, for example, monitoring data streams from a power station. Successful development would imply new insights into how anomalies occur in a system and/or when they will occur and would allow for in-depth analyses such as Root Cause Analysis. The combination of an interpretable model and Root Cause Analysis would lay foundations for developing a Reinforcement Learning based system in which the system could take active decisions on certain anomaly encounters.

Student award:

Yes

Level for award:

MSc

Astrophysics / **290**

Stellar populations of green valley galaxies

Authors: Antoine Mahoro[1]; Mirjana Povic[2]; Petri Vaisanen[3]; Pheneas Nkundabakura[4]; Kurt van der Heyden[5]

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[2] *Ethiopian Space Science and Technology Institute (ESSTI)*

[3] *south african astronomical observatory*

[4] *University of Rwanda*

[5] *University of Cape Town*

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We present a study on the stellar populations and stellar ages of a sub-sample of far-infrared AGN and non-AGN green valley galaxies at 0.6 < z < 1.0 using the data from the COSMOS field. We used long-slit spectroscopy and derived stellar populations and stellar ages using the stellar population synthesis code "STARLIGHT" and analysed the available Lick/IDS indices, such as Dn4000 and $H\delta_A$. We find that both FIR AGN and non-AGN green valley galaxies are dominated by intermediate stellar populations 67 % and 53 %, respectively. The median stellar ages for AGN and non-AGN are $\log t = 8.5 [yr]$ and $\log t = 8.4 [yr]$, respectively. We found that majority of our sources (62 % of AGN and 66 % of non-AGN) could have experienced bursts and continuous star formation. In addition, most of our FIR AGN (38 %) compared to FIR non-AGN (27 %) might have experienced a burst of SF more than 0.1 Gyr ago. We also found that our FIR AGN and non-AGN green valley galaxies have similar quenching time-scales of $\sim$70\,Myr. Therefore, the results obtained here are in line with our previous results where we do not find that our sample of FIR AGN in the green valley shows signs of negative AGN feedback, as has been suggested previously in optical studies.

Student award:

No

Level for award:

N/A

Applied Physics / **291**

Development of a luminescence imaging system for the characterization of PV cells

Authors: Roelof Roodt[1]; Ross Dix-Peek[1]; Jacqueline Crozier McCleland[1]; Ernest van Dyk[2]; Frederik Vorster[3]; George Koutsourakis[4]; Simone Meroni[5]; James Blakesley[6]; Richard Dixon[7]; Pufinji Obene[8]; Ian Arnold[9]; Tateos Tvapanyan[8]; Alexander Howe[7]; Trystan Watson[10]; Fernando Castro[4]

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As the deployment of renewable energy increases, particularly Photovoltaic (PV), non-destructive techniques become more important for characterising the materials from the cell level to complete module level. Luminescence imaging is a non-destructive characterisation technique that allows for spatially resolved optoelectrical characterisation of cells. This paper presents the development of a system comprising Photoluminescence (PL) and Electroluminescence (EL) imaging. The system is capable of imaging different technology cells at different operational points of the cells. The design, construction and optimisation of the system is discussed and preliminary results are presented. The PV technologies investigated include Si, III/V CPV (Concentrator Photovoltaic) and perovskite cells. The system is optimised based upon illumination intensity and homogeneity across the sample test plane. Different optical filters are used dependent on the material of the device imaged, allowing the system to image a range of PV devices, including tandem devices. The results demonstrate that defective regions in cells may be identified and characterised with respect to luminescence properties and associated material and device properties.

Student award:

Yes

Level for award:

MSc

Applied Physics / **292**

Analysis of degradation of Perovskite PV devices using injection dependent Photoluminescence imaging

Author: Ross Dix-Peek[1]

Co-authors: Roelof Roodt [1]; Jacqueline Crozier McCleland [1]; Ernest van Dyk [1]; Frederik Vorster [1]; George Koutsourakis [2]; Simone Meroni [3]; James Blakesley [2]; Richard Dixon [4]; Pufinji Obene [5]; Ian Arnold [5]; Tateos Tvapanyan [5]; Alexander Howe [4]; Trystan Watson [3]; Fernando Castro [2]

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Perovskite based PV devices are gaining attention due to lower predicted overall costs and high efficiency. However, the commercial viability of this technology is dependent on long term reliability and stability. This technology is more sensitive to environmental conditions such as moisture and oxygen compared to conventional PV devices. Different encapsulation methods have been proposed as plausible solutions to this issue. As moisture and oxygen ingress through the encapsulation, degradation will progress spatially through such a device, the use of spatially dependent measurements is thus an obvious choice. In this project, two separate and similar luminescence imaging systems were developed, one at Nelson Mandela University and one at the National Physical Laboratory in the UK. In this paper, results are presented based upon the quantification of degradation within Perovskite PV devices through analysis of injection dependent Photoluminescence imaging. Encapsulated perovskite devices were exposed to damp heat testing in an environmental chamber and also outdoor conditions. A method is developed based upon pixel statistics as an indicator of device degradation rather than a physical model. The results appear promising as the quantification method results appear to be correlated with the short circuit current in the trial device under test.

Student award:

No

Level for award:

N/A

Astrophysics / 293

Particle Acceleration at Reflected Shocks in Supernovae Remnants

Author: Jacobus Frederik Le Roux[1]

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Supernovae remnants (SNRs) are believed to be one of the prime sources of high-energy cosmic rays within our galaxy. SNRs are known to be efficient particle accelerators. Protons and electrons can be accelerated to very high energies of at least several tens of TeV both at the front and at the reverse shock of the remnant. These accelerated particles subsequently produce non-thermal emissions across the whole electromagnetic spectrum from radio to very-high-energy gamma-rays, which can be observed by current instruments. The mechanism for this acceleration is believed to be diffusive shock acceleration, which produces non-thermal particles with a power-law distribution in energy.

Core-collapse SNRs are expected to expand into a complex environment of the stellar wind bubble blown up by their progenitor stars, where forward shock might interact with various density inhomogeneities. Such interaction would cause the formation of reflected shocks propagating inside the remnant which can potentially be strong enough to also accelerate particles. Investigations of particle acceleration in SNRs presented in the literature are usually limited to forward and reverse shocks ignoring the complexity of the hydrodynamic picture. Although for most SNRs the observed shell-like morphology generally agrees with an idea that high energy particles originate predominantly from the forward shock (for some remnants the significant contribution from the reverse shock was also confirmed (Brose et al. 2019), precise spatially resolved measurements do not always agree with a simplified picture giving rise to alternative ideas such as interaction with dense cloudlets (see e.g. Sushch & Hnatyk, 2014). This review would be focused on the investigation of particle acceleration at the reflected shocks formed through the interaction of the forward shock with density inhomogeneities and its potential impact on the overall observational properties.

Student award:

Yes

Level for award:

MSc

Poster Session / 294

Returning to the first-year mainstream physics classroom at the University of the Western Cape after the COVID-19 pandemic

Author: Mark Herbert[1]

Co-author: Bako Audu [1]

[1] *University of the Western Cape*

Corresponding Author: dr.ms.herbert@gmail.com

The COVID-19 pandemic has disrupted teaching in a variety of institutions during 2020 and 2021. Online learning during those years became the core method of teaching the curriculum at universities. With COVID-19 running its course universities in 2022 had to return to a ''new normal" for teaching. The Department of Physics and Astronomy decided to have face-to-face classes for all its students in the "new normal". In this paper the results of a survey conducted surveying the first-year mainstream physics students experiences on returning to the university and the physics classroom in the "new normal" will be presented.

Student award:

no

Level for award:

N/A

Applied Physics / 295

Serendipitous p- to n-type response switching in β-Ga2O3 needles: A potential application to selective CO and CH4 gas sensors

Author: Nyepudzai Charsline Gatsi[1]

Co-authors: Gugu Hlengiwe Mhlongo [2]; Nosipho Moloto [3]; Rudolph M Erasmus [4]; Odireleng Martin Ntwaeaborwa [4]

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Highly selective sensors that can sense at least two gases are necessary for less expensive, effective, and reliable monitoring of air quality. Conventionally, selectivity is achieved by improving sensor response towards selected target gas. This study suggests the use of materials with unique response switching to achieve selective sensing. Monoclinic β-Ga2O3 needle-like structures were investigated for sensing towards CO and CH4 gases. Interestingly, β-Ga2O3 displays abnormal transitions between p- and n-type response towards CO and CH4, as a function of target gas concentration and the operating temperature. A mechanism is proposed to explain these temperature/concentration – dependent p-n transitions and provide suggestions on how to control them. The switching from p- to n-type sensing in β-Ga2O3 carry great potential for selective recognition and sensitive detection of trace levels of CO and CH4 with good stability. Besides, this p- to n-type switching may also lead to interesting possibilities for tailoring the electronic properties of β-Ga2O3 nanostructure-based devices.

Student award:

Yes

Level for award:

PhD

Physics for Development, Education and Outreach / 296

The effects of expert problem solving on first-year mainstream physics students' performance and results

Author: Mark Herbert[1]

Co-author: Bako Audu [1]

[1] *University of the Western Cape*

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This study investigates how to address the under preparedness of students entering first year physics in South African universities, particularly with regard to their competence in solving kinematics problems. Previous studies show that the best tool for changing and expanding the conceptual understanding of a learner is problem solving; it assists a learner in dealing with new and unfamiliar concepts. In this study students "approaches in solving kinematic problems" were investigated as well as the effects of expert problem-solving approaches on the performance and results obtained by students in first-year mainstream physics at the University of the Western Cape. The findings of this study will be presented and discuss.

Student award:

No

Level for award:

N/A

Physics for Development, Education and Outreach / 297

Flippin Amazing?

Authors: Kebra Ward[1]; Lindsay Westraadt[2]

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Physics education research shows that students learn best while actively engaged with course material, rather than passively observing a lecture. The flipped classroom curriculum and peer instruction are two complementary methods that foster active student engagement. The purpose of this study was to measure the effectiveness of these interactive engagement (IE) approaches within the post-COVID 19 South African physics classroom. In this study, a flipped classroom curriculum combined with peer instruction was implemented in three first-year physics courses at Nelson Mandela University. The success of this combined IE approach was quantitatively measured against international benchmarks using the Force Concept Inventory (FCI) test. The results of this study explore the robustness of an IE approach to teaching and learning against topical challenges, such as online learning and large classes, by studying their impact on FCI performance.

Student award:

No

Level for award:

N/A

Physics for Development, Education and Outreach / 298

Teacher's perceptions of Modeling Instruction for the South African classroom

Author: Mark Herbert[1]

Co-authors: Bako Audu [1]; Ronald Engelbrecth [2]

[1] *University of the Western Cape*

[2] *Western Cape Education Department*

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Modeling Instruction is a version of inquiry-based learning instructional practice developed for physics teaching on the notion that physicists use mental constructs called models to reason and solve problems. The study reports on the perception of In-Service teachers Modeling Instruction after being taught the concepts of force and electricity using the Modeling Instruction strategy over a two-week workshops which they attend during their June school holidays.

Student award:

No

Level for award:

N/A

Nuclear, Particle and Radiation Physics / 299

Optimization of Scintillation Properties of Plastic Scintillator for PET/CT Using GEANT4 Simulations

Author: Elijah Hornam Akakpo[1]

[1] *University of the Western Cape*

Corresponding Author: ljhornam@gmail.com

Geant4 simulation of plastic scintillator was performed to study some properties of the scintillator for possible use as a detector in SPECT/CT and PET/CT scans. The study was concentrated on the stopping power and light output of the scintillator. Different geometries such as squares, triangles, polygons, and circles were studied. The length of the different geometries varied from 5 cm to 15 cm. The reflectivity of the wrapping material of the scintillator for optimization of the optical photons was also studied in a range of 0.900 to 0.975. An annihilation gamma, 511 keV, was used in the simulation and the Compton interactions were tracked in the plastic scintillator.

Student award:

Yes

Level for award:

PhD

Physics for Development, Education and Outreach / 300

Creating Support for Tutoring Physical Sciences and Mathematics: A Collaboration Between Metro South Education District and the Department of Physics and Astronomy

Authors: Ronald Engelbrecht[1]; Mark S. Herbert [2]

[1] *Metro South Education District*

[2] *University of the Western Cape*

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The need for physical sciences and mathematics learners to take up enrolment in tertiary institutions across the country to meet national expectations has been a challenge. Research in the Western Cape province shows that the number of High schools offering physical sciences and mathematics are on the decrease across public schools. This has led the Metro Education Districts to design interventions that would sustain learners at various grades to pursue STEM career options. The Metro South Education District and the Department of Physics and Astronomy at the University of the Western Cape piloted a tutoring and mentorship programme targeting grade 12 learners with a team graduate tutors. This paper will present graduate tutors' perceptions and learners' experiences of the programme along the direction of the programme objectives.

Student award:

Yes

Level for award:

PhD

Space Science / 301

Assessment of the Cosmic-ray Soil Moisture Observing System for different agroclimatic zones

Author: KATLEGO MOLOTO[1]

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Soil moisture is a critical parameter in the forecasting and assessment of weather-induced extreme events such as heatwaves, droughts and floods, which are likely to increase in both frequency and intensity as a consequence of the projected climate change in southern Africa. Understanding the potential impacts of climate variability/change on soil moisture is essential for the development of informed adaptation strategies. However, long-term in-situ soil moisture measurements are sparse in most countries. The novel cosmic-ray method for measuring area-average soil moisture at the hectometer horizontal scale is assessed in this study. The stationary cosmic-ray soil moisture probe measures the neutrons that are generated by cosmic rays within air and soil and other materials, moderated by mainly hydrogen atoms located primarily in soil water, and emitted to the atmosphere where they mix instantaneously at a scale of hundreds of meters and whose density is inversely correlated with soil moisture. long-term soil moisture data set is critical for sustainable agricultural productivity, and efficient management and sustainable use of natural resources within the context of climate change adaptation

Student award:

No

Level for award:

N/A

Physics of Condensed Matter and Materials / 302

Simulations Synthesis of Na0.23TiO2 Nanosphere at Varied Temperatures: Beyond Li-ion Batteries

Author: Blessing Rikhotso[1]

Co-authors: Phuti Ngoepe [1]; Dean Sayle [2]

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Sodium-ion batteries (NaIBs) have been widely used in energy storage applications such as portable devices and electric vehicles [1]. The demand of lithium rapidly increases year by year, pushing up the price and making lithium resources less affordable. Thus, it is crucial to find alternative technology beyond Li-ion batteries (LIBs) employing abundant elements on earth. Sodium (Na+) becomes a suitable candidate due to its high abundance and low cost as well as the similar redox potential to lithium [1]. Generated TiO2 nanosphere-architectured [2] are promising as anode electrode materials for Na+ rechargeable batteries due to their capacity to host more Na+ ions and withstand high temperature conditions. In these study, simulation recrystallisation of nanosphere Na0.23TiO2 structure was synthesised from an amorphous precursor by running large scale molecular dynamics (MD) method using DL_POLY_2 code [3] to predict their structural stability at varied temperatures. Recrystallisation synthesis, was then proceeded by the cooling process towards 0 K, the cooled Na0.23TiO2 nanosphere structure was then heated from 100 K to 2000 K at temperature intervals of 100 K using an NVT Nose Hoover ensemble. The calculated Ti - O pair correlation was evaluated by their Radial Distribution Functions (RDF's), where the extent of crystallisation was confirmed during cooling synthesis. The simulated X-ray diffraction (XRDs) spectra agreed well with the experimental XRD's of pure TiO2 [4], as well with the modelled microstructural defects, which

all exhibited peak domains patterns of both rutile and brookite polymorphic phases, thus enhancing structural stability and energy storage characteristics. The Na+ ions transport showed an increase with an increase in temperature and maximum diffusion coefficients and activation energies of 110 x10-9 m2s-1 and 0.190 eV respectively was calculated to track the rate of Na+ ion transport in the nanosphere TiO2 structures. These results provide substantial new improvements and insights that Na0.23TiO2 nanosphere structures is an excellent anode electrode candidate for sodium ions batteries (NaIBs), since it stored more Na+ ions and have withstands high temperatures conditions without compromising their internal microstructures.

Student award:

Yes

Level for award:

PhD

Nuclear, Particle and Radiation Physics / 303

Determination of matrix elements in 62Ni to test surface vibrations in nuclei

Author: Brenden Lesch[None]

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The multiphonon model of surface vibrations, a foundational pillar that nuclear physics is built upon is being questioned using detailed spectroscopy. The breakdown of vibrational selection rules has been confirmed in the paradigmatic Cd isotopes. Such selection rules involve particular relations for reduced transition probabilities e.g.$B(E2, 0_2^+ \rightarrow 2_1^+) = 2 \times B(E2, 2_1^+ \rightarrow 0_1^+)$ or a null spectroscopic quadrupole moment for the first 2+ state, are explored in this work for the vibrational candidate ^{62}Ni. Beams of ^{62}Ni at an energy of 237.5 MeV and an intensity of ~1 pnA were accelerated for the first time to determine matrix elements directly via a Coulomb-excitation reaction, and bombarded onto a ^{194}Pt enriched target (96\%). The soccerball frame at IThemba LABS part of the GAMKA project and an upstream double-sided silicon detector with 24 rings and 32 sectors were used to measure gamma-particle coincidences. Doppler-shift methodology was used to calculate energy shifted gamma rays. The GOSIA Coulomb-excitation code was used to extract the matrix elements. Results will be presented at SAIP2022, which may shed light onto the existence of surface vibrations in nuclei.

Student award:

Yes

Level for award:

MSc

Poster Session / 304

Optimization of Digital Parameters and Offline Sorting Code for Experiments at IDS/CERN

Authors: Remember Ayanda Madonsela[None]; Nico Orce[1]; Nikita Bernier[1]

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The ISOLDE Decay Station (IDS) is an experimental setup at the ISOLDE facility at CERN dedicated to beta-decay spectroscopy for research into nuclear structure, nuclear engineering, and astrophysics. UWC has a leading experiment approved at IDS to investigate nuclear shape coexistence in ^{80,82}Sr nuclei with the beta decay of ^{80,82}Y. The study aims at measuring internal conversion electrons using the SPEDE electron spectrometer, branching ratios with four germanium clover detectors, and lifetimes with two $LaBr_3$(Ce) detectors. These measurements will complement our in-

vestigations of shape effects in ^{80,82}Sr using safe multi-step Coulomb excitation measurements carried out at TRIUMF. The new Modern African Nuclear Detector Laboratory (MANDELA) at the University of the Western Cape is equipped with a double photon counting setup using NaI scintillation detectors and a 250-MHz Pixie-16 digitizer from XIA. This digitizer is similar to the 100-MHz Pixie-16 digitizers in use at IDS. Data are acquired using the acquisition code POLL2, ROOT trees are built using the IDS sorting code xia4ids, and gamma-gamma matrices are created to examine coincidence relationships. Results in preparation of our new experiment at CERN will be presented.

Student award:

Yes

Level for award:

MSc

Applied Physics / **305**

Outdoor current-voltage testing of bifacial photovoltaic modules to determine bifaciality coefficients and gain

Author: Siyabonga Ndzonda[1]

Co-authors: Monphias Vumbugwa [1]; Ross Dix-Peek [1]; Jacqueline Crozier-McCleland [1]; Frederik Vorster [2]; Ernest van Dyk [1]

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Bifacial photovoltaic (bPV) modules utilise light incident on both front and rear surfaces. This leads to enhanced power generation characterised by the bifaciality coefficients, which is the ratio of electrical characteristics between front and rear surfaces. The amount of light reflected from the surface underneath a tilted module is a major contributing factor to the rear irradiance-driven bifaciality power gain. In this work the performance of a sample of bPV modules was investigated and a methodology refined for the outdoor baseline testing of bPV modules. A monofacial PV (mPV) modules as a reference in the determination of the bifacial gain of the bPV modules under different albedo conditions, viz. white, black, grass and concrete surfaces. The bifaciality coefficients of short-circuit current, open-circuit voltage and maximum power are measured according to the testing standard IEC TS 60904-1-2 (2019-01). The calculated values for the coefficients are 73% for maximum power and 75% for short-circuit current. The bifaciality coefficients depend on the structure and type of solar cell used in the bPV module, and for Passivated Emitter Rear Contact (PERC) modules like ones used in this study, the expected bifaciality range is 70 – 80 %. The bifaciality power gain from different reflecting surfaces was for the black cloth (+5%), concrete (+7%), grass (+10%) and white cloth (+15%). These results are as expected and indicate the performance advantages of Bifacial modules depend on the ground surface reflectance.

Student award:

No

Level for award:

N/A

Physics of Condensed Matter and Materials / **306**

Study of inorganic lead halide perovskites properties using density functional theory for photovoltaic and optoelectronic devices

Author: Prettier Morongoa Maleka

Co-authors: Steve Dima [2]; Regina Maphanga [2]; Martin Ntwaeaborwa [3]

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Cesium lead iodide perovskites have attracted significant interest due to their rapidly increasing efficiency when used in solar cells applications. Density functional theory was used to investigate the structural,electronic, elastic, and optical properties of CsPbI3, CsPbI2Br, CsPbBr2I and CsPbBr3 perovskite materials. The generalized gradient approximation, GGA-PBE was used to estimate the band gaps of these materials. There is gradual increase in the band gap values due to mixing composition of I and Br which may be attributed to the ionic radii differences b etween Br and I in the mixed halide compounds, and the hybridization tendency of the X-halide (I 5p and Br 4-p) state. Structural analysis shows that the calculated lattice parameters were consistent with experimental parameters reported in the literature. Also, mechanical properties including elastic constants, bulk modulus, shear modulus, Young's modulus, Poisson's ratio, and anisotropy factor were computed. The calculated electronic properties showed that the energy band gap of CsPbI3 could be tuned by substituting iodine with bromine. All four compounds were found to be semiconductors with direct energy band gaps in R symmetry point between 1.466 and 2.494 eV as predicted by the GGA-PBE. The optical properties of these perovskite compounds against the incident photon energy radiation indicate that the materials could be good candidates for solar cells applications. The elastic constants were also determined, and they revealed the ductile nature of these compounds.

Student award:

Yes

Level for award:

PhD

Poster Session / **307**

Resistive Switching Memory Device Fabricated Using Raw Organic Cow Milk as the Active layer

Authors: Zolile Wiseman Dlamini[1]; Sreedevi Vallabhapurapu[2]; Tebogo Sfiso Mahule[2]; Srinivasu Vijaya Vallabhapurapu[2]

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Resistive switching memory is an emerging memory that stores data using the two electrically switchable resistive states, viz., the high resistive state (HRS) as the OFF-state and the low resistive state (LRS), as the ON-state. ReRAMs have the simplest architecture comprising an active material (a thin film) sandwiched between two electrodes. This simple cell structure allows for scaling even at the sub-nanometre level, better than the memory giants, i.e., dynamic random-access memory (DRAM) and Flash memory which have already shown scaling saturation. In this work, resistive switching properties of 3.6 µm thick raw organic full cream cow milk-based film have been investigated. To better understand the system, two devices were fabricated, viz., the Ag/milk/ITO and Ag/milk/W (where Ag, ITO and W are respectively the silver, indium doped tin oxide and W is tungsten electrodes) to allow for comparative results. Both devices showed 'S-type' bipolar memory behaviour. Furthermore, the Ag/milk/ITO showed switching at 0.77 V with an ON/OFF ratio of ~ 2, which lasted for about 7 write/erase cycles, thus showing prospects for nonvolatile memory application. The Ag/milk/W device, on the other hand, showed switching characterized by low (0.1 V) voltage which lasted only for one cycle. Increasing the compliance current up to 0.5 V improved the ON/OFF ratio up to 10^2 but still the device could not follow the same hysteresis behaviour twice. Overall, our results showed that environmentally friendly resistive switching memory devices can be fabricated using spin-coated organic cow milk-based film and that the choice of electrode material affects the memory behaviour of the device.

Student award:

Yes

Level for award:

PhD

Physics for Development, Education and Outreach / 308

High School learners' difficulties with kinematics graphs

Author: Itumeleng Phage[1]

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Kinematics is one of the topics taught at high school, from Grade 10 to Grade 12. This study was conducted with Grade 11 learners to determine their understanding of kinematics graphs in physical science. A questionnaire consisting of algebraic graphs in mathematics and kinematics graphs were distributed to 98 Grade 11 learners. The responses were analysed statistically. The results showed that majority of learners have difficulties in the construction, analysis, and interpretation of not only kinematics graphs but algebraic graphs. The learners' prior knowledge of algebraic graphs and functions were supposed to assist them in the comprehension of kinematics graphs and equations. They had the difficulties with variables also in algebra as a result it made them more difficult to understand and relate variables in algebra with those in kinematics. Though learners could answer questions in algebra, they struggled to connect the meaning of the variables and to relate them to the meaning of underlying kinematics concepts. The other difficulties they encountered was setting up a scale for kinematics when constructing them. The learners in this regard showed they lacked scientific knowledge or literacy to comprehend kinematics graphs. The study also agreed with previous studies that learners are unable to integrate their mathematics knowledge with the physics concepts or transfer their kinematics knowledge to algebra.

Student award:

Yes

Level for award:

PhD

Poster Session / 309

Effects of NaOH and lime in the separation of chalcopyrite and pyrite minerals using allyl-N-diethyl dithiocarbamate as collectors: DFT and experimental studies

Authors: Peace Mkhonto[1]; peace prince mkhonto[1]

Co-authors: Xingrong Zhang [2]; Liang Lu [2]; Yangge Zhu [2]; Long Han [2]; Phuti Ngoepe [1]

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The separation of chalcopyrite and pyrite are usually done by taking advantage of the pH of the pulp. These are usually done by pH modifiers such as sodium hydroxide (NaOH) and lime ($Ca(CO)_2$) and it has been reported that these gives different recovery performance. These pH modifies have not been completely explored from the computational aspect. In this study we employed the computational density functional theory and microflotation to investigate the bonding mechanism of NaOH, lime and allyl-N-diethyl dithiocarbamate (ADEDTC) with reconstructed chalcopyrite (112) surface and pyrite (100) surface. We have found that lime has a strong adsorption on pyrite surface than on chalcopyrite surface, while the NaOH has strong adsorption on chalcopyrite surface than pyrite surface. The adsorption of the ADEDTC collectors gave strong adsorption on chalcopyrite and preferred the Cu atom over the Fe atoms, while the adsorption on pyrite Fe sites was weak. This was accompanied by micro-flotation recoveries, where the ADEDTC collector gave higher chalcopyrite recoveries of above 90%, and lower recoveries of pyrite. These findings provided a clear correlation between experiments with DFT predictions and also gave evidence of an adsorption of ADEDTC on Cu of chalcopyrite surface. Most importantly it has been demonstrated that lime will adsorb stronger on pyrite resulting in pyrite depression compared to NaOH during flotation. It is therefore suggested that the ADEDTC collectors and lime may be useful in floatation separation of chalcopyrite from pyrite minerals.

Student award:

No

Level for award:

N/A

Poster Session / 310

Kinetic Analysis of Thermoluminescence of α-Al2O3:C Annealed at 1200 ^{0}C

Author: Fiindje Elago[1]

Co-author: Makaiko Chithambo [1]

[1] *Rhodes University*

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Kinetic analysis of thermoluminescence of α-Al2O3:C, an ultra-sensitive luminescence dosimeter, annealed at 1200 ^{0}C for 1 hour is reported. The sample was annealed to modify the distribution of electron centres within it. Thermoluminescence was measured by heating the sample to 500 ^{0}C at 1 ^{0}C/s after 4 Gy beta irradiation. The glow curve reveals three peaks at 52 ^{0}C (peak I), 188 ^{0}C (peak II) and 308 ^{0}C (peak III). The Tm-Tstop method and the dependence of Tm on irradiation dose has been used to determine the orders of kinetics of the three peaks. The secondary peaks of weaker intensity, peaks I and II, have been observed to follow first order kinetics while the dominant peak II follows second order kinetics. Kinetic analysis of thermoluminescence has been carried out using the variable heating rate (VHR), whole glow peak, phosphorescence and curve fitting methods. The activation energies have been determined to be approximately 0.7 eV, 1.1 eV and 1.5 eV for peaks I, II and III respectively. Thermoluminescence intensity of the main peak decreases with heating rate in a manner consistent with thermal quenching

Student award:

No

Level for award:

N/A

Physics of Condensed Matter and Materials / 311

Property and structural characterisation of Fe and Ni bonded NbC cermets for improved tribological applications

Author: Gerrard Peters[1]

Co-authors: Deena Naidoo [2]; Rodney Genga [1]; Daniel Wamwangi [3]; Sinoyolo Ngongo [4]

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NbC cermets with Fe and Ni binders have been vacuum sintered with molybdenum carbide additives for improved high temperature tribological applications. The magnetic, electrical and thermal properties are being investigated using Mössbauer spectroscopy and the Physical Property measurement system (PPMS). The addition of 4wt% molybdenum carbide to the Fe and Ni binder grades shows an average increase of 12% in the hardness of the cermets with little compromise in the fracture toughness property. The Mössbauer spectrum of the NbC-12Fe grade shows the presence of ferromagnetic phases in the binder. The binder of the NbC-12FeNi spectrum is dominated by a paramagnetic phase and a minor ferromagnetic phase. The addition of molybdenum carbide to NbC-FeNi composite results in a completely paramagnetic structure which can be ascribed to gamma-FeNi. The spectrum for NbC-Fe with added molybdenum carbide is dominated by two ferromagnetic phases consistent with the hysteresis curves obtained by PPMS. The observed phases and properties are also being investigated using X-ray diffraction in combination with high resolution microscopy (SEM, TEM and STEM).

Student award:

Yes

Level for award:

PhD

Nuclear, Particle and Radiation Physics / **312**

Simulation of neutron and electron material damage in CuO, MgO, and Al2O3

Author: Tshepo Mahafa[1]

Co-authors: Bruce Mellado [2]; ELIAS SIDERAS-HADDAD [2]; Othmane Mouane

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One of the key requirements of materials operating in high radiation environments is that they are radiation hard. That is, they endure low to no-radiation induced damage when exposed to high radiation fields, and that is important in that such materials do not lose their performance levels. Displacement per atom (dpa) which relates the number of displaced atoms in materials by exposure to radiation is the property calculated to measure radiation damage in materials. A high material dpa signals a high material damage by radiation. CuO, MgO, and Al2O3 are candidate materials due to their high secondary electron emissions and potential radiation hardness for use as electron multipliers that are a key component of the detection system in the high radiation environment of the ATLAS detector of the Large Hadron Collider (LHC) at CERN. We performed Monte Carlo based simulations using the FLUKA code to investigate the possible radiation damage extent in CuO, MgO, and Al2O3, by calculating the neutron and electron dpa in these candidate materials.

Student award:

Yes

Level for award:

PhD

Poster Session / **313**

Traceability for future radiopharmaceuticals

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Radiopharmaceuticals are used for therapeutic and diagnostic purposes. New radiopharmaceuticals are being developed and tested continuously. Some of these radiopharmaceuticals that could be used locally in the future include C-11, N-13, Cu-64, Ho-166, Sm-153, Ac-225 and Re-188. This work will describe how primary measurement methods at the National Metrology Institute of South Africa (NMISA) can be used to accurately determine the activity of these radionuclides in order to provide traceability to the South African nuclear medicine field.

Student award:

No

Level for award:

N/A

Poster Session / **315**

Assessment of the Experimental Band Gap of AlxGa1-xN Epilayers

Authors: JAA Engelbrecht[1]; B Sephton[2]; JR Botha[1]; WE Goosen[1]; HA Engelbrecht[3]; EG Minnaar[1]; ME Lee[1]; A Henry[4]

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AlxGa1-xN epilayers prepared on sapphire substrates were assessed using Fourier Transform Infrared (FTIR) reflectance spectroscopy, photoluminescence (PL) and transmission electron microscopy (TEM). The aluminium mole fraction x of 5 samples grown at the NMU, and 3 samples grown at Linkopig were measured by using PL and FTIR. Formulae for the band gap of AlxGa1-xN as function of temperature were provided by Gaikwad et al, Varshni, Nam et al and Nepal et al. Calculations using the various formulae, and results compared to various proposed formulae to calculate the band gap. Excellent agreement between the samples and the theoretical formula for the band gap of AlxGa1-xN as function of mole fraction x was found, while the formula provided by Nepal et al was the closest to the experimental and Gaikwad formula values.

Student award:

No

Level for award:

NA

Astrophysics & Space Science / **316**

An artificial Neural Network to quickly classify transients in the era of LSST

Author: Johannes Petrus Marais[1]

Co-authors: Brian van Soelen [2]; David Buckley [3]

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With the commissioning of the Vera C. Rubin Observatory, a new era in transient astronomy is starting. The Legacy Survey of Space and Time (LSST) is expected to deliver 500 petabytes of information during it's 10 year survey mission. In order to facilitate the rapid follow-up observations, we developed an Artificial Neural Network to rapidly classify transient events detected by LSST. The network was designed to rapidly classify transients while they are being observed, with a nominal classification time of 7 days after initial detection, with each subsequent observation updating the source classification. Training was done on a custom lightcurve model database based on The Photometric LSST Astronomical Time-Series Classification Challenge (PLAsTiCC) dataset's models developed to test classification algorithms for LSST observations. We sampled a selection of supernova, RR Lyrae and Cepheid models to the LSST cadence in order to test the network. The training dataset has a 90% accuracy. The network's accuracy was tested on sources detected by the MeerLICHT telescope, based at Sutherland, South Africa, which is performing mini-surveys on the 47 Tucanae and Omega Centauri globular clusters. No transient events were detected in this region, but a number of non transient RR Lyrae and Cepheids were correctly classified from the data. This result demonstrates that the network is able to classify real sources, and will be able to detect transient events, should they be observed by either MeerLICHT or the LSST, when it stats observations.

Student award:

No

Level for award:

PhD

Physics of Condensed Matter and Materials / **317**

TEM Observation of Room Temperature Stability and Phase Transformation of SHI Induced Tetragonal Tracks in Monoclinic Zirconia

Authors: Michael Lee[1]; Vladimir Skuratov[2]; Jacques O'Connell[3]

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[2] *FLNR*

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Pure bulk zirconia (ZrO_2) is a polymorphic oxide that exists in three different low pressure crystal structures below its melting point namely, the high temperature phases cubic and tetragonal as well as the low temperature monoclinic phase [1]. Irradiation of bulk natural zirconia at room temperature along the monoclinic [100]m crystal axis were shown by transmission electron microscopy to produce non-continuos tetragonal latent tracks consisting of segments approximately 30 nm in length and rectangular cross sections of the order 2.5 nm. The segments were aligned along the [001]t crystal axis and approximately 9° to the [100]m axis[2]. It was suggested that the mechanism for the stabilisation of the high temperature phase could be due to the surface energy of the interface surfaces, which will determine the critical crystallite size for RT stabilization [3], or the presence of additional vacancies and interstitial oxygen atoms [4]. In this presentation we present results for irradiated bulk monoclinic zirconia to determine the influence of interfacial surfaces and hence critical size on the formation and stabilization of latent tracks. Monoclinic ZrO_2 from the Palaborwa complex in South Africa was irradiated with 167 MeV Xe ions to a fluence of $2x10^{10}$ ions/cm^2 at the FLNR, JINR, Dubna. Plan view and cross sectional TEM lamellae were prepared by standard FIB lift out procedure using an FEI Helios NanoLab 650 and imaged in a JEOL ARM 200F TEM operating at 200 kV. Individual ion tracks were found to be composed of the high temperature stable tetragonal phase. The c axis of the monoclinic and tetragonal regions was parallel with 45° relative rotation about the c axis. Discontinuities in the tetragonal phase together with a slight misalignment relative to the ion path was ascribed to the difference in a-c angle between the tetragonal and monoclinic phase. Although stressed, the tetragonal inclusions were found to be stable at room temperature for at least several years although thermal excitation as well as excitation by high energy electrons was able to transform the tetragonal phase back into the monoclinic phase leaving behind a train of defect clusters as is typical of ion tracks in non-amorphisable crystals. References [1] J.E. Bailey, Proc. R. Soc. A. Math. Phys. Sci., 279 (1964) 395-412 [2] J.H. O'Connell, M.E Lee, V.A Skuratov and R.A. Rymzhanov, Nucl. Inst. Meth. Phys. Res. B, 473 (2020) 1-5 [3] M.W. Pitcher, S.V. Ushakov, A. Navrotsky, B.F. Woodfield, G. Li, J. Boerio-Coates and B.M. Tissue, J. Am. Ceram. Soc., 88 (2005) 160–167 [4] X. Lu, K. Liang, S. Gu, Y. Zheng and H.Fang, J. Mater. Sci., 32 (1997) 6653-6656

Student award:

No

Level for award:

N/A

Poster Session / **318**

Microwave synthesis of a novel transition metal doped MOFs derived Ni@Mn Yolk-shell for high energy density supercapacitor electrodes

Author: GUY LEBA KABONGO[1]

Co-author: Mokhotjwa Simon Dhlamini [2]

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A series of layer-structured materials based on Transition Metals (TMs) doped MOFs derived Ni@Mn Yolk-shell were synthesized and successfully used as supercapacitor electrode materials for the first time. The as-synthesized materials exhibited exceptional electrochemical properties owing to the combined properties of its constituents, high surface area and good electrical conductivity of the Yolk-shell MOFs and TMs, respectively. Several analytical characterization techniques were employed to investigate the morphology, crystal structure atomic arrangement and elemental chemical state in the materials for which scanning electron microscopy (SEM), X-ray diffraction (XRD) and X-ray photoelectron spectroscopy (XPS) were conducted, respectively. Moreover, the electrochemical properties of the as-synthesized materials were examined by performing cyclic voltammetry (CV), galvanostatic charge-discharge (GCD) and electrochemical impedance spectroscopy (EIS) measurements. Furthermore, the effect of doping concentration on the interlayer distance of the as-synthesized layer-structured materials and the charge transfer resistance were investigated and correlated to the exceptional electrochemical properties. Such good performing electrode materials are highly promising for the next generation of energy storage devices.

Student award:

No

Level for award:

N/A

Poster Session / **319**

First principle study on the magnetic properties and electronic structure of Ce and Dy substituted on Nd2Fe14B permanent magnet.

Authors: Lesego Miya[1]; Mpho Enoch Sithole[1]; Rosinah Modiba[2]

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[2] *CSIR*

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The development of new rare-earth free Nd-Fe-B permanent magnet remains a serious issue for the transition to a green and sustainable world, as permanent magnets are an important component in the design and development of highly-efficient energy conversion machinery and devices. The effects of Ce and Dy on the electronic structures and magnetic properties of Nd2Fe14B have been studied using the density function theory (DFT) within the generalized gradient approximation (GGA). Results are presented for the total density of states (DOS), orbital-decomposed, and spin-decomposed partial DOS. The study showed that Ce slightly decreased the magnetic properties of Nd2Fe14B magnet. On the other hand, Dy decreases the magnetic moments of the magnet. The study revealed that both Cerium and Dysprosium affects the properties of permanent magnets. The calculated spin-magnetic moments on each of the six Fe sites are in good agreement with the values deduced from the neutron scattering experiment.

Student award:

Yes

Level for award:

MSc

Astrophysics & Space Science / **320**

The South African Astronomical Observatory

Authors: Vanessa McBride[1]; Petri Vaisanen[2]

[1] *Office of Astronomy for Development*

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The South African Astronomical Observatory (SAAO) provides state-of-the-art astronomy research facilities to the South African and global astronomy communities, primarily through its flagship project, the Southern African Large Telescope, but also through a unique suite of other telescopes and instruments. In addition, SAAO hosts a range of international projects, ranging from telescopes and instruments to the global office of Astronomy for Development and the African Astronomical Society. In this talk, I will present the current and future science projects underway at the SAAO, and touch on how these projects and the astronomy research they support contribute to South African society.

Student award:

No

Level for award:

N/A

Poster Session / **321**

Structural and photoluminescent properties of Y2O3, Y2O3-AG: Eu3+ (where AG = PO42-, SO42-, BO33-) nanophosphors for white-LED applications

Author: Mathe T.G. [1]

Co-authors: Reddy L. [1]; Swart H.C. [2]; Balakrishna Avula [3]; Ntwaeaborwa O.M. [4]

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This work reports on the structural and photoluminescence properties of Y2O3, Y2O3-AG: Eu3+ where AG = PO42-, SO42-, BO33-) nanophosphors synthesized via the chemical combustion method, annealed at 1100oC temperature for 4 hr. The crystal formation and the morphological behaviour of the Y2O3, Y2O3-AG: Eu3+ nanophosphors were verified through X-Ray diffraction (XRD), scanning electron microscopy (SEM) and Fourier-transform infrared (FT-IR) techniques. Further, the optical and photoluminescence properties and its corresponding CIE coordinates for its color purity was investigated. XRD results showed the pure Y2O3 phosphors were crystalized into a cubic phase structure while the Y2O3-AG phosphors showed variation in the cubic structure. This is due to the substitution of the anionic groups into pure Y2O3 nanophosphors. SEM results indicated that the particles were formed in different size and shapes in the micrometre range when Y2O3 was substituted with different anionic groups and doped Eu3+ ions. FT-IR revealed the presence of the various structural groups in the Y2O3, Y2O3-AG: Eu3+ nanophosphors. Using diffuse reflection data the optical band gap energy values were obtained with Kubelka-Munk function theory. Upon the 398 nm excitation wavelength light, Y2O3-AG: Eu3+ phosphors were emitting red color light at the 618 nm wavelength. Among all samples, Y2O3-SO4: Eu3+ produced the highest intensity of red color emission. The CIE color coordinates suggested that these phosphors are potential candidates for producing red color components in the white LEDs applications.

Student award:

Yes

Level for award:

PhD

Nuclear, Particle and Radiation Physics / **322**

Determination of E2/M1 mixing in the $J^\pi = 5/2^+$to the $J^\pi = 3/2^+$ transition in ^{21}Na and its relation to the ^{20}Ne(p,γ) stellar reaction

Author: Sumeera Gopal[1]

Co-authors: Smarajit Triambak [2]; Bhivek Singh [2]

[1] *Student*

[2] *University of the Western Cape*

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Measurements of nuclear reaction rates are crucial in determining isotopic abundances of elements produced within stellar interiors. This study focuses on the bottleneck reaction ^{20}Ne$(p,\gamma)^{21}$Na of the neon-sodium (NeNa) cycle, which is an important nuclear reaction cycle in stellar environments at temperatures greater than 0.05 GK. In particular, the ^{20}Ne(p,γ) reaction plays an important role in the hydrogen burning shells of red giants, cores of massive stars, AGB stars and nova explosions. This particular reaction rate is not well known, due to its cross section being very difficult to measure at astrophysically relevant energies. Recent experimental work showed that in order to have a better understanding of the reaction rate, one requires an accurate measurement of the electric quadrupole to magnetic dipole ($E2/M1$) mixing ratio for the γ-ray transition from the second $5/2^+$ state in ^{21}Na to the ground state. The only measurement of this mixing ratio ($\delta_{E2/M1}$) was performed nearly 60 years ago by C.Van der Leun and W.L Mouton at the Utrecht University, Netherlands. This presentation will highlight a recent ^{20}Ne(p,γ) study performed at the Center for Experimental Nuclear Physics and Astrophysics (CENPA) at the University of Washington in Seattle, to remeasure this mixing ratio with improved accuracy.

Student award:

Yes

Level for award:

MSc

Poster Session / 323

First-principle study of TiAl (100), (110) and (111) surfaces

Authors: Renny RAMBEVHA[1]; David Tshwane[2]; Mpho Enoch Sithole[1]; Rosinah Modiba[2]

[1] *Sefako Makgatho Health Sciences University*

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The lightweight-based intermetallic have attracted much interest in the last decade as prospective structural materials for aerospace applications, since they maintain a large number of outstanding properties, such as high melting point, low density and high-temperature strength.However, their surface properties remain restricted and mainly limited at the atomic scale, therefore, surface properties TiAl must be researched further. In this study the TiAl (100), (110) and (111) surfaces are investigated using the density function theory (DFT). The present findings revealed that the lower surface energy (100) than (110) and (111) surfaces, this implies that the (100) surface is more energetically favorable. Various terminations and number of layers were examined on the surfaces to identify the most stable configuration. The density of states and work function were we also investigated. Surface (100) was found to have large work function which is considered with the surface energy stability.

Student award:

Yes

Level for award:

MSc

Theoretical and Computational Physics / 324

Quantum-optical description of sum-frequency generation in terms of spatial light modes

Author: Tanita Permaul[1]

Co-author: Thomas Konrad [1]

[1] *University of KwaZulu-Natal*

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Nonlinear optical processes can offer exciting applications in quantum schemes, e.g., spontaneous parametric down-conversion is used as a source of entangled photons. However, most nonlinear optical processes are only considered classically and lack the required theoretical framework to describe what occurs on the quantum level.

Previously, a quantum derivation of difference-frequency generation was presented. Now a similar method is applied to sum-frequency generation, which thus completes the quantum optical description of second-order nonlinear processes in terms of spatial light modes. In particular, this demonstrates that on the quantum level, the output mode of sum-frequency generation is given by the product of the input modes, as predicted by classical optics. This is done for single photons as well as for coherent states. The change of amplitudes of input and output light as a function of the propagation length is calculated using elliptic functions.

Student award:

Yes

Level for award:

PhD

Theoretical and Computational Physics / 325

Is gravity quantised?

Authors: Thomas Konrad[1]; Shamik Maharaj[2]

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[2] *University of KwaZulu-Natal*

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There are models of classical (non-quantum) gravity that reconcile it with quantum mechanics [1] by simulating gravitational interaction along the lines of local operations with classical communication (LOCC). However, a way to prove that gravity necessarily is quantised would be to carry out an experiment in which gravity generates entanglement between quantum systems, since this is not possible only by means of LOCC. We here describe a simple candidate for such an experiment based on the equivalence principle, and discuss in its context the role of acceleration/gravity as cause of entanglement.

Student award:

Yes

Level for award:

PhD

Poster Session / 326

Communication distance and security improvement in satellite based quantum key distribution via photon polarization pseudo-random bases encoding

Authors: Alain Giresse TENE[None]; alain giresse tene[None]

Corresponding Author: alain.tene@aims-cameroon.org

New protocol to achieve very long-distance and secure communication between two legitimate users (Alice and Bob) namely, the pseudo-random entangled photon based QKD protocol using a low-earth-orbit (LEO) type satellite as the photon source relay is proposed. We assume the combined type-I and type-II SPDC as photon source distributing entangled photons pairs to Alice and Bob, and the quantum logistic map (QLM) as PRNG in order to pseudo-randomly select photon polarization states measurement bases. Under these considerations, the secure key rate upper bound is evaluated and numerical simulations show that, the maximum communication distance increases significantly with the photon block size, and with the error correction function. One also observes that the protocol can tolerate a secure communication up to about 19000 km under lower background error (or lower atmosphere diffraction). The secure key privacy is strongly improved since public discussion is avoided due to the use of PRNG, which guarantees identical measurement bases choice between Alice and Bob. Based on the above, our protocol is more efficient. In addition, the secure key privacy is significantly amplified.

Student award:

No

Level for award:

Postdoc

Poster Session / 327

Mechanical properties of Ti 50−xHfxPt50, (0 < x < 50) for HTSMAs applications

Authors: Mordecai Mashamaite[1]; Phuti Ngoepe[2]; Hasani Chauke[3]

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[2] *University of Limpopo*

[3] *UL*

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Shape memory alloys (SMAs) are metallic materials that can revert to their original shape when exposed to various temperatures. These materials are used in applications such as actuators and aerospace due to their remarkable properties shape memory effect and pseudo-elasticity which occurs as a result of phase transformation. TiPt undergoes a reversible martensitic transformation from B2↔B19 at higher temperatures. Previous studies showed that the TiPt alloy is mechanically unstable with the negative C′ (−32) and soft modes in the negative frequency of the phonon dispersion curves along the gamma region at 0 K. The supercell approach was used to substitute Ti with Hf on TiPt structure to evaluate their mechanical stability from elastic properties and the phonon dispersions curves. The elastic properties suggest that an increase in Hf concentration enhances the mechanical stability of ternary systems. The C'; becomes positive and larger at 25 < x < 50, which suggests a reduced martensitic transformation at x ≥ 43.75. The Ti 50−xHfxPt50 systems becomes more ductile with the increase in Hf concentration, which suggests that Hf stabilizes the system at a higher concentration. The analyses of the vibrational properties of Ti50−xHfxPt50 structures with respect to phonon dispersion are also discussed.

Student award:

No

Level for award:

N/A

Theoretical and Computational Physics / 328

Wigner functionals in Quantum optics

Author: Akshay Durgapersadh[None]

Corresponding Author: durgapersadhakshay@gmail.com

We study the spatiotemporal and particle number degrees of freedom of light in the framework of a new quantum optical formalism based on a generalised quadrature basis [1, 2]. This is an orthogonal complete basis for all quantum optical states. It gives rise to a description in terms of Wigner functionals that can incorporate all spatiotemporal degrees of freedom without approximations nor truncations of the number of light modes. Therefore, this formalism allows to calculate non-linear optical effects taking into account all experimental parameters, for example the size of apertures, input modes, the spectrum of the pump beams, etc. We focus on the non-linear effect of spontaneous parametric down conversion (SPDC) with its description in terms of the formalism of Wigner functionals [3]. A derivation of the kernel differential equations which arise from the evolution equation for the Wigner functional of the down-converted fields in the semiclassical approximation is shown. The derivation for the solution for this differential equation, which turns out to be the Magnus expansion, is also shown, along with the Wigner functional for a few operators.

References [1] Filippus S. Roux and Nicolas Fabre. Wigner functional theory for quantum optics, 2020. arXiv:1901.07782. [2] Filippus S. Roux. Combining spatiotemporal and particle-number degrees of freedom. Physical Review A, 98(4), Oct 2018. URL: http://dx.doi.org/10.1103/PhysRevA.98.043841, doi:10.1103/physreva.98.043841.

[3] Filippus S. Roux. Parametric down-conversion beyond the semi-classical approximation. Physical Review Research, 2(3), Sep 2020. URL: http://dx.doi.org/10.1103/PhysRevResearch.2.033398, doi: 10.1103/physrevresearch.2.033398.

Student award:

Yes

Level for award:

PhD

Theoretical and Computational Physics / 329

Control of quantum systems by quantum systems

Author: Thomas Konrad[1]

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Quantum systems can be controlled by other quantum systems in a reversible way, without any information leaking to the outside of the system−controller compound. Such coherent quantum control is deterministic, is less noisy than measurement-based feedback control, and has potential applications in a variety of quantum technologies, including quantum computation, quantum communication and quantum metrology. In this talk I present a coherent feedback protocol, consisting of a sequence of identical interactions with controlling quantum systems, that steers a quantum system from an arbitrary initial state into a target state. I reveal the mechanism behind the control and its relation to continuous monitoring of quantum systems.The information about the targets is encoded in the controlling quantum systems and can be the result of a quantum computation. In this way, we hope to achieve the basis for autonomous control that entirely happens within the quantum realm without the need to transform at any stage quantum information into classical information by means of measurements.

Student award:

No

Level for award:

N/A

Photonics / 330

Realizing topological relativistic dynamics with slow-light polaritons

Authors: Bertus Jordaan[1]; Mehdi Namazi[2]; Changsuk Noh[3]; Dimitris G. Angelakis[4]; Eden Figueroa[5]

[1] *NMISA*

[2] *Qunnect Inc*

[3] *Korea Institute for Advanced Study*

[4] *National University of Singapore, Technical University of Crete*

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We present a relatively unexplored direction for analogue quantum simulation based on the interaction between light and neutral atom ensembles at room temperature. The phenomenon of electromagnetically induced transparency (EIT) changes the properties of light interacting with an atomic media coherently. One result is the creation of collective excitations known as dark-state polaritons (DSPs). While one can create these DSPs in three-level lambda-configured systems, a versa-

tile "tripod" scheme creates interacting DSPs. Furthermore, interactions between different tripod-DSPs can be described by Dirac-like Hamiltonians and are called spinor slow light (SSL) setups. We conducted SSL experiments in a room temperature 87Rb ensemble. Using a probe field and two counter-propagating control fields, we create two counter-propagating tripod DSPs. Storage experiments can then be used to retrieve the 1+1 Dirac dynamics. A topological model closely related to the Dirac Hamiltonian is the Jackiw-Rebbi model. By adding a spatially varying magnetic field, we can change the two-photon detuning and mimic a mass-term needed for the model. The oscillation dynamics are increasingly suppressed as the magnetic field gradient increases. We benchmark the experimental results by comparing the outcomes with numerical and theoretical simulations of the SSL dynamics.

Student award:

No

Level for award:

N/A

Poster Session / **331**

Constructing converging control channels from unsharp measurements

Author: Siphesihle Majozi[None]

Co-author: Thomas Konrad [1]

[1] *UKZN*

Corresponding Author: sihledict@gmail.com

In this talk I review a control strategy for quantum systems where the control channel utilizes information about the system and then performs an actuation on the quantum state based on the state information [1]. The control channel is built on the polar decomposition of Kraus operators. I demonstrate that such a control channel still works even if the probability of the measurement outcome is zero, by designing unitary feedback matrices for measurement outcomes that project the system into a state orthogonal to the target state in order to drive the system back towards the target state [2].

[1] PHYSICAL REVIEW A 97, 060102 (2018) [2] PHYSICAL REVIEW A 104, 052614 (2021)

Student award:

Yes

Level for award:

Hons

Poster Session / **332**

Synthesis and evaluation of CZTS/CZTSSe nano-powders for optoelectronic applications

Author: Akin Olaleru[1]

Co-authors: Joseph Kirui [2]; Kehinde Adewoyin [3]; Nnditshedzeni Eric Maluta [4]; Olasoji Adekoya [3]

[1] *University of venda, South Africa*

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Corresponding Author: akinolaleru@gmail.com

The research focused on the solution-based synthesis of a kesterite structure CZTS/CZTSSe. Copper zinc tin sulphide (CZTS)/CZTSe nano-powders were synthesized by means of solution-based method using copper chloride, zinc acetate, tin (II) chloride and Thiourea/Selenium as precursors. In this work nano-powders were synthesized in distilled water at different annealing temperatures in order to study the resulting effect on the elemental and phase compositions as well as the morphology of the CZTS nano crystals. The annealing temperatures were selected from 100 0C to 350 0C due to suitability for the synthesis of CZTS nano-powders in solution. The structure and crystallite size were identified by the X-ray diffraction. The morphology and particle size were also investigated. Optical analysis, enabled the evaluation of the behavior under light conditions, suggesting a potential the suitability of these materials for optoelectronic applications.

Student award:

No

Level for award:

N/A

Theoretical and Computational Physics / **333**

A verification scheme for universal quantum computers

Authors: Anirudh Reddy Segireddy[1]; Thomas Konrad[1]

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We present a new verification scheme for universal quantum computers that yields the number of qubits and an error probability which measures the noise present in the system. The new scheme is based on detecting the standard deviation of the meta probability distribution of output values for an arbitrary qubit probed by random quantum gates. The results are generated directly from output statistics of the quantum computer and do not require any assistance by classical computers. With current technology quantum computers with up to 40 qubits could be tested with our method, but in future, given faster quantum processors, it might be used to prove quantum supremacy.

Student award:

No

Level for award:

N/A

Poster Session / **334**

Introduction to Ito Calculus and It's Applications

Author: Yastheer Hurriraj Bauchoo[1]

Co-author: Thomas Konrad [2]

[1] *Student at UKZN*

[2] *University of Kwa-Zulu Natal*

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The Ito calculus is a formalism which is used to study stochastic differential equations. Stochastic differential equations differ from ordinary and partial differential equations in that they contain randomly fluctuating terms which cannot be analysed using traditional calculus methods. In this talk, the Ito calculus will be explained and examples of it's application to physics will be given

Student award:

Yes

Level for award:

Hons

Theoretical and Computational Physics / 335

A generalised approach to measurement-based feedback Control of a Quantum System in a Harmonic Potential

Author: Amy Rouillard[1]

Co-author: Thomas Konrad [2]

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Measurement-based feedback control works by measuring the system and estimating its properties, and providing feedback in order to reach the desired state. This work investigates the dynamics of a system under continuous measurement and feedback. It turns out that feedback plays a limited role in determining the steady state of a particle in a harmonic trap. Instead, feedback can be used to compensate for a part of the Hamiltonian of the system or to lower the energy of the particle. Simulations, which employ the second-order weak scheme, illustrate these effects and indicate the local stability of the steady state solution.

Student award:

Yes

Level for award:

PhD

Nuclear, Particle and Radiation Physics / 336

Assessment of the radiological and heavy metal water quality of Vaal River, South Africa

Author: Kgantsi Boitshekwane[1]

[1] *University of North West*

Corresponding Author: dkkgantsi@gmail.com

The issues of an increased water quality and deterioration due to mining activities are if major concern. The river systems have deteriorated noticeably due to mining effluent and other industrial effluents.Mining activities are the major sources of the radio toxic and heavy metals pollutants.These pollutants are naturally found everywhere in the environment, and accumulate easily in the soil and water. Their concentration can negatively impact on the environment and to some extent the society. Some of the negative impacts of mining include destruction of water bodies, loss of biodiversity and food insecurity, high cost of living and water pollution.

Rivers play a significant role in providing needed portable water, which is not only a basic need but also a social, environmental and economic good wherein access to it is of radical need.The relationship between people and rivers existed for centuries as they depend on rivers for food and water, however, rivers tend to be easily misused through pollution by industries such as mining , agriculture and many other uses. It is of significance to have a functional river system that provide needed portable water to industries and domestic use.

In this study, Vaal River plays a significant role in providing needed portable water to varied industries of Gauteng and nearby Provinces of South Africa. However the river is polluted beyond acceptable measures and it is considered a dumping site for toxic pollutants such as the radiotoxic and heavy metals which affect the water quality of the river. The rate at which the river is being polluted will have severe impacts on the economy,food and the river system.

This study was selected following continuously reported pollution of the Vaal River despite several studies conducted.The study focuses on mining as the major user and pollutants of the water system, the river as a pathway of pollutants with more focus on the radiotoxic and heavy metals from the water source, hence the main objective is to assess the radiological and heavy metals. The study results is aimed at assessing the water quality and sustainability of the Vaal River for future reference, looking at all angles that may contribute to pollution, which include challenges faced when dealing with water quality of the river, monitoring and management program of the river as a way to propose a conceptual management model for the Vaal River.

Student award:

Yes

Level for award:

PhD

Physics of Condensed Matter and Materials / 337

Machine Learning Structure-Property Model for Carbon Steels

Authors: Johan Westraadt[1]; Lindsay Westraadt[1]

[1] *Nelson Mandela University*

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Carbon steels were historically widely used for steam pipes in petrochemical and power generating plants. The microstructure consists of alternative bands of ferrite and pearlite aligned with the rolling direction. During long-term service above 420°C the lamellar cementite structure either breaks up into spheriodite or converts into its thermodynamical stable phase, graphite, leading to a decrease in the mechanical properties.

Small-punch creep (SPC) rupture testing is currently used to evaluate the creep-rupture properties of steels used in the petrochemical and power generating industries. This study explores microstructure-property relationships for service-exposed carbon steels using machine learning (ML). The reduced order models can be used to rank the different microstructural features in terms of their importance on the SPC-test and potentially be used to prioritise/reduce SPC testing requirements.

An experimental dataset consisting of 120x3 steel microstructures and their associated SPC-rupture times was collected. *WeldCore®* a novel sampling and repair technique for in-situ sampling of high-pressure steam lines, turbines and related components was used to remove site specific plug samples for the investigation. The creep-rupture properties were evaluated using Small Punch Creep (SPC) testing. A 2 mm diameter ceramic ball is forced (296 N) into the steel disk (8 mm diameter and 0.5 mm thickness) at a temperature of 500 °C. The time-to-rupture was used as the target variable for this study.

Optical 2D micrographs were taken from the etched surfaces of the tested samples. These optical micrographs were segmented and quantified using various feature extraction methods including traditional image segmentation, 1- and 2-point statistics, and convolutional neural networks. The extracted microstructural features were then reduced using principle component analysis (PCA) and used as inputs for training various regression models using different ML techniques. The samples were then investigated using secondary electron imaging at a higher resolution to incorporate the finer pearlite sub-structures into the models.

The microstructurally based model can predict the SPC rupture time approaching the variability in the testing platform (Testing RMSE = 79 hours). The pearlite phase fraction, degree of spheriodisation, and pearlite banding were the most important microstructural features for predicting the SPC rupture times. This machine learning approach can be adapted to different material systems if sufficient microstructural and mechanical property data are available.

Student award:

No

Level for award:

N/A

Applied Physics / 340

Direct-couple PVWPS sizing using borehole hydraulic parameters

Author: Livhuwani Masevhe[1]

Co-author: Nnditshedzeni Eric Maluta [2]

[1] *UNIVEN*

[2] *University of Venda*

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Photovoltaic water pumping systems (PVWPS) are a promising solution to improve water accessnin isolated rural areas in developing countries. Each system must be carefully sized to satisfy local demand while being as affordable as possible. In order to design a successful and sustainable system, the knowledge of solar radiation and groundwater resources availability is crucial. There are several steps that are followed to size and model a PVWPS. The current study used the borehole and solar radiation characteristics at the Vuwani Science Resource Centre to determine the suitable pump and the size PV power for a sustainable battery-less pumping of groundwater without depletion. The hydraulic characteristics, optimal flow-rate of 69.12 m3 /day and total dynamic head of 53 m were used as inputs for the sizing of the pump. Then based on the results of the steps, Grundof online software was used to validate the sizing of a proper submersible water pump that can supply the water needs. With having the electrical load of the system, the excel was used to design a complete and optimized model of PV system. The proposed system consists of a PV, a submersible pump and storage tank. A system controller was also designed and analyzed successfully

Student award:

No

Level for award:

N/A

Theoretical and Computational Physics / 342

Higher order relativistic dissipative fluid dynamics for heavy ion collisions and astrophysics

Author: Azwinndini Muronga[1]

[1] *Nelson Mandela University*

Corresponding Author: azwinndini.muronga@mandela.ac.za

Relativistic fluid dynamics model is a useful tool in describing matter produced in heavy ion collisions at particle accelerators such as the Large Hadron Collider (LHC) and in astrophysical processes such as the core-collapse supernovae and neutron star collisions.

For the past two decades it has become clear that to describe transient phenomena in such processes using dissipative fluid dynamics one must use extended thermodynamics – also referred to as second order theories of relativistic dissipative fluid dynamics. This talk will provide motivation for going beyond Navier-Stokes equations and for the need of higher order relativistic dissipative fluid dynamics to describe systems and process in heavy ion collisions and astrophysics.

Student award:

No

Level for award:

N/A

Plenary (WIPISA) / 345

Women in STEM: a perspective from the Global South

Author: Prof. Shobhana Narasimhan[1]

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Almost everywhere in the world, women constitute a minority in the STEM workforce. A frequently misconception is that the number of women in STEM is particularly low in the Global South. In fact, on plotting the percentage of women in the STEM workforce of a nation versus its per capita income PPP, one obtains an inverted U: as a country becomes richer, the percentage of women in STEM rises sharply, then falls slowly.

Economically richer and poorer countries also tend to show differ patterns of retention in STEM ; in economically developed countries, the main problem seems to be in attracting girls to studying science, whereas in developing countries, one sees a big dropout among women studying science after the tertiary level.

Of course, women in STEM in developing countries have to deal with a lack of infrastructure and resources, and also frequently face societal challenges and biases, both within and outside their countries.

One effort to address the problems faced by women physicists in the developing world is the Career Development Workshops for Women in Physics that have been held since 2013 at the ICTP in Trieste, Italy, and also at the new ICTP-EAIFR in Kigali, Rwanda. I will briefly describe the structure of these workshops, and some of their success stories.

Student award:

No

Level for award:

N/A

Plenary 5 - Nuclear, Particle and Radiation Physics / 346

IAEA activities in support of nuclear physics research and applications

Author: Danas Ridikas[1]

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Facilitation of development and promotion of nuclear applications for peaceful purposes and related capacity building are among the IAEA missions where Physics Section contributes most [1]. The relevant activities fall under the IAEA's program on nuclear science and cover three main thematic areas: research and applications with particle accelerators and neutrons sources (incl. research reactors), nuclear instrumentation and capacity building, and controlled fusion research and technology (incl. cooperation with ITER). As a result, the Section helps IAEA's Member to advance their capabilities and progress in materials research, energy, environment, food, agriculture, health care, cultural heritage, forensics, and some other fields with a direct socioeconomic impact. The Section also operates the Nuclear Science and Instrumentation Laboratory (NSIL) at Seibersdorf [2], located approximately 40 km south of Vienna. The NSIL provides expertise, training and support in the effective utilization of nuclear instrumentation and analytical techniques in a broad range of applications, with a focus on mobile radiation monitoring, X-ray spectrometry, accelerator technologies, and compact neutron generators.

This presentation will illustrate through a number of selected examples how the IAEA supports nuclear physics research and diverse applications in order to address key development priorities in

many areas of societal importance and economic growth of the developing countries. In addition, some future plans on enhancing capabilities of the Nuclear Science and Instrumentation Laboratory as part of Physics Section will be highlighted, in particular by establishment of the neutron science facility and considerations for a compact ion beam accelerator.

Student award:

No

Level for award:

N/A

Plenary 1 - Applied Physics / 347

Scenarios for Powering the South African Electricity Grid to Supply the Electricity Demand in Future

Author: Prof. Wikus van Niekerk[1]

[1] *Stellenbosch University*

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South Africa is grappling with a number of very serious challenges to supply the country with sufficient electricity to service the requirements of all sectors of the economy as well as the demand from all our citizens. Some of these are driven by global concerns, such as the carbon emissions from coal-fired power stations causing climate change, and others specific to the South African landscape, such as the collapse of the skills base of the staff of our national utility.

In this talk we will review the current state of the electricity supply system in South Africa, the possible demand going forward and how we will be able to service this demand considering all the options available. We will focus on possible scenarios that may play out given our current context and constraints; discuss the benefits and risks of the various supply options; and theorise on the what may the best pathway in the short and medium term.

Student award:

No

Level for award:

N/A

Plenary 7 - Physics for Development, Education and Outreach / 348

Physics for Development, Education and Outreach

Author: Dr Marie Clémentine Nibamureke[1]

[1] *University of Johannesburg*

Corresponding Author: uwinezamarie@gmail.com

In 2015, countries adopted the UN 2030 Sustainable Development Goals as a universal call to end poverty. Poverty is considered as one of the greatest challenges to sustainable development in Africa as approximately 80% of people in extreme poverty are located in Sub-Saharan Africa. The lack of proper education, jobs, infrastructures, and clean water are among the mains factors contributing to perpetuating poverty in Africa. Africa, with the youngest and fast growing population, with more than 60% of the world's arable lands and 30% of the world's minerals should not be lagging behind other continents in development. One of the ways to unlock Africa's potentials is education by addressing the existing gaps in needed skills in science and technology. Community awareness programs about environmental problems and cultural bias on girls' education are also needed to achieve sustainable development in Africa. An important key step in education is improving the teaching and learning of physics in Africa. Physics as the basis of all applied sciences can help in breaking

the cycle of perpetual poverty in Africa by building sustainable renewable energy systems and finding solutions to social and environmental problems including water pollution and climate change. However, this cannot be achieved without the collaboration and communication between all stakeholders namely local communities, the scientific community, policymakers and international partners. This talk will focus on the activities and plans of the African Strategy for Fundamental and Applied Physics (ASFAP), an initiative launched by African Physicists living and working in different countries around the world in November 2020 with a vision to unlock Africa development through improved Physics education and research capabilities. Amongst ASFAP objectives are encouraging and strengthening physics education in schools (secondary and tertiary), young scientists capacity building, innovating scientific research and collaboration between countries, engaging the community through outreach programs, influencing directions of science strategies taken by policymakers and creating a proper cultural environment and conditions in which science in Africa can prosper. In summary, ASFAP is a community-drive scientific initiative to define the most impactful strategic directions for sustainable development in Physics education and research in Africa.

Student award:

No

Level for award:

N/A

Plenary 2 - Applied Physics / 349

Biophysics: an introduction to its science and applications

Author: Tjaart Krüger[1]

[1] *University of Pretoria*

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The 21st century has been called the "century of biology" since the biggest innovations are predicted at the intersection between biology and technology. Physics plays a key role in establishing this intersection. In fact, during the past couple of decades, biophysics has contributed to substantial advances in solving important and fundamental questions in biology and it is indispensable for confronting mankind's health challenges. Biophysics underpins large sections of the global bio-economy. A strong and diverse biophysics research and commercial sector is therefore vital for the success of the African economy. Biophysics bridges the complexity of life with the elegant physical laws of nature. It weds the complex beauty of biology with the rigour of physics. This presentation will serve as a broad introduction to biophysics with a particular emphasis on molecular biophysics. I will include a few examples of quantum biology that illustrate how we may draw inspiration from the biological world for our own quantum technologies. This will be followed by an introduction to selected methods for manipulating and controlling the properties of individual biomolecules. I will conclude with examples from my own laboratory, showing how the photon emission signatures of individual light-harvesting complexes can reveal new biological functions.

Student award:

No

Level for award:

N/A

Plenary 6 - Physics of Condensed Matter and Materials Science / 350

Functional Materials by Design: Developing Treasure Maps with Quantum Chemistry

Author: Prof. Matthias Wuttig[1]

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Scientists and practitioners have long dreamt of designing materials with novel properties. Yet, a hundred years after quantum mechanics lay the foundations for a systematic description of the properties of solids, it is still not possible to predict the best material in applications such as photovoltaics, superconductivity or thermoelectric energy conversion. This is a sign of the complexity of the problem, which is often exacerbated by the need to optimize conflicting material properties. Hence, one can ponder if design routes for materials can be devised. In recent years, the focus of our work has been on designing advanced functional materials with attractive opto-electronic properties, including phase change materials, thermoelectrics, photonic switches and materials for photovoltaics. To reach this goal, one can try to establish close links between material properties and chemical bonding. However, until recently it was quite difficult to adequately quantify chemical bonds. Some developments in the last decades, such as the quantum theory of atoms in molecules have provided the necessary tools to describe bonds in solids quantitatively. Using these tools, it has been possible to devise a map which separates different bonding mechanisms. This map can now be employed to correlate chemical bonding with material properties. Machine learning and property classification demonstrate the potential of this approach. These insights are subsequently employed to design phase change as well as thermoelectric materials. Yet, the discoveries presented here also force us to revisit the concept of chemical bonds and bring back a history of vivid scientific disputes about 'the nature of the chemical bond'.

Student award:

No

Level for award:

N/A

Plenary 3 - Photonics / 351

Laser Spectroscopy Applied in Environmental, Ecological, Agricultural and Medical Research

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Laser spectroscopy is a flourishing research area, which had major impact in science during recent years. In applied laser spectroscopy, the fields of combustion diagnostics, atmospheric remote sensing, agriculture and ecology, as well as biomedicine are prominent. An overview of certain applications of laser spectroscopy is given, with emphasis on the environmental, agricultural/ecological, and biomedical areas, as based on the experience of the author within these fields.

Optical probing of the atmosphere using active remote sensing techniques of the laser-radar type will be discussed. Atmospheric objects of quite varying sizes can be studied. Mercury is the only pollutant in atomic form in the atmosphere, while other pollutants are either molecular or in particle form. Light detection and ranging (Lidar) techniques provide three-dimensional mapping of such constituents. Recently, the techniques have been extended to the ecological field. Monitoring of flying insects and birds is of considerable interest, and several projects have been pursued in collaboration with biologists. Fluorescence lidar allows remote monitoring of vegetation and historical building facades. In agricultural applications, e.g., the fertilization levels of crops can be assessed. Drone-based techniques are now also augmenting the possibilities of fluorescence mapping of the environment.

Fluorescence spectroscopy has important applications in tissue characterization, using similar methods as for environmental monitoring, but now on a smaller scale. Tumours can be eradicated using photodynamic therapy. Free gases related to the human body are found, e.g., in the lungs, the middle ear, and the sinus cavities. The gas in scattering media absorption spectroscopy (GASMAS) technique has proved useful in the monitoring of lung function in neonatal children, and shows promising potential in the characterization of otitis and sinusitis. The importance of cross-disciplinary work in solving important societal problems is emphasised.

Student award:

No

Level for award:

N/A

Physics for Development, Education and Outreach / 353

Using a Kibble balance to explain physics principles in education

Authors: Landile Floyd Mndebele[1]; Aletta Karsten[2]; Thapelo Mametja[3]; Rantshi Senona[1]; Christoph Sonntag[1]; Mbuso Sibisi[1]

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Using a Kibble balance to explain physics principles in education

In metrology, a Kibble balance is an instrument used by metrologists to realize the SI unit for mass. There are several physics principles used in the operation of this instrument – namely electromagnetism, classical mechanics, electrostatics, electricity, optics, materials science, and metrology. The basis of this investigation is on all these physics disciplines applied for the functionality of the Kibble balance. However, the National Metrology Institute of South Africa (NMISA) developed a miniature version of the Kibble balance, called a Mobile Kibble balance, which serves the same purpose but with less accuracy and precision. Detailed explanations for all the mechanisms involved in its operation are given. Moreover, light is shed on possible applications for this instrument in the education space for promoting physics while raising awareness about the existence and importance of metrology.

Student award:

No

Level for award:

Hons

SPECIAL LECTURE: 10th Anniversary of Discovery of Higgs Boson / 354

The Discovery of the Higgs Boson

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At the Large Hadron Collider (LHC) at CERN, Geneva we can probe our Universe moments after the Big Bang to tackle the questions about its origin, evolution and composition. These include: What is the origin of mass? What constitutes dark matter? How many dimensions of space and time do we live in? Why is the universe composed of matter and not antimatter? The answers have the potential of altering our perception of how Nature operates at the fundamental level. The discovery in July 2012 of the Higgs boson at the Large Hadron Collider (LHC), one of the most important of this new century, completes the particle content of the standard model (SM) of particle physics, a theory that describes our visible universe in exquisite detail. This talk will describe the long journey to the discovery of the Higgs boson, briefly recalling the physics aims, outlining some of the technological and engineering challenges faced during construction, and the making of the discovery itself. The talk also will discuss the prospects for the high-luminosity operation of the LHC, especially those related to the examination of the properties of the Higgs boson with larger data samples.

Student award:

No

Level for award:

N/A

Physics Industry Day / 358

Optical fabrication technology: where are we? and where are we going?

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Optics and photonics technologies have variety of commercial, industrial and research applications. Optical elements such as lenses and prisms form the basis of optical systems in optics and photonics technologies, with each components' characteristics designed and fabricated to maximize throughput of the system. Traditional fabrication processes of optical components which involve sawing and drilling of optical glass and loose abrasive grinding and polishing methods have been developed as a result of empirical experience and has been sufficient in achieving specifications. The advent of the laser and laser interferometric tests, computer numerically controlled (CNC) machines with diamond turning tools has enabled more accurate, efficient, and automated precision manufacturing capabilities and provide more accurate measurement techniques of manufactured optical components. CNC machines have increased the demand for new and diverse components for optical systems with high tolerance specifications, the use of new raw materials and enabled high-volume manufacturability. Despite the advantages of CNC machines, along with budget constraints, there exists limitations in their use and traditional fabrication methods are preferred when manufacturing certain optical components. Along with the addition of thin film coatings applied to optical components to optimize performance, there exists many other factors that influence the manufacturing processes of optical components. An overview of optical fabrication processes will be outlined, along with the limitations and factors that influence manufacturing and industrialization procedures. An insight will be given into the research, development, constraints, and implementation of fabrication of new components are outlined

Student award:

No

Level for award:

N/A

Physics Industry Day / 359

Case Studies of deploying AI-enabled and IoT-based Solutions for Industrial Applications

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Apart from knowledge generation and knowledge transfer universities, national research facilities and science councils, these institutions over the last decade are required more and more to get involved in technology (developed by researchers) transfer (to industry). Technology transfer not only assist in translation of scientific research outputs in impactful products and services but also be of impact to society and to improve national economic growth through greater technological innovation. DataConvergence in partnership with Wits Enterprise and the Technology Innovation Platform (TIP) at iThemba LABS focuses on integration of data analysis in project development using artificial intelligence-enabled and IoT-based solutions. The skills developed by working on complex particle physics problems at the Large Hadron Collider at CERN are deployed for the development of AI-enabled and IoT-base solutions in areas such as predictive modelling (e.g. law, retail) and smart economies (e.g. energy, agriculture, mining). In this presentation a few case studies of deploying AI- enabled and IoT-based solutions for potential industrial applications will be presented.

Student award:

No

Level for award:

N/A

Physics Industry Day / 360

PVinsight: Determining photovoltaic module quality and degradation rates

Author: Jacqui Crozier McCleland[1,2]

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Solar Photovoltaic (PV) Energy is a sustainable and practical alternative to fossil-fuel power in South Africa due to the abundant solar resource. However, the quality and long-term performance of PV modules is key to the success of large-scale PV installation. Manufacturers guarantee their solar modules with an expected degradation over a twenty-year period, generally a decrease in power of less than one percent a year. Module degradation can be determined by annual measurements of the power output of a module in an indoor Solar simulator under controlled standard test conditions. Due to the small year on year change attributed to expected module degradation, data from several years is required to see the trend of degradation. At the ISO 17025 accredited PVinsight Photovoltaic Testing Laboratory based at Nelson Mandela University, advanced PV characterisation techniques are implemented to assess module quality and degradation. These tests provide guidance to the PV industry, to ensure that their systems preform as expected.

Student award:

No

Level for award:

N/A

Physics Industry Day / 361

Physics in action: a personal journey from the Space Shuttle to aeronautics, explosions, rational drug design and ocean waves

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The privilege of working on Space Shuttle plasma physics using massively parallel processors was a good introduction to the world of applied science. I will describe a series of steep personal learning curves from academia to industry and business, and to national strategy. Adapting to aeronautics appeared at first sight to be a case of taking out the fields and charges, but turned out to be a much more complex engagement with complicated geometry and validation, particularly when the safety of human beings is on the line. A hitherto unexplored factor in my life as a physicist - a sudden change in corporate strategy - meant a methodological change from cellular automata to Computational Fluid Dynamics. Predicting the behaviour of shocks in transonic flight was a difficult but rewarding field. Experience with fluid phenomena led on to simulation of explosions in coal mines, to work on ocean wave modelling, and to a new description of order and disorder in coastal breakwaters. An inclination to collaborate resulted in work on HIV/AIDS, on tuberculosis, and to research on non-linear materials as protection for the eyes of aircraft pilots from laser illumination. The relationships between these apparently disparate areas, and their value to society, will be explained from the point of view of an applied computational physicist.

Student award:

No

Level for award:

N/A

Physics Industry Day / 362

Industry Connection Roadmap

Author: Alan Matthews[1]

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The aim of an Industry Connection Roadmap for Physics in South Africa is to explore the job market for physics graduates in industry and connections between academia and industry. Physics graduates have skills in quantitative analysis that are applicable beyond physics. Although physics graduates find work in academia, the majority of jobs in the market are in digital work outside of physics domain knowledge. A roadmap should be based on a strategy document covering the job market, a directory of companies that employ physics graduates, and measures to initiate new physics activities in industry.

Student award:

No

Level for award:

N/A

Physics Industry Day / 363

Nuclear Technologies in Medicine

Author: Jan Rijn Zeevaart[1]

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The current focus of personalized medicine is towards the use of the theranostic approach- the development of an interdependent, collaborative targeted therapeutic and acompanion diagnostic test. Nuclear Medicine has provided non-invasive imaging fordecades and together with therapeutic radioisotopes it is ideally suited to contribute to this quest in medicine. Positron Emission Tomography - PET/CT imaging plays an important role in this and fortunately diversification of the use of the well-known but nonspecific 18 F-Flurodeoxyglucose-PET/CT to the use of radiometals such as 68 Ga, 64 Cu and 89 Zr has created many new opportunities in the Nuclear Medicine fraternity. The successful implementation of 68 Ga-DOTATATE and 68 Ga-PSMA in the clinic for neuroendocrine and prostate cancer imaging has opened the option for treatment of these diseases with the therapeutic pair selected from 177 Lu and 225 Ac / 213 Bi (beta and alpha emitter respectively). Not only is success achieved in oncology but also in imaging of infection (including Tuberculosis) with several new compounds under investigation; 68 Ga-UBI and 18 F-FDS. Illustrations of the processes followed in drug design, radiolabelling, radiopharmaceutical formulations and (pre)clinical outcome will be given in this presentation.

Student award:

No

Level for award:

N/A

Physics Industry Day / 364

Quantum technology for industry

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Harnessing the power of quantum states has unveiled novel applications in the fields of communication, cybersecurity, computing, sensing and imaging. Indeed the quantum industrial revolution upon us, and it is imperative to foster an emerging class of quantum scientists that would be able to leverage their knowledge in order to answer current industrial challenges, while at the same time developing the tools and technology of future. At Fraunhofer Centre for Applied Photonics, we bridge the gap between academia and industry to facilitate the smooth transfer of technology and knowledge. In this talk, I will give you a flavour of (i) the dynamics that govern our workflow and (ii) the sort of industrial challenges that we address through quantum technology.

Student award:

No

Level for award:

N/A

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