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Table of contents

Poster1 / 2

Defects and Reconstructions in Electron Beam Irradiated Graphene Sheets

Mr. FABIANE, Mopeli [1]

[1] *University of Pretoria PhD Student*

Corresponding Author: s10443682@tuks.co.za

Graphene characterization and device fabrication often require extensive use of the scanning electron microscopy (SEM) and tunneling electron microscopy (TEM). These techniques involve electron beam irradiation that usually causes defects in materials under investigation. The radiation induced defects may lead to significant damage to the material which may alter its properties, normally an undesirable phenomenon. However, recent experiments show that electron radiation can have beneficial effects in materials. Graphenic materials have the ability to reorganize their structures under irradiation like no other materials. This property can find application in radiation hard electronics owing to the technological importance of graphenic materials. Here we report the Raman and scanning tunneling microscopy (STM) results of pristine and heat treated electron -beam irradiated graphene sheets (mono-layer and double layers) to demonstrate graphenic reconstructions. STM creates images of the charge density of electrons at the Fermi level such that all surface atoms can be visible.

Poster2 / 3

Simulating chorus generation via Particle-in-cell simulations

Author: Mr. KOEN, Etienne [1]

Co-Authors: Dr. COLLIER, Andrew [2]; Dr. MAHARAJ, Shimul [1]; Ms. VAN ZYL, Marlie [2]

[1] *Hermanus Magnetic Observatory*

[2] *University of KwaZulu Natal*

Corresponding Author: koenej@gmail.com

Chorus emissions are whistler mode waves propagating through the Earth's magnetosphere in two distinct frequency bands, typically in the range of 0.1-0.8 fce, where fce is the equatorial electron gyro-frequency. Chorus consists of discrete elements, which are normally rising tones, each of which lasts for a few tenths of a second. Chorus is predominantly observed during the onset of the substorm expansion phase when energetic electrons are injected into the magnetosphere. As these electrons drift eastward around towards noon, their distribution becomes unstable to the amplifiation of whistler mode waves. It is thought that the amplification process proceeds via the Doppler-shifted cyclotron resonance interaction. Particle-in-cell (PIC) simulations, which simulate the motion of groups of similar particles on a two dimensional grid subject to the self-consistent electric and magnetic fields generated by their spatial distribution and motion, are used to simulate the amplification of whistler-mode waves propagating along the magnetic field. A population of electrons having a velocity distribution with a thermal anisotropy is injected into the plasma and the growth of the resulting waves is investigated.

Applied / 4

Numerical Field Analysis of the Magnets for a proposed Ionisation Beam Profile Monitor for High Current Synchrotron and Cooler Rings.

Author: Dr. DE VILLIERS, John Garrett [1]

Co-Authors: Dr. CONRADIE, J. L. [1]; Prof. DIETRICH, Jürgen [2]; Dr. KAMERDZHIEV, Vsevolod [2]; Mr. BOEHME, Christian [2]; Dr. FORCK, Peter [3]; Mr. GIACOMINI, T [3]

[1] *iThemba LABS*

[2] *IKP, FZ-Jülich*

[3] *GSI, Darmstadt*

Corresponding Author: gdevil@tlabs.ac.za

iThemba LABS was requested by the Institut für Kernphysik at Forschungszentrum Jülich, Germany, to design and calculate a magnet system for a proposed non-destructive Ionization Beam Profile Monitor (IBPM) that can measure beam profiles using the secondary ions produced in the rest gas, planned to be implemented with the FAIR-GSI project in Darmstadt Apart from the geometrical restrictions by the available space, the main requirements for the magnet system are to comply with the specified field intensity and homogeneity at the plane of measurement and to deliver the primary beam unchanged and aligned with the original beam direction within the GSI storage ring. The calculated magnets for the IBPM consists of four window-frame, room-temperature, water-cooled, laminated, dipole DC-electromagnets in line with the primary beam. The inner two dipoles of the set are respectively used for horizontal and vertical beam profile analysis and the correct delivery of the beam from the system is facilitated with the aid of two corrector magnets. The magnets are mounted outside and around the vacuum chamber that contains other essential components and therefore will have unusually large pole gaps that are in the order of 0.5 m, which, together with the relative short drift lengths between the magnets, cause significant interference between the magnetic flux distributions of the magnets. This necessitated the use of 3D numerical field analysis that incorporates al the magnets. The field homogeneities in the regions where the beam profiles are to be measured were found to be very sensitive to the magnet geometries and layout, but a workable solution was found and the calculated results of these magnets and multi-pole and ion beam optics analysis of the system will be presented.

Poster2 / 5

PLASMON: Data Assimilation of the Earth's Plasmasphere

Author: COLLIER, Andrew [1]

Co-Authors: LICHTENBERGER, János [2]; FRIEDEL, Reiner [3]; CLILVERD, Mark [4]; HEILIG, Balázs [5]; VELLANTE, Massimo [6]; MANNINEN, Jyrki [7]; RODGER, Craig [8]; JORGENSEN, Anders [9]; REDA, Jan [10]; HOLZWORTH, Bob [11]

[1] *Hermanus Magnetic Observatory*

[2] *Eötvös Loránd University*

[3] *Los Alamos National Laboratory*

[4] *British Antarctic Survey*

[5] *Eötvös Loránd Geophysical Institute*

[6] *University of L'Aquila*

[7] *University of Oulu*

[8] *University of Otago*

[9] *New Mexico Institute of Mining and Technology*

[10] *Institute of Geophysics, Polish Academy of Sciences*

[11] *University of Washington*

Corresponding Author: collier@ukzn.ac.za

The principal source and loss mechanisms in the Earth's radiation belts are currently not completely understood. Loss rates are important since they determine the duration of exposure of satellites to enhanced radiation conditions during a geomagnetic storm. The dominant loss process is relativistic electron precipitation via resonant interactions with a variety of wave modes. These interactions are governed by the characteristics of the plasmasphere. Current models provide an inadequate representation of the spatial and temporal evolution of the plasmasphere. In situ measurements of the plasmasphere provide only local characteristics and are thus unable to yield a complete global picture. Ground based measurements, based on the analysis of Very Low Frequency (VLF) whistlers and Field Line Resonances (FLRs), are able to describe large sections of the plasmasphere, extending over significant radial distances and many hours of local time. These measurements provide electron number and plasma mass densities. PLASMON is a funded FP7 project between 11 international partners. PLASMON intends to assimilate near real time measurements of plasmaspheric densities into a dynamic plasmasphere model. The VLF whistler analyses will be conducted by automatic retrieval of equatorial electron densities using data from AWDAnet. Equatorial mass densities will be constructed from FLR measurements along meridional magnetometer chains. The resulting model will facilitate the prediction of precipitation rates. The predicted rates will be compared to observations from the AARDDVARK network.

Poster2 / 6

Testing the Cosmic Ray-Lightning Connection Hypothesis

Author: Mr. OKIKE, Ogbonnaya [1]

Co-Author: COLLIER, Andrew [1]

[1] *University of KwaZulu-Natal*

Corresponding Author: ogbos.okike@gmail.com

The proposed dependence of atmospheric electrical properties on the ionizing influence of cosmic rays has resulted in numerous attempts to obtain convincing correlations. While most of the studies remain largely theoretical, a few results (e.g. Stozhkov, 2003) indicate that there is a plausible link between lightning activity and the cosmic ray ionization rate measured at specific locations on Earth. The present work uses data from the World Wide Lightning Location Network (WWLLN) to investigate the impact of cosmic rays on lightning on a global scale. The availability of global lightning data from WWLLN, and assimilated cosmic ray data from a global network of neutron monitors provides a good opportunity to study the relationship between cosmic ray variations and lightning occurrence on a larger spatial scale than was previously possible.

Poster2 / 7

Trajectories of electrons in a realistic model of the Earth's magnetic field

Author: NEMAIR, Mahassin [1]

Co-Author: COLLIER, Andrew [1]

[1] *University of KawZulu-Natal*

Corresponding Author: mnemair@gmail.com

During the onset of a substorm, a burst of energetic (10-100 keV) electrons is injected into the inner magnetosphere. The subsequent motion of these electrons is dictated by their energy, pitch angle and the Earth's magnetic field geometry. More specifically, if the Earth's magnetic field is not varying rapidly then the three adiabatic invariants associated with each of the electrons' periodic motions (drift, bounce and gyration) are conserved. In this work we study the motion of electrons in the Earth's magnetic field. A realistic magnetic field geometry is employed which depends on conditions in the solar wind by applying time varying magnetic filed calculated from Tsyganenko model. The initial electron source location is presumed to be at L = 9 at midnight. The trajectories of electrons with energies of 10-100 KeV are studied using Tsyganenko model of the magnetosphere. Results are compared with other model simulated .

Theoretical / 8

Enhancing the understanding of entropy through computation

Author: Dr. SALAGARAM, Trisha [1]

Co-Author: Prof. CHETTY, Nithaya [1]

[1] *University of Pretoria*

Corresponding Author: tsalagaram@gmail.com

We devise a hierarchy of computational algorithms to enumerate the microstates of a system comprising N independent, distinguishable particles. An important challenge is to cope with integers that increase exponentially with system size, and which very quickly become too large to be addressed by the computer. A related problem is that the computational time for the most obvious brute-force method scales exponentially with the system size which makes it difficult to study the system in the large N limit. Our methods address these issues in a systematic and hierarchical manner. We apply our methods to a simple model with single particle energy spectrum given by ε(p, q) = ε0 (p2 + q 4), where p and q are non-negative integers. However, our methods are very general and applicable to a wide class of problems. Working within the microcanonical ensemble, our methods enable one to directly monitor the approach to the thermodynamic limit ($N \longrightarrow \infty$), and in so doing, the equivalence with the canonical ensemble is made more manifest. Various thermodynamic quantities as a function of N may be computed using our methods; in this paper, we focus on the entropy, the chemical potential and the temperature.

CMPMS1 / 9

On the orbital rehybridization in tetrahedral amorphous carbon

Dr. UKPONG, Aniekan Magnus [1]

[1] *University of the Witwatersrand*

Corresponding Author: aniekan.ukpong2@wits.ac.za

The use of tetrahedral amorphous carbon thin films in bolometers depends strongly on the ability to tune its optical properties. This can be achieved by controlling the density of dangling bond defects and the disorder in the material. The pi-orbital axis vector theory is used in this study to investigate the phenomenon of rehybridization of the carbon bonding in tetrahedral amorphous carbon. It is shown that the correlated pi - pi* orbitals is locally entangled due to the competition between the on-site Coulomb interaction and the hybridization. A microscopic model is proposed for the reduction in strain in the material due to hydrogenation, based on the the sp3 − sp2 conversion reaction. It is demonstrated that the activation energy for this conversion is dependent on the Urbach energy, and therefore on the disorder. The implication of the results on the manifestation of strain in similar, carbon-based, materials is discussed.

CMPMS1 / 10

Studies of thermodynamic, structural and electronic properties of substitutional defects in models of single-walled carbon and boron nitride nanotubes

Mr. MASHAPA, Matete [1]

[1] *CSIR*

Corresponding Author: mmashapa@csir.co.za

We report on studies of thermodynamic, structural and electronic properties of substitutional defects involving C, B, N and vacancies in models of single-walled carbon and boron nitride nanotubes. Using the generalized gradient approximation (GGA) for the exchange-correlation functional, we perform first principles calculations within the framework of density functional theory to optimize fully the geometries of the systems in their ground states. We give detailed accounts of the relaxed geometries. We compare the heats of formation of the various point defects, and we draw conclusions about the relative stability of the these defects. We study the changes to the electronic structure for these defect systems, and further investigate the detailed nature of the defects. We make a comparative study of the C and BN nanotube systems.Where data is available, comparisons are made.

APSS / 11

Lightning induced whistler waves as a cause of electron precipitation

Author: Ms. VAN ZYL, Marlie [1]

Co-Author: Dr. COLLIER, Andrew [2]

[1] *University of KwaZulu-Natal*

[2] *Hermanus Magnetic Observatory*

Corresponding Author: vanzyl.marlie@gmail.com

Lightning induced whistler waves are one of the primary causes of energetic electron loss from the Earth's radiation belts. This is mainly due to the pitch angle scattering of the particles by whistler mode waves, leading to precipitation. The detailed spatial and temporal influence of lightning on precipitation losses is, however, not well known. The World Wide Lightning Location Network (WWLLN) gives continuous global lightning coverage with good time resolution. Since the detection efficiency of WWLLN is relatively low, it was compared to LIS/OTD data. However, whereas WWLLN records strokes, LIS/OTD record flashes. Therefore the flash multiplicity has to be taken into account. By incorporating multiplicity and lightning stroke orientation to the WWLLN global lightning distribution and then transforming the resulting data to geomagnetic(MAG)coordinates, the average VLF power that is radiated into the ionosphere can be estimated. This can be used to determine the energy and the spectrum of the waves that go on to enter the magnetosphere. Hence the precipitation losses due to whistler mode waves can be studied.

Poster1 / 12

The synthesis and characterization of tin oxide SnO2 nanorods

Ms. SHOZI, Nolwazi [1]

[1] *none*

Corresponding Author: nolwazishozi@gmail.com

In 2003, photoluminescence emission in tin dioxide nanoribbons was reported and it was later demonstrated that the absorption of nitrogen dioxide by these structures quenches the intensity of visible light emission in SnO2 nanobelts which suggested he possibility of developing a new class of contactless devices based on gas sensitive optical devices. The motivation behind this project is to clarify the fundamental aspects of light emission mechanisms of nanorods instead of nanoribbons and to characterise their response to gas species in view of their possible applications. The benefits of this project may include enhancing the sensitivity of conductometric gas sensors through the design and synthesis of porous three-dimensional tin oxide nanostructures. Several methods have been used to prepare SnO2 nanorods including thermal evaporation, thermal decomposition, solution phase growth and hydrothermal methods. Amongst these, the thermal evaporation approach has been used to synthesize a wide variety of 1-D materials. This often has involved the use of a catalyst in which nanowire growth proceeds by vapour-liquid-solid (VLS) mechanism. However metal catalysts can serve as impurities and contaminate the nanowires, possibly forming defect states that limit their applications in devices. The experiental procedure that will be used to deposit the tin dioxide (SnO2) nanorods is called pulsed laser deposition (PLD). These structures were characterized using X-ray powder diffraction, scanning electron microscope, transmission electron microscope and photoluminescence spectroscopy. The XRD patterns of the SnO2 nanorods showed peaks with 2θ values of 26.97 °, 34.34 °, 38.26 °, 52.01 °, 54.90 °, 71.28 °, and 78.40 °, corresponding to SnO2 tetragonal rutile crystal planes of (110), (101), (200), (211), (220), (202) and (321) respectively. Raman spectra taken at room temperature for Sno2 nanorods which shows bands at 576 and 359 cm-1 in addition to the Ag1 vibrational mode at 635 cm-1. TEM image of the SnO2 nanorods indicates a relatively uniform rod-like morphology. These rods are of 15-20nm in length and 2.5-5nm in diameter. The room temperature photoluminescence spectra for SnO2 nanorods showed a red emission at 580nm was observed from the SnO2 nanorods using the He-Cd laser (~325nm) as the excitation source.

Poster1 / 13

Synthesis & Characterization of Porphyrin Nanotubes/Rods for Solar Radiation Harvesting and Solar Cells

Author: Ms. MONGWAKETSI, nametso [1]

Co-Authors: Prof. MAAZA, Malik [1]; Dr. SPARROW, Raymond [2]; Prof. KLUMPERMAN, Bert [3]

[1] *iThemba LABS*

[2] *CSIR*

[3] *Stellenbosch University*

Corresponding Author: nanky@tlabs.ac.za

Porphyrins are macro-cycles often organized into nano-scale structures which perform many of the essential light-harvesting-, electron- and energy-transfer functions in various natural and synthetic systems. In addition to the sub-picosecond charge generation and transfer, they exhibit various shapes and functional properties that make them useful for the construction of ultrafast nanodevices and more specifically solar cells. This latter case would require to expand their specific J, S and Q absorption bands; a task of this research work. They are related to chlorophyll molecules found in natural systems that carry out light harvesting, charge separation and energy conversion. Using the free base and diacid forms of tetrakis (4-sulfonatophenyl) porphyrin and by varying the ionic strength of aqueous solutions used, Schwab et al were able to form single and bundled nanorods, whereas Wang et al used the mixture of tetrakis (4-sulfonatophenyl) porphyrin and Sn(IV) tetrakis(4-pyridyl) porphyrin to form a mixture of nanotubes and nanorods. Once synthesized, the incorporation of such nanostructures into a functional device presents its own set of unique problems, but one promising approach is to incorporate the nanotubes/rods onto a support to obtain an array that can be directly used as a device. Properties investigated after synthesis included the optical (UV-visible spectroscopy), physical (Transmission electron microscopy) and the growth mechanism of the nanotubes/rods. Understanding the sizes and growth mechanism of nanorods is essential for the successful implementation in PV-like solar cells hybrid systems.

Theoretical / 14

Antimatter production in pp and in heavy-ion collisions at ultrarelativistic energies

Prof. CLEYMANS, Jean [1]

[1] *University of Cape Town*

Corresponding Author: jean.cleymans@gmail.com

One of the striking features of particle production at high beam energies is the near equal abundance of matter and antimatter in the central rapidity region. In this paper we would like to study how this symmetry is reached as the beam energy is increased. In particular we quantify explicitly the energy dependence of the approach to matter/antimatter symmetry. Expectations are presented for the production of more complex forms of antimatter like antihypernuclei.

Poster2 / 15

Metal-Semiconductor Ohmic Contacts: An ab initio Density Functional Theory Study of the Structural and Electronic Properties of Metal-Diamond (111)-(1x1) Interfaces.

Mr. MOTOCHI, Isaac [1]

[1] *PhD student, University of the Witwatersrand*

Corresponding Author: ismotochi@gmail.com

Metal contacts on clean, hydrogenated and oxygenated diamond surfaces have been studied using ab initio Density Functional Theory. Five metals, i.e., gold, titanium, tantalum, vanadium and palladium on the three surfaces were considered. Gold and palladium were found to form weak bonds on clean, hydrogenated or oxygenated diamond (111) surfaces compared to the other three metals. Bulk properties were also studied following the formation of the respective ohmic contacts on the three surfaces. The clean diamond surface was found to have surface states which were modified by oxygen but removed by hydrogen. Density of states studies revealed that all the investigated metals had an effect on the electrical properties of the diamond surface. A peak that is characteristic of diamond was observed at ≈ -11.8 eV. For the clean diamond surface terminated with gold and palladium, states due to Au-2p orbitals were observed at ≈ -2.5 eV and ≈ -1.5 eV, while Pd-5s orbitals were located at ≈ -1.7 eV and ≈ -0.5 eV on the same surface. Titanium, tantalum and vanadium showed unique states at high binding energies of ≈ -38 eV for vanadium, ≈ -34 eV for tantalum and ≈ -32.5 eV for titanium, which were thought to be responsible for their strong bonding. Key words: Metal-diamond interface, Adsorption, ohmic contacts

Theoretical / 16

The Physics of Exceptional Points

Prof. HEISS, W. Dieter [1]

[1] *Dpt of Physics, University Stellenbosch*

Corresponding Author: dieter@physics.sun.ac.za

A short resume about the nature of EPs followed by a discussion about their ubiquitous occurrence in a great variety of physical problems. EPs feature in quantum phase transition, quantum chaos, they produce dramatic effects in multichannel scattering, specific time dependence and more. In nuclear physics they are associated with instabilities and affect approximation schemes. EPs could be of interest for weakly bound states such as halos and nuclei along the drip line.

Education / 17

Lightning – Scientific knowledge versus mythological beliefs

Author: Mr. RAMAILA, Sam [1]

Co-Authors: Dr. REDDY, Leelakrishna [1]; Dr. NAIR, Padmanabhan [1]

[1] *University of Johannesburg*

Corresponding Author: samr@uj.ac.za

Lightning has in recent times wreaked havoc during the rainy season in several parts of South Africa and this prompted the physics community under the auspices of the South African Institute of Physics (SAIP) to devise meaningful strategies for promoting public awareness. In response to this call, first year physics students at the University of Johannesburg responded to a carefully designed questionnaire that seeks to probe students' level of understanding of lightning. Analysis of responses reveals lack of scientific understanding of lightning as a natural phenomenon. Amongst others, this can to some degree be attributed to superstitious or cultural beliefs.

Education / 18

National Curriculum Statement achievement levels – Can they serve as a measure of science students' preparedness for university study?

Author: Dr. NAIR, Padmanabhan [1]

Co-Authors: Mr. RAMAILA, Sam [1]; Dr. REDDY, Leelakrishna [1]

[1] *University of Johannesburg*

Corresponding Author: samr@uj.ac.za

The preparedness of matriculants for university studies has been a subject of intense debate and interrogation at various levels of public discourse. In addition, the standardization of Grade 12 assessment marks in various subjects by the Quality Assurance Body (Umalusi) has of late become a highly contentious issue. It is in recognition of these considerations that we undertook to investigate the extent to which Grade 12 achievement levels in Mathematics, Physical Science and English can serve as a measure of science students' preparedness for university study. Some of the underlying critical factors that may have a significant bearing on the aforementioned scenario were also investigated.

Poster1 / 19

Pt –Al203 nanocoatings for high temprature concentrated solar thermal power applications

Author: Ms. NURU, Zebib Yenus [1]

Co-Authors: Prof. MALIK, Maaza [2]; Prof. CHRISTOPHER, Arendsen [3]

[1] *iThemba LABS*

[2] *iThamba labs*

[3] *University of Western Cape*

Corresponding Author: zebib@tlabs.ac.za

Nano-pahsed structures based on metal-dielectric composites also called cermets (Ceramic-Metal) are considered among the most effective spectrally selective solar absorbers. For high temperature applications (stable up to 650°C) noble metals nanoparticles and refractory oxide host matrices are ideal as per their high temperature chemical inertness and stability: Pt/Al2O3 cermet nano-composites are a representative family. This contribution reports on the optical properties of Pt/Al2O3 cermet nano-composites deposited in a multilayered tandem structure. The radio-frequency sputtering optimized Pt/Al2O3 solar absorbers consist of stainless steel substrate/ Mo coating layer/ Pt-Al2O3/ protective Al2O3 layer and stainless steel substrate/ Mo coating layer /Pt-Al2O3 for different composition and thickness of the Pt-Al2O3 cermet coatings. The coatings microstructure, morphology, composition, optical properties were analyzed by x-ray diffraction, atomic force microscopy, infrared attenuated total reflection and UV-VI-NIR specular reflectances.

Poster2 / 20

Clay/sawdust porous pots for water treatment

Author: Dr. VARKEY, Joseph A [1]

Co-Author: Prof. DLAMINI, Mgidi D [1]

[1] *University of Swaziland*

Corresponding Author: varkey@uniswa.sz

The supply of adequate clean water to communities is a problem in many countries, especially in Africa where the rural population depend on water from rivers, dams and streams for domestic use. Such water contains many chemical substances and microorganisms that affect the health of human beings and animals. Use of simple water purification systems, like filters, by households, is a possible solution to this problem. In our laboratory, we have developed a porous pot water filter using sawdust and clay. Both materials are available locally. Sawdust was sieved using 100, 250 and 600 micrometer sieve and then mixed with clay in the clay/sawdust ratio of 1:3 by volume. The mixture was then used to make pots, which were porous. These pots were tested for their capacity to purify contaminated water collected from rivers. The filtration rate, as a function of the clay/coal ratio, was also measured. Subsequently, quality tests were done on the filtered water and raw water to determine the potability of the filtered water. The tests included microbiological, physical and chemical properties. The results were then compared with standards provided by World Health Organization.

Theoretical / 21

Density-matrix renormalization group study of the electro-absorption in conjugated polymers

Author: Mr. ABDELWAHAB, Anas [1]

Co-Authors: Prof. JECKELMANN, Eric [2]; ARTOLI, Abdel Monim [3]

[1] *Sudan University of Science and Technology*

[2] *Institut für Theoretische Physik, Leibniz Universität Hannover*

[3] *Faculty of Science-School of Physics,Al neelain University*

Corresponding Author: anasomer@sustech.edu

A symmetrized and dynamical density matrix renormalization group is used to study 1-dimensional extended Peierls-Hubbard model at half-filling. We have investigated the optical conductivity spectrum and electro-absorption spectrum for low-lying optical exciton with strong, intermediate and weak coupling parameter sets for the on-site and neighbor interactions. We were able to capture the Stark effect in the case of strong coupling under static electric field. The intermediate coupling was found to be clear for weak electric field and destroyed for strong one. We were not able to resolve the splitting in the case of weak coupling due to the small binding energy so that small value of electric field could distroy the exciton.

Theoretical / 22

Algebraic density functionals

Author: Prof. KARATAGLIDIS, Steven [1]

Co-Author: Prof. GIRAUD, Bertrand [2]

[1] *University of Johannesburg*

[2] *CEA/Saclay*

Corresponding Author: stevenka@uj.ac.za

A systematic strategy for the algebraic calculation of density functionals consists in coding information about the density and the energy into polynomials of the degrees of freedom of the wave functions. Density functionals and Kohn-Sham potentials are then obtained by standard elimination procedures of such degrees of freedom between the polynomials. Numerical examples illustrate the formalism.

CMPMS2 / 24

Synthesis and characterization of Water soluble Covellite Copper Sulphide Quantum Dots

Author: Ms. NELWAMONDO, Swikisani [1]

Co-Authors: Prof. MOLOTO, Makwena [2]; Prof. KRAUSE, Rui [1]; Dr. MOLOTO, Nosipho [3]

[1] *University of Johannesburg*

[2] *Vaal university of technology*

[3] *Wits University*

Corresponding Author: mmudanalwo@yahoo.com

Covellite copper monosulphide (CuS) is a representative I–VI chalcogenide semiconductor with the unique photoelectricity transformation characteristic. Due to quantum confinement effect, CuS nanoparticles exhibit optical and electrical properties as compared to the bulk materials. CuS is an indirect semiconductor with a bandgap around 1.7 eV. At high temperature CuS exhibits fast ion conduction and shows metal-like electrical conductivity and is an important semiconductor because of its excellent optical and electronic functionality. Colloidal method was used to develop CuS nanoparticles from copper acetate monohydrate and Thioacetamide in water and methanol using alanine as a stabilizing agent at pH 10 at different low temperatures. Water soluble CuS quantum dots in the form of rods and spherical shaped with an average diameter of 3-10 nm has been successfully obtained. The as-obtained CuS nanoparticles were characterized by X-ray diffractometry (XRD), scanning electron microscope (SEM), energy-dispersive X-ray spectroscopy (EDS), Infrared spectra (FT-IR), UV-visible spectroscopy (UV) and Photoluminescence (PL). Effect of temperature was investigated for the stability of nanoparticles

APSS / 25

Genetic algorithms in astronomy and astrophysics

Mr. RAJPAUL, Vinesh [1]

[1] *UCT*

Corresponding Author: vinesh.rajpaul@uct.ac.za

Genetic algorithms form a class of search heuristics that incorporate, in a computational setting, the biological notion of evolution by means of mutation and natural selection. Compared to more conventional search and optimisation techniques, genetic algorithms are very easy to implement and they tend to be extremely robust and versatile. Although already ubiquitous in fields such as computer science, engineering and artificial intelligence, genetic algorithms have not yet been widely adopted in the physical sciences. I provide a very brief introduction to genetic algorithms and outline their relevance to a number of diverse problems in astronomy and astrophysics, from stellar structure modelling and astroseismological analyses to robotic telescope scheduling. In particular I discuss a difficult optimisation problem in gravitational microlensing analysis for which it is hoped that genetic algorithms might facilitate an efficient exploration of an enormous parameter space.

Theoretical / 26

Finite Element Calculations for Molecules with multiple Coulomb Centers

Prof. BRAUN, Moritz [1]

[1] *University of South Africa*

Corresponding Author: moritz.braun@gmail.com

Efficient and reliable methods to solve effective three dimensional Schroedinger equations are an important ingredient for both density functional as well as Hartree Fock methods used to calculate the properties of molecules and solids. In order to judge the accuracy of popular methods such as using Gaussian basis functions or smooth pseudo potentials it is desirable to use a method that promises to be less basis dependent. Such a method is the finite element method, where the convergence of the wave functions and eigen values can be systemically improved. In combination with using a product ansatz of a function f(r) satisfying the cusp conditions at all nuclei and a smooth function phi(r) for the wave function this provides a method to calculate all electron wave functions. The efficiency of this approach in practice depends crucially on finding a finite element grid which provides enough points where needed but does not “waste “ points where not required. In this contribution results obtained for simple molecules via two and three dimensional calculations are given.In addition the finite element calculations are discussed in some detail.

NPRP / 27

Mirror symmetry for nuclei near or beyond the proton drip line

Author: Prof. KARATAGLIDIS, Steven [1]

Co-Authors: Prof. AMOS, Ken [2]; Prof. SVENNE, Juris [3]; Prof. CANTON, Luciano [4]; Dr. FRASER, Paul [5]; Mr. VAN DER KNIJFF, Dirk [2]

[1] *University of Johannesburg*

[2] *School of Physics, University of Melbourne*

[3] *Department of Physics and Astronomy, University of Manitoba*

[4] *Isituto Nazionale di Fisica Nucleare, University of Padova*

[5] *Instituto di Ciencias Nucleares, Universidad Nacional Autonoma de Mexico*

Corresponding Author: stevenka@uj.ac.za

The notion of mirror symmetry is well-established for nuclei on or near the valley of stability, and this has its roots in the (largely) charge independent nature of the nuclear force. We have applied this assumption to nuclei near or beyond the drip lines, in particular, the mass-15 system for 15F and 15C. Using information on the bound states in 15C we predicted states in 15F in 2006 which were subsequently found in 2009. We have extended our searches to other mirror pairs of exotic nuclei: in particular mass-17. In the case of mass-17 nuclei, we obtain interactions by considering the states in 17C, from which we may obtain information on other exotic mass-17 nuclei.

APSS / 28

Properties of the Interstellar medium in nearby galaxies

Mr. IANJAMASIMANANA, Roger [1]

[1] *University of Cape Town*

Corresponding Author: ianjamasimanana26@gmail.com

We use the HI velocity profi les of The HI Nearby Galaxy Survey (THINGS) to study the phase structure of the ISM and its relation to galaxy properties and morphology. To construct high S/N profiles, we use a method analogous to the stacking method sometimes used in high redshift HI observations. We call these high S/N profi les super pro files. By decomposing the super profiles into Gaussian components, we found broad and narrow components which are evidence of the presence of Cold Neutral Medium (CNM) and Warm Neutral Medium (WNM). We also derive radial super profi les of the THINGS galaxies and we found some correspondance between the shapes of the super profi les and their location within the galaxies. We found that the narrrow components dominate inside the optical radius r25. We also analyze the shapes of the super profi les in low, moderate and high star formation rate (SFR) regions and we found that the narrow component dominates in high SFR regions. The pro files also tend to be more asymmetric and broader in high SFR regions.

Poster2 / 29

Evaluation of WC-9Co-4Cr laser surface alloyed coatings on stainless steel

Author: Mr. OBADELE, BABATUNDE [1]

Co-Authors: Prof. PITYANA, SISA [2]; Mrs. POPOOLA, PATRICIA [1]; Dr. OLUBAMBI, PETER [1]

[1] *TSHWANE UNIVERSITY OF TECHNOLOGY*

[2] *Center for Scientific and Industrial Research- National Laser Centre*

Corresponding Author: obadele4@gmail.com

In order to examine the effect of Cr on the microstructure and hardness behaviour of WC cermet, coatings have been obtained by laser surface alloying technique. WC-9Co-4Cr particulate was injected into the surface of AISI 304L stainless steel under different processing variables. The morphologies and microstructures of the composite coatings were investigated using optical microscopy and high resolution scanning electron microscopy, while the phase changed were observed using x-ray diffraction. The surface hardness was determined using the Vickers microhardness tester. The excessive heat from the laser beam partially melt the WC-Co which results in carbon deficiency and precipitation of carbon as graphite to form CO2 pores within the coatings. 4% Cr has been added to compensate for the precipitation of graphite to form Cr3C2. A considerable increase in hardness value from 246 to 1331 Hv0.1 was achieved when alloying was carried out at high laser power and speed, the pores being completely eliminated.

Poster2 / 31

A Diagnostic 'tool' to prevent the consequences of material failure

Dr. SIKAKANA, Ike [1]

[1] *Vaal University of Technology*

Corresponding Author: ike@vut.ac.za

In materials' manufacturing, evaluation and/or characterization is a key final stage in the production process. This quality assurance tests whether the product meets an industry norm or specified standard required by the customer. The evaluation is also required on machinery / plant parts that are already in operation. The parts are periodically 'tested' to ascertain as to whether they can still function safely and as originally designed. The evaluation, characterization, testing is conducted using techniques that do not damage these parts / materials. This novel way of materials' examination; referred to as Non-Destructive Testing / Evaluation (NDT/E); is finding increasing applications is numerous industries. This paper focuses, first, on the use of NDT/E in selected industries and its critical nature in the safe operation of plant machinery and structures. Secondly, an overview of the education and training required in NDT/E is discussed. The qualification offered at the Vaal University of Technology (VUT) and its impact on the NDT/E profession in South Africa is reflected upon. Thirdly, the rewards of an NDT/E career are discussed. This is contrasted with the perceived low profile of NDT/E amongst practicing engineers in South Africa. Lastly, an argument for the urgent need of a legislative framework for the regulation and recognition of NDT/E qualifications and certification in South Africa is advanced. It is emphasized that this is a necessary measure to have accountability and a code of ethics entrenched in this growing profession.

Theoretical / 32

Successes and Failures of Numerical Solutions to the 1-Dimentional Marchenko Integral Equation for Quantum Inverse Scattering

Author: Mr. SHUMAN, Serle [1]

Co-Author: Prof. BOTHA, Andre [1]

[1] *UNISA*

Corresponding Author: serle@infoworker.co.za

The origin of numerical errors, which in certain cases lead to complete failure of the direct method for solving the 1-dimensional Marchenko integral equation, are investigated. Bargmann and block potentials, for which exact analytical expressions exist, are used to compare the accuracy of numerical results. In particular, numerical results from the Nystrom method are compared to those of two novel collocation methods. The results indicate that, for roughly the same computational effort, the three method may be ranked in order of increasing accuracy: Nystrom method, equidistant collocation method and non-equidistant collocation method. In all three cases the origin of the failure, which occurs for barrier-like potentials of relatively large width and height, may be attributed to the numerical instability introduced in both the Fourier inversion and the linearization steps. Subsequently these errors produce perturbations on the matrix elements of the inversion matrix, a matrix which is found to become increasingly ill-conditioned as the height and width of the potential increases. At the current limits of successful inversion, we attribute the "early" onset of inversion failures, to the aforementioned matrix element perturbations. However at still higher potential height and width, the inherent ill-conditioning of the inversion matrix alone, accounts for the inversion failures. We therefore conclude that there is an inherent upper-bound on the application of the direct inversion method for inverting relatively high and wide potentials.

Poster2 / 33

Vanadium Dioxide Nanoplatelets Based nanocomposites for IR Solar Radiation Modulation

Ms. SIMO, Aline [1]; Mr. MALIK, Maaza [2]

[1] *PHD Student*

[2] *iThemba Labs*

Corresponding Author: simo@tlabs.ac.za

Examples of novel coating technologies towards Infrared solar radiation regulation/modulation in smart glass windows for the satellite sector include electrochromic and thermochromic based high vacuum manufactured dynamic coatings. The latter two technologies are solar radiations control oriented technologies in the visible and infrared radiation respectively. The thermochromic smart coated windows are infrared active and self regulating systems. Due to its natural phase transition around 68°C, vanadium dioxide coated systems exhibit an exceptional reversible and self induced optical modulation in the infrared solar spectrum. If the temperature of the vanadium dioxide coated on a glass window is smaller than 68°C, the smart window is transparent to the solar infrared radiations i.e. heat transmitting while it reflects the infrared radiations if its temperature is higher than 68°C i.e. heat opaque. To apply such a thermochromic smart material on a large scale in automotive and building sector, it is required to shift their transition temperature to about 25°C as well as innovating a physical-chemical process for production of large surface coatings. While the first requirement can be achieved by tungsten doping, the second could be reached by a hybrid polymer- VO_2 (M) nanoparticles based coatings. This contribution reports the physical and specifically the optical characteristics of VO_2 nanoplatelets/PVP nano-composites.

Theoretical / 34

Optimised Hyperchaotic Modes of a Triple Pendulum

Author: Prof. BOTHA, André [1]

Co-Author: Prof. QI, Guoyuan [2]

[1] *Unisa*

[2] *F'SATIE, TUT*

Corresponding Author: bothaae@unisa.ac.za

Analytical equations of motion, in the form $\mathrm{d}x_i / \mathrm{d}t = f_i(\boldsymbol{x},t)$, are derived for a damped harmonically driven triple plane pendulum. This form of the equations clearly displays the nature of the non-linear coupling and provides a basis for physical interpretation. The equations also facilitate the derivation of the Jacobian matrix in analytical form, a result which is important for the accurate numerical computation of the Lyapunov exponents. It is shown that sets of optimised parameters, such as the lengths and masses of the pendulum, may be derived by using the Nelder-Mead simplex optimisation algorithm. This method gives precise control over the Lyapunov exponents and may be useful in a wide variety of other non-linear applications, such as those occurring in biophysics and information technology (for secure communication). As an example of the technique it is used to predict periodic and quasi-periodic orbits of the un-damped pendulum, as well as its chaotic and hyperchaotic modes. The maximum positive Lyapunov exponents for the pendulum are found to vary from zero, for periodic orbits, to as high as ten for the optimised hyperchaotic modes. Numerical simulations, coded in Python, are used to visualise the results.

Poster2 / 36

Influence of solvent effects on Qy transitions in chlorophyll

Author: Dr. SMIT, Jacoba [1]

Co-Authors: Dr. PRINSLOO, Linda [2]; Dr. NEL, Jacqueline [2]; Dr. GROBLER, Anne [3]; Dr. SPARROW, Raymond [1]

[1] *CSIR Biosciences, Pretoria, South Africa*

[2] *Department of Physics, University of Pretoria, Pretoria, South Africa*

[3] *Unit for Drug Research and Development, School of Pharmacy, North-West University, Potchefstroom Campus, Potchefstroom, South Africa*

Corresponding Author: ksmit@csir.co.za

The most abundant and efficient light harvesting, energy transfer and transduction systems are found in nature within the process of photosynthesis. Although the processing sequences of an absorbed solar photon in the photosynthetic apparatus have been deciphered, the underlying physical basis of photosynthesis is not well understood yet. Our research aims to contribute to this understanding by characterising the level of organisation of the Light Harvesting II complexes (LHCII) and energy transfer systems when incorporated into artificial vesicles called Pheroid^{TM}. LHCII was extracted from spinach leaves in a 20 mM Tricine buffer to stabilise the proteins. Raman, FTIR and absorbance spectra of samples were compared. The Qy transitions of chlorophyll in the red (Qy) region of the absorption spectra appears to red-shift by 3.5 – 5.5 nm; indicating a possible change in organisation of the light harvesting system after incorporation into the Pheroid^{TM}. These shifts however could also be interpreted as bathochromic solvent effects due to the Tricine buffer. The objectives of this study were (1) to investigate whether the red-shifts were due to the Tricine buffer and (2) if so, whether the alternative use of a 20 mM K_2HPO_4 / KH_2PO_4 buffer could eliminate the bathochromic solvent effects. The Tricine buffer was dialysed out of the samples directly into a 20 mM K_2HPO_4 / KH_2PO_4 buffer to prevent denaturing of the LHCII proteins. Preliminary results indicated a lessening of the bathochromic effects with the K_2HPO_4 / KH_2PO_4 buffer.

APSS / 37

Modeling X-ray Emission and the SED of the Binary Radio Pulsar AE Aquarii

Author: Mr. ORURU, Bosco [1]

Co-Author: Prof. MEINTJES, Pieter Johannes [1]

[1] *University of the Free State*

Corresponding Author: orurub.sci@ufs.ac.za

The highly transient novalike variable AE Aqr is perhaps an ideal laboratory to study accretion related astrophysical fluid dynamics. It consists of a fast spinning highly magnetic white dwarf (WD) orbiting, and accreting mass, from a low-mass main sequence companion. The system emits, and has been detected in almost all wavelengths. AE Aqr is in a propeller state, and most of its emission properties are associated with the turbulent interaction between the accretion flow and the fast rotating magnetosphere of the WD. We have analysed its X-ray spectra using contemporaneous Chandra and Swift X-ray data. The results of this study show that the X-ray emission has both thermal and non-thermal characteristics. The thermal X-ray emission is modeled to be the result of bremsstrahlung emission of heated mass outflow above the polar caps, whereas the non-thermal X-ray emission is the result of synchrotron radiation of accelerated electrons outside the light cylinder radius of the WD. In this paper, some of the results, based on the constraints of the proposed thermal and non-thermal emission mechanisms, will be presented.

APSS / 38

ThunderKAT: The MeerKAT Large Survey Project for Radio Transients

Author: Prof. WOUDT, Patrick [1]

Co-Author: Prof. FENDER, Rob [2]

[1] *Department of Astronomy, University of Cape Town*

[2] *University of Southampton*

Corresponding Author: pwoudt@ast.uct.ac.za

ThunderKAT is one of ten accepted MeerKAT Large Survey Projects. ThunderKAT will study all aspects of transient radio emission associated with accretion and explosive events. Through a comprehensive and complementary programme of monitoring Galactic synchrotron transients (across a range of compact accretors and a range of other explosive phenomena) and exploring distinct populations of extragalactic synchrotron transients (microquasars, supernovae (SNe) and possibly yet unknown transient phenomena) we will revolutionise our understanding of the dynamic and explosive transient radio sky. We will give an overview of ThunderKAT and discuss the prospects of studying the transient sky with KAT-7.

APSS / 39

Campaign for Vicarious Calibration of SumbandilaSat in Argentina

Author: Mr. VHENGANI, Lufuno [1]

Co-Authors: Mr. GRIFFITH, Derek [1]; Dr. LYSKO, Meena [1]

[1] *CSIR*

Corresponding Author: lvhengani@csir.co.za

The importance of calibrating satellite imagers has been explained in literature such as K Arai (2007) and K J Thome (2001). Calibration of satellite sensors (imagers) is crucial for data consistency, reliability and comparability. To perform a meaningful analysis of a satellite image, the Digital Numbers (DNs) of the image are first converted to absolute radiance by using the sensor-specific radiometric calibration coefficients. Satellite imagers are calibrated pre-launch and for continuous assessment, they are also calibrated post-launch. Various post-launch techniques exist including cross-sensor, solar, lunar and vicarious calibration. Vicarious calibration relies on *in-situ* measurements of surface reflectance and atmospheric transmittance to estimate Top-Of-Atmosphere (TOA) spectral radiance. A vicarious calibration field campaign was executed in Argentina to support monitoring of the radiometric response of the multispectral imager aboard SumbandilaSat. Results obtained using two Radiative Transfer Codes (RTCs) MODTRAN and 6S are presented.

Poster2 / 41

Simple Pendulum: A first year students' dilemma.

Author: Mr. PHAGE, Itumeleng [1]

Co-Author: Mr. KOMATI, Frank [2]

[1] *Honorary*

[2] *No*

Corresponding Author: phageh@gmail.com

Investigation of the First-year students' abilities to use mathematical concepts of straight line equation and graph to analyse Physics properties with particular references to a Simple Pendulum motion experiment.

Poster1 / 42

The Infrared Plasma Resonance of P in SiC

Author: Prof. ENGELBRECHT, JAPIE [1]

Co-Author: Dr. IJ VAN ROOYEN, Isabel [2]

[1] *NMMU*

[2] *CSIR-NLC*

Corresponding Author: japie.engelbrecht@nmmu.ac.za

The concentration of any dopant in a semiconductor can usually easily and readily be established using the plasma resonance minimum. Infrared reflectance spectroscopy was used to assess the doping of SiC wafers by phosphor implantation. However, results obtained did not match the theoretical predictions. The problem was investigated, including an assessment of the applicable theory. Results will be presented and discussed.

APSS / 44

NON-SPECIALIST: The Recommissioning of SALT

Prof. CHARLES, Phil [1]

[1] *SAAO*

Corresponding Author: pac@saao.ac.za

Following the repair of the SALT optics in late 2010, the telescope has reentered the commissioning phase with its principal scientific instruments, SALTICAM and RSS. Both these instruments have undergone major refurbishments in their own right, and their current status and that of the telescope will be described, together with an update on its performance.

CMPMS1 / 45

Germanium-Carbide Formation on Crystal Germanium Substrate

Dr. MOLA, Genene Tessema [1]

[1] *University of Kwazulu-Natal*

Corresponding Author: mola@ukzn.ac.za

Microcrystalline germanium-carbide formation was studied in germanium substrate using perturbed gamma-gamma angular correlation (PAC) method. Information about the lattice location of carbon atoms, in the host matrix, can be obtained via the interaction between carbon and unstable probe nucleus (111In). At high dose carbon implantation, in crystal germanium substrate, two defect complexes have been identified by the corresponding unique nuclear quadrupole interaction frequencies. The measured frequencies, ⊠Q = 207(1) MHz (eta = 0.2) and ⊠Q = 500(1) MHz (eta= 0), are associated with the formation of carbon related microcrystalline system in germanium. The frequencies are attributed to two different types of carbon-indium pairs in the substrate lattice. The orientations of the measured electric field gradients and thermal stability of the defect complexes are studied. The results are encouraging towards attaining germanium carbide crystal which has interesting potential for applications.

Poster2 / 46

KIC Rumple, the binary system with eclipses and δ Scuti pulsations

Author: Mr. MIDDLETON, Christopher [1]

Co-Author: Dr. ENGELBRECHT, Chris [1]

[1] *University of Johannesburg*

Corresponding Author: wbrooke@netactive.co.za

Studying pulsating stars in Eclipsing binaries has the potential to be an exacting test of theoretical stellar models as a result of the large number of constraints physically that can be imposed on individual components in the binary system. In this particular example, Kpl Rumple, the measurement of the large number of frequencies in the star of precisely known mass and radius from binary modelling will enable the identification of pulsation modes. This is vital as a proper physical understanding of δ Scuti pulsations will ensue. It also holds the promise of direct detection of the spatial distribution of pulsations on stellar surfaces. Asteroseismology is the ultimate goal: the derivation of internal rotational behaviour in stars, accurate determination of stellar aging with associated metallicities and the determination of the amount of convective core overshooting in stellar interiors. The research involves the analysis of data obtained through membership of the Kepler Asteroseismic Consortium Working Group 9, analysing proprietary data received from the Kepler Space Telescope. The data are de-trended, and subject to refined sophisticated analysis routines using many software platforms based on sound physical principles in the determination of the binary parameters and pulsating frequencies of the pair. Anticipated conclusions that might be derived from the conclusion of this project are discussed.

CMPMS1 / 47

Investigation of broken symmetry of Sb/Cu(111) surface alloys by VT-STM

Author: Mr. NDLOVU, Gebhu [1]

Co-Authors: Prof. HILLIE, K.T [2]; Prof. ROOS, W.D [3]; Dr. ASANTE, J.K.O [4]

[1] *Student*

[2] *Principal researcher*

[3] *promoter*

[4] *HOD*

Corresponding Author: gndlovu@csir.co.za

The adsorption of Sb on the (111) plane of noble metals surfaces such as copper and silver has long been of practical interest in the fields of surface science and technology. The electronic properties of such surface alloys are important for several surface and interface related applications like metal-metal or semiconductor-metal heteroepitaxy, heterogeneous catalysis, sensors and spintronics applications. The structure of these monolayers on metal substrates is a complex interplay of electronic, stress and geometric effects, all related to each other. Theoretical calculations have suggested that the energetics of the Sb/Cu(111) system are such that in the ordered 0.33 ML Cu(111) (√3x√3) R30°-Sb phase the Sb atoms substitute one-third of the outermost Cu atoms to produce an ordered surface alloy after annealing. Due to its ability to act as a surfactant (low surface energy), Sb segregates from the bulk of the substrate to remain on the surface, thus forming a surface alloy. This work present an in situ Variable Temperature Scanning Tunneling Microscopy (VT-STM) study of the segregation and dissolution kinetics of Sb/Cu(111) studied at various temperatures. The study shows the growth mechanism of Sb mediated by the kinetics and thermodynamics at the substrate surface. After deposition of ~0.3 ML Sb on a clean Cu(111) surface, STM images exhibit Sb atoms as bright spots surrounded by six copper atoms at the surface with perturbed atomic positions resulting in a broken structural inversion symmetry at the surface.. The atomic arrangements of Sb remain stable during several STM scans.

APSS / 49

Optical study of the Southern high mass star forming region RCW 34

Mr. CZANIK, Robert [1]

[1] *North-West University, Potchefstroom*

Corresponding Author: robert.czanik@gmail.com

To understand the formation of stars one must be able to identify young objects. RCW 34 is a star forming region in the constellation of Vela. A study was conducted in the near-infrared where it was found that a large number of stars surrounding the nebula shows NIR characteristics of lower mass pre-main sequence stars. To prove the suspicions a follow-up study was conducted in the optical. The results of a photometric and spectroscopic study on the the nebula and stars within a 7 arcmin x 7 arcmin region around the nebula will be presented.

CMPMS1 / 50

The decoration of vicinal copper polycrystalline surfaces by Antimony

Author: Mr. NDLOVU, Gebhu [1]

Co-Authors: Dr. ASANTE, J.K.O [2]; Prof. ROOS, W.D [3]; Prof. HILLIE, K.T [4]

[1] *Student*

[2] *HOD*

[3] *promoter*

[4] *Principal researcher*

Corresponding Author: gndlovu@csir.co.za

Most properties of polycrystalline materials are controlled by the structure and interfaces they possess – e.g., grain boundaries. When a Cu surface is alloyed with antimony, the Sb atoms appear to diffuse to the growth surface and continuing to act as a surfactant throughout the growth process. Copper alloys are important commercial materials, which are often used at temperatures where segregation and diffusion processes has a huge influence on their properties. An important characteristic of these alloys is that segregation of one component to the alloy surface causes the surface composition to differ significantly from the bulk composition. This study utilizes an ultrahigh vaccum Variable temperature Scanning Tunneling Microscopy (UHV-VTSTM) and Low-Energy Electron Diffraction-Auger Electron Spectroscopy (LEED-AES) to determine the segregation and dissolution temperatures of Sb on Cu polycrystals and the growth mechanism. The VT-STM images of the Cu surfaces showed localization of Sb atoms in the vicinity of the step edges. The STM data showed that alloying initially occurred at the monatomic steps and a homogeneously spread Cu-Sb surface alloy was formed by the migration of Sb atoms.

APSS / 51

Multi-instrument observations of spread F irregularities over South Africa

Author: Mr. AMABAYO, Emirant Bertillas [1]

Co-Authors: Dr. LEE-ANNE, Mckinnell [1]; Dr. PIERRE, Cilliers [2]

[1] *SANSA Space Science and Rhodes University*

[2] *SANSA Space Science*

Corresponding Author: emirant.amabayo@gmail.com

An ionospheric eight year study (2001-2008) over South Africa (SA) was conducted using ionosonde data observed by DPS-4 digisondes with a time resolution of 10, 15 and 30 minutes from Madimbo, Grahamstown and Louisvale. Spread F (SF) characterized by ionograms is observed when the pulses returned from the F region of the ionosphere are of longer duration than the transmitted signals. Separate occurrence of horizontal and vertical spreading of the returned echoes from the ionosphere are classified as range spread F (RSF) and frequency spread F (FSF) respectively. The overlap of echoes of range and frequency spreading can occur simultaneously giving rise to mixed SF (MSF). These types of SF show a seasonal, solar cycle and diurnal patterns over this midlatitude region. These variational patterns were obtained by viewing the ionograms from the ionosondes manually using the SAO Explorer. The diurnal pattern of SF peaks between 23:00 UT and 00:00 UT for all seasons and types of SF in 2001 and 2005, except during autumn and spring (for RSF) in 2001. The \% occurrence of both MSF and FSF tends to increase with decreasing sunspot number (SSN). The MSF and FSF occurrence maximum are most frequent during the winter months in 2007 and 2006 respectively.

Poster1 / 52

The study of the distortion of F- and Ba- sublattices in superionic BaF2 at elevated temperatures using positron annihilation technique.

Author: Mr. JILI, Thulani [1]

Co-Authors: Prof. SIDERAS-HADDAD, Elias [2]; Dr. WAMWANGI, Daniel [2]

[1] *University of Zululand*

[2] *University of the Witwatersrand*

Corresponding Author: jili@tlabs.ac.za

There is a general misunderstanding regarding the creation of Frenkel pairs in the vicinity of the observed critical temperature Tc in superionic materials. The measured conductivity increases sharply at a temperature coinciding with the deviation of temperature-dependent lattice constant from 6.2086 A. Frenkel pairs responsible for superionic conduction are gradually generated well below the critical temperature and this is informed by the calculation of S-parameter through the measurements of Doppler Broadening at various temperature points. It is interesting to note that the lattice constant plays a pivotal role in the superionic conductivity threshold. Positron annihilation spectroscopy, through the determination of positron lifetime and Doppler broadening, reveals that the generation rate of Frenkel pairs becomes prominent at 100 K below the critical temperature of 693 K. This is also a clear indication of continuous disordering of fluorine sublattice noticeable at a temperature of 593 K. The fact that the defect positron lifetime is constant in the temperature range (300 – 900) K confirms a non-distortion of Ba-sublattice.

Applied / 53

Predicting human epidermal melanin concentrations for different skin tones

Author: Dr. SMIT, Jacoba [1]

Co-Authors: Mrs. KARSTEN, Aletta [2]; Dr. SPARROW, Raymond [3]

[1] *CSIR*

[2] *CSIR National Laser Centre, Pretoria, South Africa*

[3] *CSIR Biosciences, Pretoria, South Africa*

Corresponding Author: ksmit@csir.co.za

In the past 50 years lasers has found numerous applications in medicine. One of their advantages is their use for minimalistic or non-invasive diagnosis and treatment. Often that means light penetration through skin and the correct dose required relies on accurate information regarding the skin's optical properties. Light absorption in the epidermal layer is a major factor in determining the laser light fluence that reaches the deeper skin levels. Darker skin has an epidermal melanin volume fraction about twice that of lighter skin. Due to melanin absorption, less laser light reaches the deeper skin layers in dark skin tones. Laser-tissue interaction modelling software can correct for this by adapting the dose applied to the skin. To correctly apply such software it is important to characterise the skin in terms of skin tone with an easy and reliable method. Measuring the melanin content of the skin is the best method, but it needs to be done non-invasively. However, access to samples of all skin types is often limited and skin-like phantoms are used instead. The objective of this study is to compare experimentally measured absorption features of liquid skin-like phantoms representing Skin Types I to VI with computational simulated skin from the Realistic Skin Model (RSM) part of the ASAP® software from Breault Research. Skin-like phantoms were prepared by adding Intralipid (20% fat emulsion) to samples of increasing melanin concentration at pH ~ 7. UV-VIS transmittance spectra of the samples were measured over the wavelength range 370 to 900 nm and compared to simulated results from ASAP® using the same optical parameters. Experimental and computational results indicated that at shorter wavelengths melanin absorption displayed non-monotonic features that may allow for more accurate ways of determining melanin concentration and therefore the expected absorption through the epidermal layer. This suggests that the phantoms may be able to represent optical characteristics of real skin.

APSS / 54

Evaluation of satellites LAGEOS I and II; general relativistic accelerations in the Schwarzschild field of Earth

Prof. COMBRINCK, Ludwig [1]

[1] *HartRAO*

Corresponding Author: ludwig@hartrao.ac.za

Solutions of General Relativity Theory (GRT) pertaining to space geodesy are weak field, slow motion approximations. These approximations are valid as the gravitational field in which the solutions are performed has a potential of small magnitude and the velocities involved for any of the satellites are much smaller than the velocity of light. The basic effects of GRT on space geodetic measurements are related to how GRT affects the observables and dynamics of satellite orbits. We evaluate the GRT accelerations ascribed to the Schwarzschild field, as well as those due to Lense-Thirring precession (frame dragging) and de Sitter precession. The Shapiro delay for a laser pulse as applied to Satellite LAser Ranging (SLR)is calculated and the importance of including this GRT correction in the range corrections for SLR is described in terms of evaluation of the Observed-Computed residuals. Post-post Newtonian corrections are calculated and their relevance discussed in terms of accuracy improvements.

Applied / 55

Optical Coherence Tomography as a diagnostic tool (Biophysics)

Author: Ms. SINGH, Ann [1]

Co-Author: Mrs. KARSTEN, Aletta [1]

[1] *CSIR,National Laser Centre*

Corresponding Author: asingh1@csir.co.za

Optical Coherence tomography (OCT) is a non-invasive imaging technique that is known to be used to monitor changes and differences in different types of materials. In the field of Biophysics/Biophotonics OCT can be used to non-invasively detect changes occurring in tissue. This study will look at using OCT to detect skin cancer. Similar work has been done by other groups, however the influence of skin tone for such detection has not been evaluated to a great extent. The effect of skin tone on detection of skin cancer will form a core part of the investigations as well as determining the efficacy of the system for early cancer detection. Preliminary work will be done using phantoms that simulate the different skin tones. Melanin is the component found in the skin, largely responsible for the different skin tones and will incorporated into our phantoms as carbon black, black ink or synthetic melanin. The optical properties of such phantoms can be determined on the Integrating Sphere (IS) and OCT systems. A correlation will then be drawn between the optical properties and the OCT signals obtained. Once the preliminary tests are done to optimise the method for image analysis, further studies will be done on patients and compared against conventional histology results. This talk will thus look at some OCT applications, some of the preliminary work done using our OCT system and the steps to determining the effect of skin tone on cancer detection.

APSS / 56

Statistical Analysis of Outer Electron Radiation Belt Dropouts: Geosynchronous and Low Earth Orbit Responses During Stream Interfaces

Author: Mr. OGUNJOBI, Olakunle [1]

Co-Authors: Dr. COLLIER, A. B [2]; Dr. RODGER, C. J. [3]

[1] *University of KwaZulu-Natal*

[2] *Hermanus Magnetic Observatory*

[3] *University of Otago, New Zealand*

Corresponding Author: olakunle.ukzn@gmail.com

The OMNI-2 data set enables a correlation study of solar wind and geomagnetic parameters, allowing the stream Interfaces events (SIs) to be examined. A superposed epoch analysis of these events was performed to determine the threshold levels of IMF Bz and other geophysical parameters. Based on energy, temporal and spatial characteristics, statistical analysis of electron flux data from LANL-SOPA and NOAA-POES satellites were use to study outer zone electron dropouts and precipitation. The deepest minimum of electron flux was observed after the impact of a SI, which coincided with the time of slower-decaying peak of electron precipitation. Result suggest that the mechanism causing the precipitation could also be responsible for the observe electron flux dropout during Stream Interference.

NPRP / 57

Study of rare modes of "collinear cluster tri-partition" of 252Cf(sf)

Authors: Mr. MALAZA, Vusi [1]; Dr. JACOBS, Noel [2]

Co-Authors: Prof. PYATKOV, Yuri [3]; Prof. KAMANIN, Dmitri [3]

[1] *Stellenbosch University, Military Academy, SAIP member*

[2] *Stellenbosch University, Military Academy*

[3] *Joint Institute of Nuclear Research*

Corresponding Author: mavoora@gmail.com

In our experiments devoted to studying of a new ternary decay of low excited heavy nuclei called "collinear cluster tri-partition" (CCT) a specific CCT mode was observed based on double magic 132Sn cluster. Pre-scission configuration which presumably gives rise to the mode under discussion can be obtained. The Sn cluster can "move" as a whole along the cylinder-like configuration that consists of residual nucleons. Two light fragments accompanying this cluster and marked by symbols M1 and M2 were actually detected in previous experiments. The value of M2 lies between 0amu and the difference between the initial mass of 252Cf and the detected fragments. M1 cannot assume any value less than 95amu (deformed magic 95Rb). The question that arises is whether 132Sn can also be changed by double magic 208Pb. This would lead to a new type of lead radioactivity. Searching for such a mode is one of the goals of our forthcoming experiment, which will require better statistics and more precise time-of-flights measurements. Testing of a specially designed setup aimed at addressing and solving these problems is one of our current plans.

Applied / 58

Resin phantoms as skin simulating layers

Author: Mrs. KARSTEN, Aletta [1]

Co-Authors: Mrs. NDHUNDHUMA, Ivy [1]; Ms. SINGH, Ann [1]

[1] *CSIR, National Laser Centre*

Corresponding Author: akarsten@csir.co.za

In order to apply light treatment to skin, the absorption through the outer layers of the skin needs to be considered. Human skin is a highly scattering medium and the melanin in the epidermal layer of the skin is a major absorber of light in the visible and near infrared wavelengths. Darker skin has a higher concentration of melanin in the epidermis and absorbs more light than fair skin. Ideally the effect of the skin treatment on the outer layers of the skin should be tested on in vitro multi layer skin models. This is not always feasible. For this work phantoms were used together with skin cancer cells to test the effect of outer layer absorption on the efficiency of Photo Dynamic Therapy treatment. Three solid phantoms were prepared from clear resin, TiO particles (scattering particles) and carbon black (absorption particles). Different carbon black concentrations were used to simulate different skin types. Cells were prepared and treated with the photosensitiser. The phantoms were placed inside the wells containing the photosensitised cells, just touching the media in the well. The attenuation of the different phantoms was calculated and the laser treatment times were adjusted to keep the light dose delivered to the cells at 4.5 J/cm2. After laser treatment cell viability was measured, using the Cell Titer Blue Viability Assay, for each of the wells. The phantoms attenuated the laser light by between 10 and 30%. Cell viability for the wells with the phantoms was less than without the phantoms and the differences are attributed to the reduced oxygen in the presence of the phantom. The initial results of the experiment indicate that the phantoms can be used to optically mimic the effect of the outer skin layers. For future work the experimental set-up will be refined.

Poster2 / 59

Enhancement of hydrogen production using biomass gasification process

Author: Ms. MABUDA, Azwihangwisi Iren [1]

Co-Authors: Prof. MEYER, Edson [2]; Dr. MAMPHWELI, Sampson [2]

[1] *University of Fort Hare*

[2] *University of Fort Hare, Institute of Technology*

Corresponding Author: smamphweli@ufh.ac.za

Hydrogen production from biomass holds the greatest promise, since biomass is abundantly available everywhere in the world. However, hydrogen from biomass has major challenges. The yield of hydrogen is low from biomass since the hydrogen content in biomass is low to begin with (approximately 6%) and the energy content is low due to the 40% oxygen content of biomass. A novel gasification method for hydrogen production from carbonaceous materials using a CO2 sorbent has been widely used. It mainly uses steam as gasification agent. For this study the above method has been adopted to test if it will work for air-blown biomass gasifiers. The main purpose of this project is to enhance the yield of hydrogen from air-blown biomass gasification process. The produced hydrogen will be further separated and purified for fuel cell application. Ultimate and proximate analyses of the biomass material were conducted and the obtained results were used for the simulations in order to determine the efficiency of the gasifier with biomass and biomass/sorbent blends. It was found that the biomass/sorbent blends increase the yield of not only H2 but also other syngas constituents such as CO leading to enhancement of the gasifier efficiency since it is dependent on the volume of combustible gases.

Poster1 / 60

Non-resonant microwave absorption in FeSi thin films

Author: Mr. GAVI, Happison [1]

Co-Authors: Prof. MANYALA, Ncholu [1]; Prof. VIJAYA SRINIVASU, Vallabhapurapu [2]

[1] *UP*

[2] *UNISA*

Corresponding Author: hgabi2002@yahoo.com

Non-resonant microwave absorption measurements at 9.4 GHz(X-band)using electron spin resonance spectrometer (ESR), were carried out on pulsed laser deposited(PLD)polycrystalline FeSi thin films grown on Si(111)substrate. The low-field microwave absorption(LFA)properties of the films were investigated as a function of DC modulation field, temperature, microwave power and angle. The DC field and AC field were orientated parallel to the film surface. The DC field was orientated normal to the AC field. The anisotropy field was observed to have a central influence on the LFA shape on all the measurements made, which makes LFA very similar to giant magneto-impedance(GMI). Thin films of FeSi could be potential candidates for magnetic field sensors(based on their GMI). Magnetic anisotropy could be a signature of ferromagnetic state of a material and hence thin films of FeSi are promising candidates for Spintronics applications.

Poster1 / 61

Magnetic vector charges in the realization of nonzero magnetic work

Dr. CHIRWA, Max [1]

[1] *Walter Sisulu University*

Corresponding Author: mmchirwa@wsu.ac.za

Traditionally magnetic forces are supposed to act on moving electric scalar charges and the hitherto undetected Dirac's magnetic (scalar) charges, and that work done by such forces is always zero. Any possible evidence to the contrary is vehemently denied in order to justify this long held myth. Following our recently developed and validated concept of magnetic vector charges as sources of magnetic fields, we show that magnetic forces, like gravitational and electric forces, act on objects with corresponding physical attributes, and do nonzero work. This is illustrated here by depicting the mechanical generation of electricity and operation of simple electric motors in terms of magnetic vector charges. Other supporting examples and technological applications that can be cited include the jumping ring experiment, Gouy magnetic balance, Hall magnetic field probe, vibrating sample magnetometer, magnetic levitation and magnetic separation of materials. This simple realization may have far-reaching implications on our overall understanding of magnetism and its ultimate effective utilization.

CMPMS1 / 62

Nanoscale manipulataion of lamellar copolymers using electric fields.

Dr. MKHONTA, Simiso [1]

[1] *University of Swaziland*

Corresponding Author: smkhonta@uniswa.sz

Block copolymers can self-assemble into lamellar and cylindrical phases with a fundamental period of 10-100nm. These nanoscopic phases are a basis for a great range of applications in nanotechnology. We describe how electric fields can be utilized to tune the lamellar period of copolymers that consist of liquid-crystal sub-units. Copolymers that are swollen in liquid-crystals have anisotropic chains and liquid-crystals have a dielectric anisotropy. We evaluate the critical electric field required to tilt the liquid-crystal director relative to the lamellar normal in terms of the repulsive interaction between the chemical dissimilar copolymer blocks. We show that the tilting of the liquid-crystal director can lead to an adjustment of the lamellar period with an amplitude that is proportional the chain anisotropy. This reversible tuning of the lamellar period of block copolymers can lead to interesting applications in nanotechnology.

APSS / 63

Theoretical derivation of an equation for planetary distances from the sun

Prof. WAGENER, Pieter [1]

[1] *Dept Physics, NMMU*

Corresponding Author: pcwagener@axxess.co.za

Applying the quantisation of action variables to a theory of gravitation one derives discrete values for planetary distances from the sun. The calculated values agree with the observed values of all the planets. The derived equation also applies to the exoplanets. The application is similar to that of the Wilson-Sommerfeld rule for atomic orbits.

CMPMS1 / 64

Solution-processed CuSe Quantum Dots Photovoltaics

Author: Dr. MOLOTO, Nosipho [1]

Co-Author: Mr. PUGGENS, Hendry [1]

[1] *University of the Witwatersrand*

Corresponding Author: nosipho.moloto@wits.ac.za

There have been tremendous inputs into improving the efficiencies of nanostructure solar cells by extending their absorption wavelength to the near-infrared. This can potentially be achieved by using colloidal nanocrystal quantum dots as the light-harvesting material, as their optical band gap can be tuned to a desired range. Copper selenide is an interesting semiconductor with a bulk band gap of 1.39 eV. It has been shown to have good electrical conductivity properties. It is also used as a precursor for the preparation of CIDS solar cells. Herein, colloidal CuSe nanocrystals are synthesized using a modified solvothermal method and characterized with absorption and photoluminescence spectroscopy, XRD and HRTEM. The resultant nanocrystals are then used as the active material in a Schottky and hybrid solar cell.

Applied / 65

A synthetic diamond probe for both low-energy mammography X-rays and high-energy electron therapy beams

Author: Mr. ADE, Nicholas [1]

Co-Author: Prof. NAM, Tom [2]

[1] *None*

[2] *Member, DST/NRF Centre of Excellence in Strong Materials, University of the Witwatersrand*

Corresponding Author: leroinicholson@yahoo.ca

Although diamond has been studied for dosimetry principally due to its near tissue-equivalence, its use in both low-energy X-rays and high-energy electron beams has not been reported. This report is based on dosimetric studies of a synthetic diamond probe when subjected to diagnostic mammography X-ray photons and megavoltage electron therapy beams. The probe, constructed using entirely tissue-equivalent Perspex body was configured for radiation dose measurement in either 'edge-on' or 'flat-on' exposure geometry without having first, to re-orientate the diamond within the body of the detector, and it was designed to be compatible with commercial electrometer systems. The radiation response of the diamond tested showed negligible energy dependence; its minimal background signal, high sensitivity (547.52 nC $Gy^{-1}mm^{-3}$) and suitability for measurements in small radiation fields of steep dose gradients due to its small size make it suitable for clinical dosimetry. The presented probe has the potential advantage of replacing conventional radiation dosimeters.

Poster1 / 66

Photoluminescence Surface Mapping as a Probe for Quantum Well Disorder

Dr. CHINYAMA, Kaumba Godfrey [1]

[1] *University of Fort Hare*

Corresponding Author: kchinyama@ufh.ac.za

Surface mapping of quantum well structures using photoluminescence measurements is ideal for determining the overall behaviour of such samples with regard to their chemical composition and well-width fluctuations. In some areas where the structural variations are large over a sample, photoluminescence mapping can yield information which would otherwise require several samples to be grown. Well thickness and strain variations across a sample will show as a small spatially-dependent change in the peak energy and the full wave half maximum, so that variations in confinement energies in the QW due to non-uniformity in the film growth can be observed with this method. In this work, spatial variations in the exciton band of photoluminescence spectra were measured using surface mapping of the emission by scanning the sample laterally in the plane of the quantum well across the sample area. The luminescence intensity was then mapped as a function of the emission peak energy (and emission linewidth) and the spatial coordinates x and y, resulting in contour plots. The results show that knowledge about whether the structures are alloy-disordered or rough (characterised by thickness fluctuations) can be derived through this simple photoluminescence mapping. In rough structures, there is strong correlation between variations in peak energy position and linewidth of the main exciton band. On the other hand, in alloy-disordered structures, there is virtually no correlation between the peak energy and linewidth in comparison to the rough structures. Surface mapping has also revealed variations in peak energy across the rough samples do not only correspond to monolayer fluctuations in well-width, but fluctuations in steps of submonolayers are very common. This explains why thinner QWs give narrower lines compared to thicker ones in these CdSe-ZnSe systems studied here. Further, this analysis shows alloy-disordered structures give good quality samples in terms of optical properties.

Poster1 / 68

Dependence of Aspect Ratio of InSb Self-Assembled Quantum Dots on Thickness and Indium Mole Fractions of Spacer Layers

Author: Mr. GODBOLE, MOHIT [1]

Co-Authors: Dr. OLIVIER, Jaco [1]; Mr. MIYA, senzo [1]; Dr. WAGENER, viera [1]; Prof. NEETHLING, Jan [1]; Prof. BOTHA, Reinhardt [1]

[1] *NELSON MANDELA METROPOLITAN UNIVERSITY*

Corresponding Author: mohit.godbole@nmmu.ac.za

Short range biaxial and hydrostatic strains in quantum dots caused by spacer layers affect the aspect ratio to a great extent, leading to variations in the conduction and valence band energy levels. This paper aims to study the effect of the indium mole fraction and thickness of the spacer layer on the size and shape of multi-stack quantum dots grown by metalorganic vapour phase epitaxy. Quantum dots of varying aspect ratios (height:width) have been grown. Structures containing two stacks of quantum dots have been grown on etched GaSb (001) substrate, with different thickness and indium content of the GaInSb spacer layers. Experiments are currently under way to study the effect of the thickness of the spacer and the composition on the size distribution, shape and density of three stacks of InSb quantum dots. The structures are characterized by X-ray diffraction, photoluminescence, scanning and transmission electron microscopy.

APSS / 70

The unusual Seyfert Markarian 926 - a link to the LINERs?

Prof. WINKLER, Hartmut [1]

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

Corresponding Author: hwinkler@uj.ac.za

Markarian 926 (= MCG-2-58-22) is one of the earliest Seyfert galaxies identified. At discovery it was one of the most luminous nearby active galactic nuclei (AGN), with strong, wide broad lines. In the late 1980's it started fading, eventually settling at barely ~10% of its recorded peak luminosity. The luminosity decrease was accompanied by significant spectral changes, with the broad-line component now much weaker and highly asymmetrical. Low ionisation narrow lines, however, are now unusually strong, more typical of the AGN class referred to as LINERs rather than a Seyfert. This peculiar low-luminosity phase spectum has remained relatively constant over the last decade. The paper will discuss the spectral and other characteristics of Markarian 926 and compare these to standard Seyfert models. It will furthermore investigate Markarian 926's relationship to the LINERs, and whether SALT observations of this object could shed light on the interrelationship between Seyferts and LINERs.

APSS / 72

Eclipsing Contact Binary Stars – Period Analysis using SuperWASP data

Ms. SKELTON, Patricia [1]

[1] *UNISA*

Corresponding Author: skeltpl@unisa.ac.za

Some eclipsing contact binary stars of the W UMa-type are known to undergo changes in orbital period. These changes can be as a result of the light travel time effect if the contact binary is a member of a multiple stellar system or due to some intrinsic phenomena that are poorly understood at this stage. Analysing systems that appear to be undergoing changes in orbital period may shed some light on the important physical processes that occur in close binary systems. Pilecki et al. (2007) searched through the All Sky Automated Survey (ASAS) database for semi-detached and contact binary systems with high period change rates. They present 31 interacting binaries whose periods either increased (10) or decreased (21) in a five year interval of observations. Using data from the Wide Angle Search for Planets (SuperWASP) project, it has been possible to do period analyses using O – C diagrams which provide a more reliable measure of period change. The results of the analyses will be presented.

Poster2 / 74

Development of a laser cooling and magneto-optical trapping experiment for Rubidium 87 atoms

Author: Mr. RIGBY, Charles [1]

Co-Authors: Dr. STEENKAMP, Christine [1]; Prof. ROHWER, Erich [1]

[1] *Laser Research Institute, Stellenbosch University*

Corresponding Author: rigby@sun.ac.za

A magneto optical trap (MOT) is capable of trapping a vapor cloud consisting of atoms cooled down to the micro Kelvin range. Three orthogonal pairs of counter-propagating laser beams of the correct circular polarisation form an optical molasses which facilitates the cooling of neutral atoms. Additionally a spatially non-uniform magnetic field produced by two current carrying coils in a Maxwell gradient configuration is used to trap the cooled atoms. In this poster the effects of the trap parameters, including the laser beam intensity and frequency detuning, beam diameter and magnetic field gradient, on the number of trapped atoms are discussed. The nature of the beam polarisation and its importance in the context of the experiment is measured and discussed. The current status of our development of an experimental setup for laser cooling and trapping of ^{87}Rb atoms in vacuum with the aid of a MOT is presented.

Poster2 / 75

Daytime modeling of VLF radio waves over land and sea, comparison to DEMETER satellite data.

Author: Mr. MEYER, Stephen [1]

Co-Authors: Dr. COLLIER, Andrew [1]; Dr. RODGER, Craig [2]

[1] *Hermanus Magnetic Observatory*

[2] *University of Otago, New Zealand*

Corresponding Author: stphngmeyer@gmail.com

Very Low Frequency (VLF) radio waves travel with little attenuation in the Earth-ionosphere waveguide. The waveguide propagation conditions are determined by a variety of factors including the surface of the Earth and the free electron density profile. Perturbations of the lower ionosphere modify the waveguide and the propagation conditions in it. A model based on Wait's mode theory is developed and used to investigate the propagation of VLF radio waves under different conditions. As the VLF radio waves reflect off the lower ionosphere, a portion of the energy leaks up into space, leaving a 'fingerprint' of the modal interference pattern of the waveguide modes. This idea is used to test the validity of the model by comparing simulation results with satellite data from DEMETER taken over the NWC transmitter in North-West Australia.

Theoretical / 76

Bilinear expansion of the photon quantum field and the emergence of classical mechanics from quantum field theory

Dr. GREBEN, Jan [1]

[1] *CSIR*

Corresponding Author: jgreben@csir.co.za

The electro-magnetic field is expanded in a bilinear series consisting of products of quark creation and annihilation operators. This bilinear form is suggested by the equations of motion for the electromagnetic field and provides a very powerful quantum representation, which is devoid of many of the technical problems associated with standard quantization. In this approach the energy of the physical photon can be expressed as an expectation value of the energy-momentum tensor. The direct term already yields the correct result, so one has to eliminate the additional cross term to maintain this correct result. In order to affect this elimination one needs to introduce a continuous set of “hidden” quantum numbers, which can be related to the classical positional coordinate of the particle. These “big bang variables” are introduced as state labels, just like the momentum variable. The quantum amplitudes are insensitive to the choice of these coordinates, so that the introduction of classical coordinates does not conflict with standard quantum field theory calculations or with the Heisenberg uncertainty principle. However, in a many-body system coherence make these coordinates emerge as the relative classical coordinates. Hence, classical mechanics emerges naturally from many-body quantum field theory. Without violating quantum mechanics, particles can thus be specified in terms of momentum and position, in clear analogy to classical physics and statistical mechanics. Composite particle systems are then identified by having identical classical coordinate labels, while independent particles have distinct labels and are not subject to the Pauli principle in the remaining variables.

APSS / 78

Numerical modelling of stellar winds for supernova progenitors

Mr. VAN DEN HEEVER, Stefanus Petrus [1]

[1] *North West University*

Corresponding Author: 13077724@nwu.ac.za

A two-dimensional hydrodynamic numerical model is extended and applied to simulate the interaction between stellar winds and the interstellar medium (ISM). In particular, the stellar wind evolution of O-and B-type stars is calculated. First, the evolution of a stellar wind into the ISM and also a more dense molecular cloud are considered for the case of no relative motion between the star and the ISM. This interaction results in a cavity being blown into the ISM. Of importance is the boundary radius (astropause) and the location where the outflow speed decreases from supersonic to subsonic speeds, the termination shock. Parameters like ISM density, outflow speed and mass-loss rate were varied to study the difference in the computed astropause (AP) and termination shock (TS) radii. The evolution of these structures is presented to a simulation time of 1 My. The evolution of stellar winds into the ISM including relative motion is also considered. It is shown that the positions of the TS and AP are dependent on the mass-loss rate and stellar wind outflow speed of the star and the interstellar medium density and relative speed. When these massive stars reach the end of their life, they end their life in a supernova explosion. The explosion results in a blast wave moving outward, called the forward shock (FS) and a reverse shock (RS) also forms which moves inward. Ferreira and de Jager 2008 simulated supernova remnant (SNR) evolution for the case of evolution into the undisturbed ISM (no cavity). The evolution of SNR is simulated taking also into account the pre-existing cavity blown out by the stellar winds of these massive stars. The results of this study showed that the evolution of the SNR is definitely influenced by the presence of a stellar wind cavity even if the cavity is only a few pc in extent.

APSS / 79

Photometric solutions of eclipsing binary stars

Prof. SMITS, Derck [1]

[1] *University of SA*

Corresponding Author: smitsdp@unisa.ac.za

Kazarovets et al. (1999) gave General Catalogue of Variable Star (GCVS) designations to 3157 variable stars that had been identified from observations made using the Hipparcos satellite. The variables were classified into standard GCVS categories according to their photometric light curves, but no other parameters of the variables were documented. V-band photometric data for many of the Hipparcos-identified eclipsing binaries can be found in the All Sky Automated Survey (ASAS) and Wide Angle Search for Planets (SuperWASP) databases. In several cases the ASAS classifications, which were done semi-automatically and without cross referencing other databases, differ from those presented in IBVS 4659. Using the ASAS and/or SuperWASP data, the classifications are being checked, orbital periods are being determined and, where possible, photometric solutions to the light curves are being obtained. This talk will present the results of this investigation.

Education / 80

Training Senior student to be "IIL" competent Physics lecturers

Dr. MOJI, CABLE [1]

[1] *UNIVERSITY OF PRETORIA*

Corresponding Author: mojinc@postino.up.ac.za

Traditional lecturing of Physics in a preaching pattern to a multitude stduent masses in a large lecture theatre, has not succeeded in attracting more number into Physics further than second year. University of Pretoria Physics Education Research Group (UPPERG) has introduced "Interactive-Inquiry Learning" Teaching where Masters and Doctoral students are guided to lecture groups of 40 BSc4Y program students, in smaller laboratories: discussing Physics theories and concepts while supervising practiacls and encouraging these youger students into excercises and tutorials of Physics. Regular observation is done where eight senior students of Physics Department of the University of Pretoria lecture the twelve groups of students in the BSc4Y program. "Lecturers" use the IIL Teaching method. Some results of this teaching are shown. Further observation show that contact and consultation are more spontaneous to younger senior students lecturers than to older folk lecturers. Bitter interacions in cases of "accommodation in conceptual change" ensue often leading to successful learning, which otherwise would seldonm occur when a "matured proffessor" lectures the youngsters.

APSS / 81

Orbital Environment Risk Assessment for SumbandilaSAT

Mr. NWOSA, Chijioke [1]

[1] *NASSP/SAAO*

Corresponding Author: chijiokenwosa@gmail.com

Satellites have to operate in a hostile space environment that poses numerous threats from radiation, charged particles, residual atmosphere, micrometeoritic impacts, space debris and other operational and defunct satellites. The region of outer space around the Earth is becoming polluted from anthropogenic space system junk and fragments. Currently, according to US Space Surveillance Network, 21,000 objects (roughly 10cm or larger) orbiting Earth are tracked. With the Knowledge of the state of the Sun's behavior, in terms of the 11-year solar cycle and sun-induced space weather phenomena, the passage through meteor showers and the population of known man-made space objects, it is possible to model the environmental impositions on Sumbandila during its operational lifetime. This paper aims to assess the risk posed by the natural space material and man-made space objects to SumbandilaSAT during its operational lifetime.

Poster1 / 83

Ab-initio study of structural stability and electronic structure of monoclinic and cubic $ZrO_{2-x}S_x$x for $0 \leq X < 2$

Author: Mr. MULAUDZI, Masilu Godfrey [1]

Co-Authors: Dr. ACKERMANN, Lutz [1]; Prof. NGOEPE, Phuti [1]

[1] *University of Limpopo*

Corresponding Author: mulaudzimg@ul.ac.za

The system $ZrO_{2-x}S_x$x is limited by the cases ZrO_2 and ZrS_2 (x = 0, 2). Physical properties of such systems for $0 < x < 2$ are of great interest, but difficult to obtain from first principles calculation. A recently suggested approach, i.e virtual crystal approximation, allows simulation for changes in composition, while retaining a small unit cell. In this paper we employ Density Functional Theory (DFT) within the Generalized Gradient Approximation (GGA)to study the zirconium dioxide – sulfide system $ZrO_{2-x}S_x$x, using the CASTEP code. We investigated geometric cell size effects, mechanical properties and electronic structure for these systems at various amounts of sulfur concentrations. For the treatment of solid solutions in the recently introduced VCA approach, CASTEP allows to define partial occupancies for atomic sites; in our case, the anionic lattice sites of $ZrO_{2-x}S_x$x crystal are defined to be less than fully oxygen occupied: (2-x); and consequently similar sites can then be attributed a partial sulfur character: (x). The lattice parameters and cell size increases for zirconia as the sulfur content is increased. Furthermore, the trend of Fermi level and the electron distributions differ, giving rise to reduced band gap as S is increased. The cubic structure $ZrO_{2-x}S_x$x is stable for $x<1.2$, however, the structure gives negative tetragonal shear modulus at $x \geq 1.2$, condition of mechanical instability.

Theoretical / 84

South African e-Infrastructure for physics applications

Author: Dr. BECKER, Bruce [1]

Co-Authors: Mr. MURRAY, Sean [2]; Mr. BALLESTRERO, Sergio [3]; Ms. ARDIZZONE, Valeria [4]; Mr. LEWIS, Andrew [5]; Mr. CARR, Timothy [5]; Mr. VAN ECK, Albert [6]; Prof. HAZELHURST, Scott [7]; Mr. HARTMAN, Jonathan [8]; Mr. LAMBROPOULOS, Stavros [8]; Prof. JOUBERT, Fourie [9]; Mr. KRIEL, Hannes [10]; Mr. MOLAMBO, Thabo [10]; Mr. WOLMARANS, Francois [8]

[1] *Meraka Institute*

[2] *iThemba LABS*

[3] *CERN/UJ*

[4] *INFN, Sezione di Catania*

[5] *University of Cape Town (ICTS)*

[6] *University of the Free State (Computer Services)*

[7] *University of the Witwatersrand*

[8] *University of Johannesburg*

[9] *University of Pretoria (FABI)*

[10] *North West University*

Corresponding Author: bbecker@csir.co.za

Physics is one of the most digitally-intensive areas of modern research and has traditionally led the development of tools to increase the efficiency and capability of research activities. The integration of the tools necessary for today's competitive physics research projects, from HPC centres to data resources, metadata catalogues, and services to enable collaboration in virtual organisations has been done to a great extent in South Africa through the activities of the South African National Grid (SAGrid). By forming a collaboration to integrate their various computing facilities through the deployment of a common middleware, the members of the SAGrid Joint Research Unit provide many research communities with an integrated services infrastructure for collaboration. We will give an overview of the grid in South Africa and how it is connected to other regional infrastructure in Europe, North Africa, Latin America and the U.S. We will show how it has enabled the South African physicsists working on LHC experiments at CERN (ATLAS and ALICE) to conduct their work irrespective of their location. We will also show some examples of how the grid has enabled collaborative research in areas of physics, and what application porting and user training services are at the disposal of the general research communities. Advanced aspects of the grid middleware, such as data management, workflow, and usage of metadata catalogues will also be presented.

Poster2 / 85

Effect of carbon modification on the electrical, structural and optical properties of TiO2 electrodes and their performance in lab-scale dye sensitized solar cells

Author: Mr. TAZIWA, Raymond [1]

Co-Author: Dr. MWAKIKUNGA, Bpnnex [2]

[1] *University of Fort hare*

[2] *CSIR*

Corresponding Author: rtaziwa@ufh.ac.za

Carbon modified titanium dioxide nanoparticles (C:TiO2 NPs) have been synthesized by ultrasonic nebulizer spray pyrolysis (USP) and pneumatic spray pyrolysis (PSP) techniques using titanium tetraethoxide as the precursor solution. High resolution transmission electron microscopy on the NPs shows difference in lattice spacing in the NP structures prepared by the two methods – 2.02 Å for the USP NPs and an average of 3.74 Å for the PSP NPs. The most probable particle sizes are 3.11 nm and 5.5 nm respectively. The carbon doping only changes the lattice spacings of the TiO2 lattice; the most predominant plane is the (101) in TiO2 reciprocal lattice as determined from the fast Fourier transform of most of the particle images. Raman spectroscopy supported by FTIR confirms the TiO2 polymorph to be anatase with the intense phonon frequency at 153 cm-1 blue-shifted from 141 cm-1 due to both carbon doping and particle size. A modified phonon confinement model for nanoparticles has been used to extract phonon dispersion and other parameters for anatase for the first time. Electronic measurements show "negative conductance" at some critical bias voltage, which is characteristic of n-type conductivity in the carbon doped TiO2 NPs as confirmed by the calculated areas under the I-V curves. This is a necessary material property for the Grätzel type of solar cells application. Practical solar cells built from carbon doped TiO2 electrodes show up to 5 times improvement in efficiency compared to pure TiO2 electrodes of similar construction.

Poster1 / 86

Heat treatment of glassy carbon implanted with strontium at room and high temperatures

Author: Mr. LANGA, Dolly [1]

Co-Authors: Prof. WENDLER, Elke [2]; Dr. VAN DER BERG, Nic [3]; Prof. FRIEDLAND, Erich [4]; Prof. MALHERBE, Johan [3]; Mr. BOTHA, Andre [3]; Prof. CHAKRABORTY, Purushottam [5]

[1] *University of Limpopo and University of Pretoria*

[2] *Friedrich-Schiller University Jena, Germany*

[3] *University of Pretoria, South Africa*

[4] *University of Pretoria, Souht Africa*

[5] *Saha Institute for Nuclear Science, India*

Corresponding Author: dlanga@ul.ac.za

The effects of annealing temperature and time on glassy carbon implanted with 360 keV strontium ions at room and high temperatures are reported. The samples were implanted with strontium ions to a fluence of 2 x 10^{16} ions/cm^2 at room temperatures, 350°C and 600°C. The room temperature implanted samples were isochronally vacuum annealed at temperatures from 200°C to 700°C for 1 hour. The depth profiles of the implanted samples before and after annealing were obtained by ion beam technique, viz. Rutherford Backscattering Scattering (RBS). Scanning Electron Microscopy (SEM) was employed to investigate the effect of implanted ions and annealing temperatures on the microstructure of the substrate.

Applied / 87

Identification of compounds in materials using tomography imaging, a possibility at the SANRAD facility

Author: Mr. NSHIMIRIMANA, Robert [1]

Co-Authors: Mr. HOFFMAN, Jakobus [2]; Mr. BAM, Lunga [2]; Mr. CORFIELD, Archie [3]; CHETTY, Deshenthree [3]; Mr. DE BEER, Frikkie [2]; Mr. RADEBE, Mabuti [2]

[1] *NECSA*

[2] *Necsa*

[3] *Mintek*

Corresponding Author: robert.nshimirimana@necsa.co.za

The South African Neutron Radiography (SANRAD) facility hosts a neutron/x-ray tomography system which is extensively being utilized in non-destructive examination experiments where it is necessary to characterize and determine the properties (e.g. size, porosity, permeability and morphology) of samples. Sometimes, quantitative information is needed about the type elemental composition of the sample or the constituencies of the sample, in a non-destructive manner. Different compounds within the sample interact differently with a neutron/x-ray source, hence it is possible not only to reveal the internal structure of the material but also to identify the compound within the material. This talk demonstrates first research results obtained at the SANRAD facility for the calibration and quantifying of compounds, or minerals, within geological samples by means of transmission radiography and tomography.

NPRP / 88

Emittance measurements of ion beams extracted from a prototype microwave ion source using the Slit-Grid technique

Author: Mr. LOMBERG, Blaine B. D. [1]

Co-Authors: Dr. THOMAE, R. W. [2]; Dr. CONRADIE, J. L. [2]; Dr. KRITZINGER, J. [2]

[1] *University of the Western Cape & iThemba LABS*

[2] *iThemba LABS*

Corresponding Author: blainelomberg@gmail.com

In recent years the need to produce low charge state ion beams with good beam quality and ion sources with good gas efficiency are on an increasing demand. The various applications of these specific ion beams are ranging from radioactive ion beam production to high energy ion implanters. The Accelerator Physics Department at iThemba LABS has developed a prototype microwave ion source. The source consists of a ceramic plasma chamber, a four bar permanent-magnet arrangement and a coaxial microwave feed. This paper involves measurements that were carried out to characterize the ion beam quality from the source. A slit-grid emittance device with a computer controlled data acquisition system was used to measure the transverse phase space distribution of ion beams. These measurements included beam RMS-emittance with noise filtering and TWISS parameter determinations. The beam emittance is fundamentally inferred by taking spatial and angular positions of beam-lets of particles and mapping it into a four-dimensional phase space.

Poster1 / 89

Reactive DC magnetron sputter deposition and characterization of ZrN thin films

Author: Mr. NYAWO, Thembinkosi Goodman [1]

Co-Author: Prof. NDWANDWE, Muzi [1]

[1] *University of Zululand*

Corresponding Author: tnyawo@pan.uzulu.ac.za

ZrN films were deposited on Si<100> substrates, Al and brass strips by DC magnetron sputtering under varying conditions of power, pressure, argon and nitrogen gas flow rates as well as temperature and characterized by SEM, AFM, RBS, resonant RBS, and XRD. The films are transparent and semiconducting. They tend to absorb oxygen. The films were found to adhere well to the substrates. The colour of the films varied depending on deposition conditions and have been expressed in the Lab* colour system. Potential uses of such films are as protective hard coatings as well as decorative layers.

Poster1 / 90

XPS analysis and luminescence properties of commercially Gd2O2S:Tb powder phosphor

Author: Dr. DOLO, JAPPIE [1]

Co-Author: Prof. SWART, Hendrik [2]

[1] *University of the free state*

[2] *UFS*

Corresponding Author: dolojj@qwa.ufs.ac.za

We report on the characterization of commercially terbium doped gadolinium oxysulfide (Gd2O2S:Tb) phosphor and the degradation of the Gd2O2S:Tb green phosphor for its application in CRT screens. As a result, degradation of the cathodoluminescence (CL) intensity during irradiation of the powder with 2 keV electrons in an oxygen pressure of 1 x 10-6 Torr was studied. The ESSCR mechanisms was used to explain the effects of sulphur desorption and the formation of a non-luminescent oxide layer. A dead layer of Gd2O3 and Gd2S3 are responsible for the degradation of the CL intensity with an increase in electron dose. The XPS results have proved the presence of Gd2O3 and Gd2S3 on the degraded powder spots.

Poster2 / 91

Towards Scientific Establishment and Validation of Quality Standards for Digital Thermal Neutron Imaging

Author: Mr. RADEBE, Mabuti Jacob Radebe [1]

Co-Authors: Prof. SIDERAS-HADDAD, Elias [2]; Mr. DE BEER, Frikkie [1]; Dr. NOTHNAGEL, Gawie [1]

[1] *Necsa*

[2] *Wits University*

Corresponding Author: mabuti.radebe@necsa.co.za

Digital thermal neutron imaging (radiography and tomography) is a powerful non-destructive analytical tool and has demonstrated its importance in industrial and research application world-wide. However, standards through test samples, methods and procedures, which are essential when the technique is to be applied in the national and international industrial and research environment, do not exist yet. Firstly, characterization of the hardware facilities is essential in order to determine their capabilities in terms of beam properties, detection properties and subsequent combinations of the two such as spatial and temporal resolution, acquisition period, L/D, S/N ratio, etc. This can be achieved through the implementation of test samples and test methods which entails the efforts towards achieving the correct test specimens, procedures and practices. Secondly, obtaining accurate quantitative information from digital thermal neutron images is an important development of this decade, and establishment and finalization of standardization in this regard is essential. A properly validated methodology to standardize quantitative digital thermal neutron imaging is of importance in a number of current research fields of global interest which includes in-situ investigations of fuel cell dynamics as well as quantification in porous media. This presentation provides the layout of the proposal for the PhD study intended at contributing towards the establishment of national and international standards for digital thermal neutron imaging. This entails a contribution towards the establishment, evaluation, validation and improvement of special test specimens as well as the creation and refinement of measurements, procedures and practice utilizing digital neutron radiographs and tomograms.

Poster2 / 92

The extent of the chorus observed at Marion Island

Author: Mr. DELPORT, Brett [1]

Co-Authors: Dr. COLLIER, Andrew [2]; Dr. PARROT, Michel [3]; Dr. CLILVERD, Mark [4]

[1] *University of KwaZulu-Natal*

[2] *Hermanus Magnetic Observatory*

[3] *LPCE/CNRS*

[4] *British Antarctic Survery*

Corresponding Author: brettdelport@gmail.com

On the 4 August 2010, chorus was observed at Marion Island from 03:00 - 07:00 UT (06:00 - 10:00 LT). Marion Island (46.9°S/37.1°E, L = 2.62) is within the plasmasphere during periods of low geomagnetic disturbance, making the observation of chorus there a rare occurrence. On the 4 August, a moderate geomagnetic storm occurred, with a maximum Kp of 6+, and a minumum DST of -70nT. These conditions compressed the plasmasphere to such an extent that Marion Island was near to, or outside, the plasmaspause at the time of the emission, making the observation of chorus possible. On the same day, there chorus was also observed at SANAE IV (L = 4.32). The spectral properties of these chorus are different, meaning that the chorus observed at SANAE IV was generated in a different region to that observed at Marion Island. We present broadband data from both Marion Island and SANAE IV, and extent of the chorus generating region is inferred from DEMETER data.

CMPMS1 / 93

Modification of the bandoffset in boronitrene

Author: Mr. OBODO, Kingsley [1]

Co-Authors: Mr. ANDREW, Richard C. [1]; Prof. CHETTY, Nithaya [1]

[1] *University of Pretoria, South Africa*

Corresponding Author: obodokingsley@gmail.com

We carried out *ab initio* self-consistent calculations to study the modification of the band offsets by polar layers. We considered a double line of C in a monolayer of hexagonal BN, also known as Boronitrene. This effectively introduces a line of dipoles at the interface. We considered BN/C zigzag and armchair configurations. The BN/C zigzag-short is found to be energetically most stable and with the smallest (1.51eV). We show that a two dimensional diode can be constructed from this structure, with changes to the electronic and optical properties of the host system.

Poster2 / 94

Computational study of some Carbon modification

Authors: Ms. SHAI, MOSHIBUDI [1]; Dr. MOSUANG, Thuto [1]

Co-Author: Prof. RAMMUTLA, Erasmus [1]

[1] *UNIVERSITY OF LIMPOPO*

Corresponding Author: moshibudis@gmail.com

Classical molecular dynamics simulations were used to study the modification of some carbon forms. The type of carbons that were used is diamond and nanocarbon. Carbon is unique among other elements in its ability to form strong chemical bonds with a variety of coordination numbers. The simulations predict that the behaviour of diamond and nanocarbon are similar although the nanotube has low minimum energy compared to the bulk diamond. The radial distribution functions of the two forms differ by half a magnitude.

CMPMS1 / 95

Black Cr/α-Cr2O3 Nanoparticles Based Solar Absorbers: Growth Kinetic

Author: Mr. KHAMLICH, Saleh [1]

Co-Authors: Dr. NEMRAOUI, Oaisin [2]; Prof. MCCRINDLE, Rob [3]; Prof. NDUMISO, Cingo [4]; Prof. MAAZA, Malik [1]

[1] *iThemba LABS*

[2] *University of Zululand*

[3] *Tshwane University of Technology*

[4] *Council for Scientific and Industrial Research*

Corresponding Author: skhamlich@gmail.com

Black chromium-chromium (III) oxide cermet (Ceramic-Metal) nano-composites exhibit attractive solar absorbance characteristics. They are used widely as selective solar heat thermal collector nano-coatings. These black chromium-chromium (III) oxide selective solar absorbers are produced by various physical vapor deposition techniques such as DC and RF reactive sputtering, pulsed sputtering method, and e-beam and thermal evaporation techniques. This contribution reports on large surface coatings of black chromium-chromium (III) oxide cermet by using a novel cost effective physical-chemical method: the Aqueous Chemical Growth (ACG). More specifically, the present study addresses the growth mechanism of the uniform fine (in the range of micron to nano)-spherical particles of α-Cr2O3 using the ACG method at low temperature. The growth kinetic of the quasi-mono-dispersed spherical particles of chromium (III) oxide, α-Cr2O3, in aqueous solution was studied as a function of ageing time. The small fine spherical particles of α-Cr2O3 revealed by SEM micrographs suggests a growth mechanism based on the diffusion-limited Ostwald ripening process on the basis of LSW theory. The experimental data were analyzed in the frame of existing coarsening and particle growth mechanisms, i.e. Ostwald ripening. A good fits of the growth of α-Cr2O3 particles with d3 model confirms the growth mechanism to be mainly diffusion-controlled.Two major configurations have been considered initially: Cr black coated α-Cr2O3 nano-particles coatings/Cupper substrate and Cr black coated α-Cr2O3 nano-particles coatings/discontinuous ultra-thin Cr layer/Cupper substrate. The optimized configurations exhibit a low diffuse reflectance as well as low transmittance in the VIS-NIR spectrum sustaining therefore their high solar absorbance property.

Theoretical / 96

B3-B1 phase transition in GaAs: A Quantum Monte Carlo Study

Author: Mr. OUMA, Cecil [1]

Co-Authors: Dr. MAPELU, Joseph [2]; Dr. MAKAU, Nicholas [2]; Dr. MAEZONO, Ryo [3]; Dr. AMOLO, George [2]

[1] *Student*

[2] *Computational Materials Sciences Group, Department of Physics, Moi University,*

[3] *School of Information Science, Japan Advanced Institute of Science and Technology, Asahidai 1-1, Nomi, Ishikawa 923-1292, Japan*

Corresponding Author: moronaphtaly84@gmail.com

The pressure induced B3-B1 phase transition has been studied using both density functional theory (DFT) and quantum Monte Carlo (QMC) methods. We present results obtained using the local density approximation (LDA), PW91-GGA generalized gradient approximation, hybrid density functionals and QMC. The changes in the equation of state has also been investigated using the different functionals and form the results obtained, we find that the choice of functional significantly effect the to the equation of state. The results of the B3-B1 phase transition pressure for DFT using the different functionals and QMC are reported and they demonstrate good agreement with experimental data.

CMPMS1 / 97

Assessment of glassy carbon as a high-level nuclear waste containment material

Prof. MALHERBE, Johan [1]

[1] *University of Pretoria*

Corresponding Author: johan.malherbe@up.ac.za

The world is experiencing an ever-growing demand for energy. This coupled with the demand to decrease the carbon-footprint have led to a reconsideration of nuclear power as an alternative to fossil fuel power stations. Many countries have either started again to build nuclear power plants while others, like South Africa, are planning to build ones in the near future. One of the most negative aspects of nuclear power plants is the long term storage of radioactive nuclear waste. The type of container material and containment materials and methods are still issues being actively researched. Presently borosilicate and phosphate glasses are the preferred materials for capturing high-level radioactive in a solid matrix. This waste is then stored in multi-walled stainless steel chambers. A favoured method is to then store these in containers in geological stable sites like Vaalputs in the Northern Cape. These containers must fulfill a number of criteria, such as a high resistance against radiation damage from the radioactive waste, chemical-resistance against corrosive materials, thermally conductive to dissipate the heat generated by the nuclear decay processing happening in the waste, a diffusion barrier for the radioactive waste in order not to contaminate the environment, etc. Glassy carbon, also known as vitrious carbon or as polymeric carbon, is a relatively new form of carbon with many properties completely different to the common graphite form of carbon. This talk will argue the case that glassy should be considered as a container material for the (solid) nuclear waste in stead of the usual metallic (such as steel) materials. Some of the research being done at the University of Pretoria will also be presented.

Poster2 / 98

Atmospheric turbidity over Gauteng

Author: Mr. SETHABANE, Thabang [1]

Co-Author: Prof. WINKLER, Hartmut [1]

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

Corresponding Author: hwinkler@uj.ac.za

We have analysed broad-band global solar irradiation measurements collected at the Soweto campus of the University of Johannesburg over the two-year period 1998-1999. We estimate the direct and diffuse irradiation using radiation models, and utilise the results to determine the atmospheric turbidity for all cloud-free days. From this we calculate aerosol densities and the solar radiation potential for the location. We further evaluate the applicability of several irradiation models, incorporating molecular absorption, Rayleigh and Mie scattering, to this part of Gauteng.

CMPMS1 / 99

Intermediate valence and antiferromagnetic Kondo lattice behaviour in $Ce(Au_{1-x}Ni_x)_2Si_2$.

Author: Prof. TCHOULA TCHOKONTE, Moise Bertin [1]

Co-Authors: Prof. DU PLESSIS, Paul de Villiers [2]; Prof. KACZOROWSKI, Dariuzs [3]; Prof. DOYLE, Terry [4]

[1] *University of the Western Cape*

[2] *University of Johannesburg*

[3] *Polish Academy of Sciences, Poland*

[4] *iThemba LABS*

Corresponding Author: mtchokonte@uwc.ac.za

The transition from intermediate valence (IV) behaviour in $CeNi_2Si_2$ to magnetically ordered Kondo lattice behaviour in $CeAu_2Si_2$ is investigated through measurements of X-ray diffraction (XRD), electrical resistivity ρ(T), magnetization σ(μ0H) and magnetic susceptibility χ(T) on the polycrystalline $Ce(Au_{1-x}Ni_x)_2Si_2$ ($0 \le x \le 1$) alloy series. Lattice parameters as derived from XRD measurements deviate from Vegard's rule around x = 0.6 − 0.8. ρ(T) data indicate Kondo lattice behavior in the presence of a crystal field for $x \le 0.6$, the occurrence of magnetic ordering for x = 0 and fluctuating valency for $x \ge 0.8$. χ(T) data at high temperatures, follow the Curie-Weiss relation for alloys in the concentration $0 \le x \le 0.6$ (Kondo lattice region) and give effective magnetic moment values μ_{eff} close to that expected for the free Ce^{3+}-ion. The low temperature χ(T) data indicate the onset of antiferromagnetic ordering for $x \le 0.78$. For alloys in the concentration range $0.8 \le x \le 1$ (IV region), χ(T) data are described within the framework of the paramagnon model. $\sigma(\mu_0H)$ measurements indicate metamagnetic behavior for alloys in the concentration range $0 \le x \le 0.1$.

LOS / 100

Laser-induced breakdown spectroscopy for monitoring heavy metals in soils

Author: Dr. AMBUSHE, Abayneh [1]

Co-Authors: Dr. DU PLESSIS, Anton [2]; Prof. MCCRINDLE, Robert [3]

[1] *CSIR and Tshwane University of Technology*

[2] *CSIR, National Laser Centre*

[3] *Tshwane University of Technology, Department of Chemistry*

Corresponding Author: aambushe@csir.co.za

The growing social concern for environmental protection and human health has driven widespread interest in analysis of heavy metals in the various environmental compartments including soil. Soil is unanimously considered as one of the recipients of heavy metals released by several human activities. Rapid analysis of heavy metals in soil is an important factor in modelling the effect of industrial pollution on agricultural soil. Quantification of heavy metals in natural and polluted soils is generally conducted using flame-atomic absorption spectrometry (F-AAS), graphite furnace-atomic absorption spectrometry (GF-AAS), inductively coupled plasma-optical emission spectrometry (ICP-OES) and inductively coupled plasma-mass spectrometry (ICP-MS) after appropriate sample pre-treatment. The use of laser-induced breakdown spectroscopy (LIBS) has emerged as a good alternative technique for quantitative analysis of heavy metals in environmental matrices. There is no need for pre-treatment of the sample in LIBS. Furthermore, the speed of analysis is far superior to other techniques, and the technique may be developed for in situ analysis. In this work we demonstrate the feasibility of LIBS for detection and quantification of heavy metals in soils and sediments and identify best parameters for such analysis.

CMPMS1 / 101

Theoretical study on possible structures for crystalline silicon dicarbide

Author: Mr. ANDREW, Richard [1]

Co-Authors: Prof. CHETTY, Nithaya [1]; Prof. BRAUN, Max [1]

[1] *University of Pretoria*

Corresponding Author: richard.andrew@up.ac.za

Si, C and SiC are very well known technologically important materials. They have been extensively studied in their multitude of structures and polytypes, but there is a surprising dearth of information for off-50:50 compounds involving Si and C. What are the possible stable structures for such compounds? Using *ab initio* techniques, we investigate two proposed structures for crystalline SiC_2: cubic pyrite and a tetragonal glitter structure. We find both structures to be metallic and mechanically stable. From their elastic properties, we make an assessment of the hardness of both structures. We find the tetragonal glitter phase to be lowest in energy with a pressure transition from the glitter to pyrite phase at 24.7 GPa.

Poster1 / 103

Magnetic behavior of the Cr-Al alloys system round the triple point concentration

Author: Dr. SHEPPARD, Charles [1]

Co-Authors: Prof. PRINSLOO, Aletta [1]; Prof. ALBERTS, Herman [1]; Prof. STRYDOM, Andre [1]

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

Corresponding Author: cjsheppard@uj.ac.za

Recent measurements on an antiferromagnetic (AFM) $Cr_{0.978}Al_{0.022}$ alloy single crystal suggest that the triple point (TP) on the magnetic phase diagram (MPD) might be a special type of critical point. This suggestion is further investigated here through electrical resistivity and specific heat measurements on a series of $Cr_{1-x}Al_x$ alloy single crystals with x around the triple point concentration (x_c). Néel temperatures (T_N), obtained from the resistivity measurements, indicate that $x_c \approx 0.02$ is situated at the position of a rather sharp and deep minimum of the AFM-paramagnetic phase transition line on the T - x MPD. The minimum is deeper than that generally accepted for this alloy system. The Sommerfeld electronic specific heat coefficient, obtained from the specific heat measurements, shows an interesting aspect. The Sommerfeld electronic specific heat coefficient as function of Al concentration peaks relatively sharply at x_c, an aspect for which the explanation is two-fold: either the phase boundary line separating the incommensurate (I) and commensurate (C) spin-density-wave (SDW) phases on the MPD, starts at the TP and reaches T = 0 K vertically below this point, or the TP itself is situated close to T = 0 K. It is reasoned that the latter seems a more likely possibility, making this system unique in exhibiting a critical point at 0 K where ISDW, CSDW and paramagnetic (P) phases coexist.

Poster1 / 104

Effect of pH on the morphology and orientation of Fe2O3 nanostructures grown using aqueous chemical growth

Mr. NDLANGAMANDLA, Cebo [1]

[1] *Student*

Corresponding Author: cebo@tlabs.ac.za

Fe2O3 nanostructures were synthesized for various pH values on Corning glass substrates by aqueous chemical growth (ACG) using a solution of ferric chloride (FeCl3). It was found that increasing the pH from 1.16 to 5.0 of the solution significantly leads to a modification of the Fe2O3 morphology or orientation from randomly parallel needle shaped rod-like to randomly perpendicular rectangular structure on to a substrate.

Poster1 / 105

Effect of growth rate and ZnO buffer layer on the structural and optical properties of MOCVD-grown MgxZn1-xO thin films

Author: Mr. TALLA, Kharouna [1]

Co-Authors: Dr. DANGBEGNON, J K [1]; Prof. WAGENER, M C [1]; Prof. BOTHA, J R [1]

[1] *Nelson Mandela Metropolitan University*

Corresponding Author: s208090592@live.nmmu.ac.za

MgxZn1-xO films were grown on c-plane sapphire substrates by metal organic chemical vapour deposition. The effects of growth rate and low temperature (280°C) ZnO buffer layer thickness on the incorporation efficiency of Mg as well as the optical and structural properties of the MgxZn1-xO films were investigated. Low growth rates enhance the segregation of Mg, leading to a magnesium rich region near the interface with the sapphire substrate. Hence, a shoulder is observed on the higher energy side of the main donor bound exciton in the photoluminescence spectrum. The effect of a ZnO buffer layer grown for 5 min and 10 min at 280°C for MgxZn1-xO films with low Mg content (xv = 0.2) and for MgxZn1-xO with high Mg content (xv = 0.5) was also investigated. The ZnO buffer layer causes an improvement in the Mg incorporation but deteriorates the structural and optical properties for all the films. The MgxZn1-xO thin films grown on a thinner ZnO buffer layer showed the best optical and structural properties. Furthermore, the deposition of thin films on a ZnO buffer layer leads to an increase in lateral growth rate, which enhances the width of columnar grains. A ZnO buffer layer does not prevent the formation of a Mg rich interfacial layer.

Education / 106

Learners' Understanding of Ammeter and Voltmeter in a DC Schematic Circuit

Author: Mr. MAUTJANA, Ramaite Thomas [1]

Co-Author: Prof. NETSHISAULU, Thomas [2]

[1] *NMISA and University of Limpopo*

[2] *University of Limpopo*

Corresponding Author: tmautjana@nmisa.org

This study explores learners' knowledge of measuring instruments (Ammeter and Voltmeter) in a direct current resistive circuit. It investigates learners' understanding of how instruments should be connected and why they have to be connected in a particular way. Ammeter and voltmeter are used to determine the behavior of a circuit by indicating the readings of current and voltage, respectively. An educator sees an ammeter as an "invisible" component because it does not change the characteristics of a circuit. However, a learner views an ammeter differently. A paper-and-pencil questionnaire was administerd to grade 12 learners. Group interviews were conducted in order to validate and support the results of the questionnaire. The results indicate that learners lacked the basic understanding of the role played by meters (why we need them in electrical circuits). It was also evident that due to lack of practical experience with real circuits, learners did not know how these meters should be connected. This paper will report on some of the results and their implications for teaching/learning of electricity.

Applied / 107

Determining optical performance and current generation of a CPV due to intensity distribution

Author: Mr. SCHULTZ, Ross [1]

Co-Authors: Prof. VAN DYK, Ernest [1]; Dr. VORSTER, Frederik [1]

[1] *Nelson Mandela Metropolitian University*

Corresponding Author: s206029578@nmmu.ac.za

High concentration photovoltaic (CPV) systems utilize non-imaging optics to concentrate and distribute the solar flux uniformly onto a solar receiver to achieve maximum performance and power output from a CPV module. However, in many cases due to mechanical misalignment, tracker error and imperfections in the optical material, the optimum performance of the module is compromised. A LabVIEW programme employing visualization was used to determine the main contributing factor for current generation, i.e. position and intensity of the distribution. The topography was determined by multiple roster scans with a spectroradiometer and optical fiber in the plane of the reflective secondary's aperture where the cell would be placed. The results showed different currents been generated at different points on the cell surface. These results were put into a CPV cell current-voltage (I-V) characteristic simulator to extract I-V curve at each point. These were then compared with measured I-V curves obtained from the CPV system. The results showed that there was a non-uniform current densities (Jsc) distribution due to non-uniform spectral and intensity distribution across the cell surface.

Applied / 108

Laser Irradiation: A Complementary Treatment for Wounds?

Author: Dr. HOURELD, Nicolette [1]

Co-Author: Prof. ABRAHAMSE, Heidi [1]

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

Corresponding Author: nhoureld@uj.ac.za

Since the invention of the laser, its application in the health sector has been studied and in an attempt to discover effective alternative treatments, Low Level Laser Therapy (LLLT), commonly known as biostimulation or photo-biostimulation, has emerged. This therapy has been successfully used both in in vitro and in vivo studies in wound healing. Although this therapy is in use worldwide, the full mechanisms of action are not fully understood. Various cell culture models, such as wounded, diabetic wounded and hypoxic, have been exposed to visible and infra-red laser light and the effect on cell migration, cell survival, proliferation, cytotoxicity, mitochondrial responses, nitric oxide, secondary messengers, DNA damage and pro-inflammatory cytokines have been studied. Laser irradiation at the correct wavelength and fluence has shown to have a positive effect on stressed cells in vitro. There is an increase in migration, survival and proliferation, mitochondrial activity, nitric oxide and secondary messengers. A decrease in cytotoxicity, DNA damage and pro-inflammatory cytokines is also seen. LLLT offers an alternative wound healing therapy. At a biochemical level there is a positive effect on cells, with stressed cells being pushed into cell survival pathways.

Poster2 / 110

Micromachining of optical fibers with a Nd:YAG laser at 532 nm using a spatial filter

Author: Dr. SCHMIEDER, Diethelm [1]

Co-Author: Mr. SAMARADIWAKERA, Rajatha [1]

[1] *University of Johannesburg*

Corresponding Author: dschmieder@uj.ac.za

Micromachining of single-mode telecommunication fibres (SMF28) was accomplished with a Nd:YAG laser at a wavelength of 532 nm. The goal of the micromachining process is to machine miniature Fabry-Perot interferometers in the fiber to manufacture fast temperature sensors. To produce micro features by direct machining the laser beam is focused to spot sizes of 30 µm and below. The different shapes of the micro features are accomplished with small apertures in close proximity and in line with the machining lens (focal length 24.5 mm). We describe the experimental setup and the monitoring process. Two mirrors BB1-E02 were installed at an angle of 45 degrees to eliminate the infrared radiation at 1.064 µm. The apertures in line with the machining lens are projected onto the fiber, which was mounted on a three axis translation stage. The apertures could also be projected against the wall to assure homogeneous illumination. The fiber can be shifted between the machining area and a camera with 400 x magnification. The images are recorded with ProScope software, stored in a computer and displayed on a screen. The focal point is established by generating a white light supercontinuum by air breakdown. The centre position on the fibre is found with the help of the diffraction pattern produced by the fibre. The machining frequency was 10 Hz and we found the best laser beam powers between $1-3$ mW or $0.1-0.3$ mJ/pulse. We managed to machine right through the fiber. The machining results will be presented.

Poster1 / 112

DRS, XRD and SEM studies of the effects of metal dopants (Pt, Au and Pd) on the structural and optical properties of TiO2.

Authors: Prof. RAMMUTLA, Erasmus Koena [1]; Mr. MOLOANTOA, Jacob Ramodika [1]

Co-Authors: Dr. MOSUANG, Thuto [1]; Dr. ERASMUS, Rudolph [2]; Prof. HILLIE, Thembela [3]

[1] *University of Limpopo*

[2] *University of the Witwatersrand*

[3] *CSIR*

Corresponding Author: rammutlae@ul.ac.za

Titania is a cheap and nontoxic polymorphic material of current interest for a variety of technological applications like in gas sensing and photovoltaic cells. Generally, TiO2, with a band gap of 3.2 eV, can only be excited by a small UV fraction of solar light, which accounts for only 3-5% of the solar energy. Various strategies have been pursued including doping with metallic elements (e.g. Fe) or nonmetallic elements (e.g. N) with the aim of shifting the absorption into the visible range. In the present work TiO2 was doped with platinum (Pt), palladium (Pd) and gold (Au) at doping levels of 5% weight, following the standard sol-gel methods. Structural characterization was carried out using scanning electron microscopy (SEM) and X-ray diffraction (XRD). Optical properties were studied using the Diffuse Reflectance Spectroscopy (DRS). The results of the lattice parameter calculations from the XRD patterns of metal loaded TiO2 are almost the same as for the undoped. Doping with Pt and Pd resulted in a lower anatase to rutile phase transformation temperature while doping with Au did not affect the transformation temperature. SEM micrographs show that the surface contains irregular shaped particles which are the aggregation of tiny crystals for lower temperatures. At higher temperatures (900 °C), we observe spheroids of metallic nanocrystals on the surface of TiO2.The reflectance spectra of the metal loaded TiO2 reveal substantial reduction in reflection (i.e. they show enhanced absorption)from 400nm to the entire visible region.

Theoretical / 113

Ferromagnetism in nuclear matter

Author: Mr. DIENER, Jacobus [1]

Co-Author: Prof. SCHOLTZ, Frederick [1]

[1] *Stellenbosch University*

Corresponding Author: jpwd@sun.ac.za

Understanding the magnetic effects of ultra-dense, cold nuclear matter is of particular importance when investigating the magnetic properties of dense matter systems such as neutron stars. One property that we are interested in is the possibility of generating a magnetic field in nuclear matter as the central density increases. We investigate this possibility by employing a relativistic, self-consistent calculation to capture the interaction of the neutrons, protons and electrons with the magnetic field. In this talk we present this model for describing ferromagnetism in dense nuclear matter systems. Our current results will also be presented.

APSS / 114

Ferromagnetic neutron stars

Author: Mr. DIENER, Jacobus [1]

Co-Author: Prof. SCHOLTZ, Frederick [1]

[1] *Stellenbosch University*

Corresponding Author: jpwd@sun.ac.za

It is well known that neutron stars have very strong magnetic fields and that these fields impact the behaviour of the star. The focus of our research is on the interaction between the magnetic field and the constituent matter in the neutron star's interior. In particular we investigate the possibility of a ferromagnetic phase in the neutron star interior being the source of the star's ultra-strong magnetic field. Considering such a phase provides us with a feedback mechanism between the constituent matter and the magnetic field and vice versa, which we believe is a necessary component in understanding the evolution of the neutron star's magnetic field. In this talk we will shortly introduce a description of ferromagnetism in the neutron star interior. We will also discuss the impact of such a phase as well as allude to possible observational consequences.

NPRP / 115

Transitional 150Sm and 152Gd

Author: Ms. BVUMBI, Suzan Phumudzo [1]

Co-Authors: Prof. SHARPEY-SCHAFER, John [2]; Prof. CONNELL, Simon [1]; Dr. MULLINS, Simon [3]

[1] *University of Johannesburg*

[2] *University of the western cape*

[3] *iThemba LABS*

Corresponding Author: suzan@tlabs.ac.za

Nuclei near N=90 are considered transitional, since they lie between nuclei that display vibrational spectra and nuclei that display rotational spectra. The structure of these transitional nulei, in particular the nature of the low-lying first excited states |0+2> still pose a great challenge with various theoretical models competing. A new perspective to the understanding of the structure of the N=88 and N=90 nuclei is brought by the proposition that the low-lying first excited 0+ states in these nuclei are not β-vibrations but constitute a second vacuum |0+2> coexisting with the ground state vacuum |0+1>. As part of a campaign studying nuclei near N=90, the low and high spin states of the N=88 nucleus 150Sm have been populated via 148Nd(α, 2n)150Sm at a beam energy of25MeV and 136Xe(18O, 4n)150Sm at 75MeV respectively. These experiments have been conducted on world-class multi-detector gamma-ray spectrometer arrays, namely JUROGAM at Jyvakyla in Finland as well as the AFRODITE at iThemba LABS Cape town here in South Africa. The isotone 152Gd has been studied via 152Sm(α,4n)152Gd at 45MeV fusion evaporation reaction taken with AFRODITE. Preliminary results focusing on the observed band structres for the two isotones 150Sm and 152Gd will be presented.

CMPMS1 / 117

Thermodynamic Properties and Inelastic Neutron Scattering of Ferromagnetic CeCuSi

Author: Ms. SONDEZI-MHLUNGU, Buyi [1]

Co-Authors: Prof. STRYDOM, Andre [1]; Prof. ADROJA, D. [2]

[1] *University of Johannesburg*

[2] *Rutherford Laboratory*

Corresponding Author: bmhlungu@uj.ac.za

Cerium-based ternary compounds demonstrate different and interesting phenomena depending on the valence of the Ce ion. The hybridization between Ce-4f electrons and the neighbouring conduction electrons is responsible for the anomolous properties observed in different systems. Depending on the strength of the f-ligand hybridization, one observes in these compounds phenomena such as magnetic ordering, heavy fermion behaviour, Kondo effect and valence fluctuations. The derived local magnetic moments associated with the state of Ce ions order antiferromagnetically in most cases. CeCuGe, CeCuSi and CeAuGe belong to a small family of equiatomic Ce based compounds that order ferromagnetically at low temperatures. The ordering temperatures are TC = 10 K, 15.5 K and 10 K for CeCuGe, CeCuSi and CeAuGe respectively. Here we report on the continuation of our studies into the thermodynamic and magnetic-field sensitivity of magnetic ordering, TC in CeCuSi compound, which has been identified to exhibit ferromagnetic ground state below TC = 15 K. CeCuSi crystallizes in an ordered hexagonal ZrBeSi-type structure (space group P63/mmc No. 194). Magnetization and susceptibility measurements were performed and the fit to the Curie-Weiss law was done, calculating paramagnetic temperature, and effective moment. The ferromagnetic nature of the transition in this compound is indicated by a lamda-type anomaly at low temperatures from specific heat (Cp) data. At higher temperatures, the magnetic contribution to the specific heat, C4f (T) (which is accessed by subtracting an isostructural non-magnetic reference data, LaCuSi) is characterized by a broad Schottky anomaly resulting from electronic excitations to crystal electric field (CEF) levels. Least-squares Schottky fit for a two-level system yielded energy separation value of about 110 K. The presence of CEF in this compound was confirmed by inelastic neutron scattering (INS) data.

Education / 118

Investigation of First Year University Students' Interpretation of Graphs in Mathematics and Kinematics

Author: Mr. PHAGE, Itumeleng [1]

Co-Author: Dr. LEMMER, Miriam [2]

[1] *Honorary*

[2] *member*

Corresponding Author: phageh@gmail.com

Mathematics is an essential tool in studying physics, i.e., it will be difficult to study Physics without the sound basics of Mathematics. It is even called the "language of physics" (Redish, 2005). Physicists blend conceptual physics with mathematical skills and use them to solve and interpret equations and graphs. For instance, in kinematics, different aspects from mathematics such as knowledge of functions and the solving of equations are combined with physics concepts. Many introductory physics students perform poorly on the use of mathematical skills and interpretations of graphs in physics. Two possible reasons may be: (1) Students lack the necessary mathematical skills needed to solve the physics problems and (2) Students do not know how to apply and relate their mathematical skills in the context of physics. These possible reasons were investigated in a Masters Research project which is still in progress, which probed first year university students' interpretations of graphs in kinematics and in mathematics. This paper will use the idea of Beichner's standardized questionnaire on kinematic graphs. From this questionnaire, an equivalent questionnaire was devised in the context of Mathematical equations and graphs. The results of the investigation tend to indicate the deficiencies in the students' mathematical conceptual knowledge as well as in the transfer of mathematical skills that they possess to solve kinematic equations and graphs.

APSS / 119

Frequency spectrum of nonlinear electric field structures in a magnetized dusty plasma

Author: Dr. MAHARAJ, Shimul Kumar [1]

Co-Authors: Prof. BHARUTHRAM, Ramesh [2]; Prof. SINGH, Satya Vir [3]; Prof. PILLAY, Sadha [4]; Prof. LAKHINA, Gurbax [3]

[1] *South African National Space Agency (SANSA) Space Science (formally NRF Hermanus Magnetic Observatory)*

[2] *University of the Western Cape, Modderdam Road, Bellville 7535*

[3] *Indian Institute of Geomagnetism, New Panvel (W), Navi Mumbai 410218, India*

[4] *School of Physics, University of KwaZulu-Natal, Private Bag X54001, Durban 4000*

Corresponding Author: smaharaj@hmo.ac.za

A magnetized dusty plasma composed of an adiabatic negatively charged dust fluid, Boltzmann ions and Boltzmann electrons is considered for which coupled nonlinear dust-acoustic and dust-cyclotron waves having sinusoidal, sawtooth or spiky electric field waveforms are found to be supported when charge neutrality is assumed (Maharaj et al, 2008). The focus of this investigation is to make use of a suitable Fast Fourier Transform (FFT) algorithm to decompose the nonlinear waveforms into Fourier components in an attempt to identify the dominant frequency components of the nonlinear structures. The possibility of obtaining oscilloton solutions will also be investigated.

Poster1 / 120

Electrical and surface morphological studies of palladium and ruthenium Schottky diodes on n-Ge (100)

Author: Prof. CHAWANDA, Albert [1]

Co-Authors: Prof. AURET, F.D [1]; Mr. MTANGI, W [1]; Dr. NEL, J.M. [1]; Dr. DIALE, M [1]; Dr. NYAMHERE, C [2]

[1] *University of Pretoria*

[2] *Nelson Mandela Metropolitan University*

Corresponding Author: albert.chawanda@up.ac.za

Palladium (Pd) and ruthenium (Ru) Schottky barrier diodes were fabricated on (100) Sb-doped n-type germanium using resistive evaporation and electron beam deposition systems, respectively. Electrical characterization of these diodes using current-voltage (I-V) measurements was performed under various annealing conditions. The morphological evolution of the surface was analysed using the scanning electron microscopy. The variation of the electrical and structural properties of these Schottky diodes can be attributed to combined effects of interfacial reaction and phase transformation during the annealing process. Thermal stability of both the Pd/n-Ge (100) and Ru/n-Ge (100) Schottky diodes is maintained up to annealing temperature of 550°C. Results have also indicated that the onset temperature for agglomeration in Pd/n-Ge (100) system occurs between 500 – 600°C, and in Ru/n-Ge (100) system occurs between 600 – 700°C.

CMPMS1 / 121

Monte Carlo Simulations of Magnetite Nanoparticles Stabilised With Sebaccic Acid and 1, 10-Decanediol Surfactants

Author: Dr. HARRIS, Richard [1]

Co-Author: Mrs. VAN DER WALT, Hendriette [1]

[1] *Mintek*

Corresponding Author: richardh@mintek.co.za

Iron oxide-based nanomagnets, such as maghemite (Fe2O3) and magnetite (Fe3O4), have attracted a great deal of attention in nanomedicine over the past decade. On the nanoscale, superparamagnetic iron oxide nanoparticles can only be magnetized in the presence of an external magnetic field. This property makes these nanoparticles capable of forming stable colloids in a physio-biological medium. Their superparamagnetic property, together with other intrinsic properties, such as low cytotoxicity, colloidal stability and bioactive-conjugation, makes such nanomagnets ideal for both in vitro and in vivo biomedical applications. Several methods for the synthesis of iron oxide nanoparticles have been developed. The most common ones for contrast agent synthesis are based on the precipitation of magnetite nanoparticles from solutions containing stabilizing agents such as synthetic or natural polymers; or adsorption of stabilizing agents on the magnetite particle surface after synthesis. The first method often leads to the formation of multicore particles, while the second one demands coating stabilisation by cross-linking, that can lead to particle aggregation. For this reason the stabilising properties of two surfactants, sebaccic acid (with carboxylic acid groups on the peripheries) and 1, 10-decanediol (with hydroxyl groups on the peripheries), were investigated and compared theoretically. DFT adsorbance simulations were run and the average total energies of the two ligands adsorbed onto the magnetite nanoparticles were compared. XRD measurements also revealed a change in crystal structure for the Fe3O4 nanoparticles when stabilised with the different ligands.

CMPMS1 / 122

Reversible Semiconductor – Metal Transition study in nano-FePt system

Author: Mr. NKOSI, Steven [1]

Co-Author: Prof. SIDERAS-HADDAD, Elias [2]

[1] *CSIR and University of the Witwatersrand*

[2] *University of the Witwatersrand*

Corresponding Author: snkosi@csir.co.za

Highly crystalline nano-spherical Fe-Pt systems were produced by 248 nm laser irradiation of liquid precursor at different laser fluence ranging from 100 – 375 mJ/cm2. The influence of laser intensity on the particle size, iron composition and vibrational properties was systematically investigated. The study reveals that the larger particles have higher iron content. The prepared precursor solution through Fe (III) acetyacetonate and Pt (II) acetyacetonate underwent a deep photolysis to polycrystalline of nano Fe-Pt alloys. Fe (II) and Pt (I) acetyacetone decompose into Fe0 and Pt0 nanoparticles (NPs). The material is shown to contain only iron and platinum by EDS. We have observed hysteretic loop in structural phase transition of Fe60Pt40 NPs. The material shows high resistance (~2,700 Ohms) at lower temperatures and low resistance (~2,200 Ohms) at higher temperatures. Pan theory was used to exemplify the phase transition.

Education / 123

Active Learning in the Third Year Statistical Physics Course at the University of the Witwatersrand

Dr. KEARTLAND, Jonathan [1]

[1] *University of the Witwatersrand*

Corresponding Author: jonathan.keartland@wits.ac.za

Active learning techniques were used for the first time in the Statistical Physics module presented to third year students at the University of the Witwatersrand in the first semester of 2009. The reaction of the students, recorded in a formal Student Assessment of Lecturer Performance, administered by the Centre for Teaching and Learning Development at the University, was overwhelmingly positive. In addition, the final results of the students were excellent. This paper reports on the methods employed, the results of the student survey and the course results. These results are compared with the results of the same group of students in the second year Thermal Physics module, taught by the same lecturer using more traditional methods of instruction, during the second semester of 2008. The employment of innovative teaching strategies makes a significant difference to the confidence and attitude of the students, and an increase in the level of performance of the majority of students is apparent. Active learning is now the standard method of instruction in both the second and third year Thermal and Statistical Physics courses, and details of the materials developed over the last three years will be provided.

CMPMS1 / 124

Characterization of nitrogen-doped carbon nanospheres using electron magnetic resonance

Author: Dr. KEARTLAND, Jonathan [1]

Co-Authors: Mr. DUBAZANE, Makhosonke [1]; Mr. MARSICANO, Vincent [1]

[1] *University of the Witwatersrand*

Corresponding Author: jonathan.keartland@wits.ac.za

Carbon nanospheres were produced using two different sets of apparatus in the School of Chemistry at the University of the Witwatersrand. Nitrogen was introduced into the samples using a several sources of nitrogen, including pyridine. Electron magnetic resonance (EMR) was used to characterize a range of samples of varying concentrations of nitrogen at room temperature. The spheres doped with nitrogen show a strong paramagnetic peak at g = 2, indicating that the nitrogen takes up substitutional sites in the carbon matrix. Careful analysis enables us to determine the nitrogen content in each of the samples by integration of the resonance peak, and normalising to the mass of the sample. Comparison with a reference sample allows us the extract the g for each sample. Power saturation experiments show the the relaxation rates of the nitrogen ions are large in all the samples studied.

Education / 125

Instructional Design Principles applied to Physics laboratory and tutorial courses

Author: Dr. NAIDOO, Deena [1]

Co-Author: Mr. CLERK, Douglas [2]

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

[2] *University of the Witwatersrand*

Corresponding Author: deena.naidoo@wits.ac.za

This study examines the effect on the learning experiences of students of changes to the running of laboratory and tutorial sessions of the first year auxiliary physics course at the University of the Witwatersrand, between 2001 and 2010. This research is underpinned by the principles of indirect interactive instructional skills and experiential learning. Two concerns drove this study: the first being a mismatch between the marks awarded to students for their laboratory reports, and their subsequent performance in formal practical tests. The second was the students' poor engagement – and hence performance in problem solving - during tutorial sessions. Several possible contributing factors were identified and changes were implemented in an attempt to improve the learning experienced by the students. Three sources of data suggest that the changes have had a positive effect on the learning of physics by the students in this course.

APSS / 126

Brightest Cluster Galaxies - Ages and metallicities of stellar populations

Ms. DANIÈL, Viljoen [1]

[1] *North-West University*

Corresponding Author: 20569513@student.nwu.ac.za

The aim of this project is to study the stellar populations, and thereby evolution and star formation histories of brightest cluster galaxies (BCGs). In particular, I will determine if a Single Stellar Populations (SSP) or Composite Stellar Populations (CSP) provides the most significant fit for the BCGs using high signal-to-noise ratio (S/N), long-slit spectra, obtained on the Gemini and WHT telescopes. By using the ULySS software package, the data will be fitted against the Pegase. HR and Vazdekis/Miles stellar population models to simultaneously derive the SSP equivalent ages and metallicities of the BCGs. Furthermore the stellar populations will be decomposed into two or more components, and the chi square (χ2) value for each component is used to determine whether a SSP or CSP represents the BCGs most accurately. We find that both young and old stars are present in the stellar populations of these BCGs, and those BCGs, therefore show surprisingly diverse star formation histories.

Poster1 / 127

Thermoluminescence Study of Long Persistent $CaAl_2O_4$:Eu^{2+}, Nd^{3+} and/or Dy^{3+}.

Author: Mr. WAKO, Ali [1]

Co-Authors: Prof. DEJENE, Francis [2]; Prof. SWART, Hendrik [2]

[1] *University Of The Free State, QwaQwa Campus.*

[2] *University of The Free State*

Corresponding Author: wakoah@qwa.ufs.ac.za

It is evident that the Eu^{2+} ion acts as a luminescent centre emitting in the blue (λmax ~ 440 nm) spectral region for $CaAl_2O_4$:Eu^{2+}. The R^{3+} ion is believed to act as a trap or somehow modify the trap properties in these phosphors. Despite a large number of research on the phenomenon the mechanism of the persistent luminescence of the $CaAl_2$O4:Eu^{2+},R^{3+} materials has not been well presented. The theories that have so far been put forward are generally contradictory therefore much less agreement exists on the role of the R^{3+} co-dopant. New emerging applications for the long phosphorescent materials such as radiation detection and sensors for structural damage, fracture of materials and temperature, require the exact luminescence mechanisms and the identification of the trap levels/locations. Analysis of the thermoluminescence (TL) glow curves is one of the most significant ways to measure the number and also the activation energy of the trapping levels in these materials. In the present study the TL properties of the Eu^{2+}, R^{3+} doped $CaAl_2O_4$:Eu^{2+}, Nd^{3+}/Dy^{3+} were investigated above room temperature. The trap depths were estimated with the aid of the peak shape method. The glow curve of $CaAl_2O_4$:Eu^{2+} with a first peak at 50 °C was found to correspond to several traps. The Nd^{3+} and Dy^{3+} ions were observed to greatly enhance the intensity of the high-temperature TL peaks and also form most of the traps suitable for intense and long-lasting persistent luminescence. The trap- depths and the R^{3+} or R^{2+} level positions did not exhibit any well defined relationship. The traps may thus involve more complex mechanisms than the simple charge transfer to (or from) the R^{3+} ions.

Poster1 / 128

Red emission of Pr3+ enhancement by addition of Ba2+ and In3+ in CaTiO3:Pr phosphor

Author: Mr. NOTO, Luyanda Lunga [1]

Co-Authors: Dr. PITALE, Shreyas [2]; Prof. TERBLANS, JJ [2]; Prof. NTWAEABORWA, OM [2]; Prof. SWART, HC [2]

[1] *University of Free State (Student)*

[2] *University of Free State*

Corresponding Author: luyanda.noto@gmail.com

CaTiO3 exhibits a Perovskite structures that has an ABO3 stochiometry where A and B represent metal cations with a combined charge of 6+ valency and O with 6- valency, and thus bring about charge neutrality to the compound. Upon introducing Pr3+ ions in the site of Ca2+ ions, charge imbalance occurs by introducing a 7+ valency, and this force the material to compensate for this effect by introducing negative Ca & Ti vacancies, and positive O vacancies. These act by hampering the material luminescence. Thus substitution of Ti4+ by co-doping with Ba2+ and In3+ ions result into a 6+ valency and thus an electrically neutral compound. This reinforces the red emission of Pr3+ ions inside CaTiO3. CaTiO3: Pr3+ exhibiting red emission is synthesized via solid state reaction, and its luminescence is enhanced by co-doping with Ba2+ and In3+ that act as charge compensators. This optimal emission of CaTiO3:Pr3+,Ba2+,In2+ is achieved by solid state reaction at 1300 oC for 4h, by direct firing, according to 1:1 molar ratio of TiO2 Anatase and CaCO3 compounds, doping with 0.3 mol%Pr3+ (PrCl3) and charge compensating by adding In3+ (In(NO3)3) and Ba2+ (Ba(NO3)2).The observed 613 nm photoluminescence (PL) peak, when exciting the material with 330 nm ultraviolet light to promote (2p(O) → 3d (Ti)) absorption using the PL spectrometer, is attributed to the 1D2 → 3H4 transition of the Pr3+ ions. The glow curves were measured using Thermo luminescence (TL) spectroscopy. Addition of Ba2+ and In3+ ions into CaTiO3:Pr3+ phosphor enhances the optical performance of the Pr3+ red-emission. Additionally the phase was identified using the X-ray diffraction (XRD) and the surface morphology identified using Scanning Electron Microscopy (SEM).

Poster1 / 129

Measuring the effect of surface evaporation on the segregation process

Author: Mr. CRONJE, S [1]

Co-Authors: ROOS, W D [1]; KROON, R E [1]; ASANTE, J K O [2]

[1] *UFS*

[2] *TUT*

Corresponding Author: cronjes@ufs.ac.za

Metallurgical products play an important role in everyday life. The search for alloys with better material properties such as strength, wear and corrosion resistance continues to this day. In addition to these desirable properties, the search for ways to reduce production costs and time has led to a large amount of research being conducted on the processes which determines the material properties of metals and alloys. One of these processes is known as segregation. To improve segregation studies the influence of surface evaporation should be considered. As experimental segregation studies are performed under high vacuum conditions, certain elements are prone to this neglected phenomenon. Although some attempts have been made to develop segregations models that take surface evaporation into account, these models can only predict segregation in either the kinetic region or when equilibrium has been reached. In addition the effect of evaporation has received little attention in previous experimental studies. In this study surface evaporation during segregation of a Sb/Cu system was measured. These results together with the modified Darken model will be used to simultaneously predict kinetic and equilibrium segregation including the effects of surface evaporation. A first approximation will be discussed as well as modifications made to an Auger system in order to measure the actual surface evaporation that takes place during segregation.

CMPMS2 / 130

Conductivity crossover in hot filament CVD grown nano-crystalline diamond films doped with nitrogen.

Author: Mr. CHIMOWA, George [1]

Co-Authors: Prof. BHATTACHARYYA, Somnath [1]; Dr. CHUROCHKIN, Dmitry [1]

[1] *Wits*

Corresponding Author: gchimowa@yahoo.com

We report on the synthesis and electrical characterization of nano-crystalline diamond films grown by hot filament chemical vapor deposition. Low temperature magnetoresistance measurements have shown a crossover in conductivity from hopping, activated to semi-metallic conduction as the nitrogen level in the CVD chamber is increased from 10% - 15%, 20% to 22% respectively. Raman spectroscopy studies and SEM micrograph indicate a change in morphology with deposition parameters such as pressure, temperature and gas chemistry while AFM micrograph suggests a columnar growth process. In the semi-metallic regime the conduction is characterized by anisotropic 3D weak localization mechanism with a weak temperature dependence of the dephasing time (D) approximately (D) T-0.7. Such behavior has been reported in Superlattice structures. Understanding of the transport properties in nano-crystalline diamond films is a perquisite for the application of diamond films in nano-electronics for fast switching and field emission devices.

CMPMS2 / 131

Synthesis and Characterization of Structural and Luminescent properties of long afterglow $CaAl_2O_4$: Eu^{2+}, Nd^{3+}, Dy^{3+} nano-scaled phosphors by solution – combustion technique.

Author: Mr. WAKO, Ali [1]

Co-Authors: Prof. DEJENE, Francis [2]; Prof. SWART, Hendrik [2]

[1] *University Of The Free State, QwaQwa Campus.*

[2] *University of The Free State*

Corresponding Author: wakoah@qwa.ufs.ac.za

Long afterglow calcium aluminate phosphors doped with Eu^{2+} and co-doped with Nd^{3+} /or Dy^{3+} ($CaAl_2O4:Eu^{2+}$, Nd^{3+}, Dy^{3+}) were fabricated by urea-nitrate solution – combustion method at 500 °C. The effects of varying concentrations of Ca:Al and co-dopants molar ratio (Nd^{3+}:Dy^{3+}) on the structural and luminescent properties of the phosphor were investigated. It was observed that Ca:Al molar ratios greatly affect the crystalline structure of the material. The results of the X-ray diffraction (XRD) analysis reveal that the formation of several crystalline phases depends on the molar ratios of the host material. The peaks show the presence of other phases such as $Ca_3Al_2O_6$ and $CaAl_4O_7$ but the predominant phase formed was that of $CaAl_2O_4$. As the concentration of Ca ions increase, the peak intensity increase which led to formation of monoclinic $CaAl_2O_4$ as a single phase for the 1.5% Ca. However it was found that the crystalline structure is generally not affected by variation of the co-dopants concentration. PL studies revealed a general rise in intensity with increase in the mole ratio of Ca:Al . The highest PL intensity was observed with 1.5% Ca but was weak with 0.1% Ca. Also it is evident that as the fraction of Nd^{3+} increase and that of Dy^{3+} decrease proportionally good emission intensities are formed in the region 400nm-500nm at the ratio 1:1. The initial luminescent intensity and rate of decay vary from each other when co-doped with various proportions of Nd^{3+} and Dy^{3+}. Low Nd^{3+} exhibited high initial luminescent intensity but low decay rate because of insufficient trap vacancies in the host matrix.

Poster1 / 132

Effect of annealing on the Ce3+/Ce4+ ratio measured by XPS in luminescent SiO2:Ce

Author: Mr. SEED AHMED, Hassan [1]

Co-Authors: Dr. KROON, RE [1]; Prof. NTWAEABORWA, OM [1]; Prof. SWART, HC [1]

[1] *University of the Free State*

Corresponding Author: seedahmedaa.sci@ufs.ac.za

Ce doped silica has potential applications for a luminescent material as phosphors for cathodoluminescence, scintillators and detectors. Ce ions can occur in a trivalent or a tetravalent state: only the trivalent Ce^{3+} state with a single 4f electron is optically active, while the tetravalent Ce^{4+} ion is non-luminescent. X-ray photoelectron spectroscopy (XPS) is a suitable technique to investigate the oxidation states of Ce in cerium oxides and such studies have been carried out because of the importance of CeO_2/Ce_2O_3 conversion in automotive exhaust catalysts. However, the XPS Ce(3d) spectrum of cerium oxide is rather complex as it contains ten closely spaced and overlapping peaks on a strong background. The main challenge is to obtain accurate fits to experimental data while still maintaining a good physical basis for the fitting parameters. The analysis of Ce in SiO_2:Ce is even more challenging since the Ce concentration for luminescent samples is only in the region of 1%. Although it has been experimentally shown that to improve the luminescence efficiency of Ce doped silica it can be useful to anneal the glass in a reducing atmosphere, with the implication that this increases the concentration of Ce^{3+} luminescent ions, we are not aware of XPS measurements that correlate the relative concentrations of the Ce^{3+} and Ce^{4+} ions to the luminescent properties. In this work, cerium doped silica was prepared by the sol-gel method. The effect of annealing temperature and atmosphere on the luminescent properties are correlated to XPS measurements of the oxidation state of Ce in the samples.

NPRP / 133

Characterization of Cluster States in ^{16}O with the (p,t) reaction

Authors: Dr. MABIALA, Justin [1]; Dr. PAPKA, Paul [1]; Dr. NEVELING, Retief [2]

Co-Authors: Dr. STEYN, G.F. [2]; Mr. SWARTZ, J.A. [1]; Dr. USMAN, Iyabo [2]; Dr. WYNGAARDT, S.M. [3]; Mr. VAN ZYL, J.J. [3]; Dr. BUTHELEZI, E. Zinhle [2]; Prof. COWLEY, Anthony A. [1]; Dr. FOERTSCH, Siegfried [2]; Prof. FREER, Martin [4]; Dr. IBRAHIM, Taofiq T. [1]; Mr. MIRA, Joele [1]; Dr. SMIT, F.D. [2]

[1] *Stellenbosch University/iThemba LABS*

[2] *iThemba LABS*

[3] *Stellenbosch University*

[4] *School of Physics and Astronomy, University of Birmingham*

Corresponding Author: mabiala@sun.ac.za

Motivated by several theoretical cluster calculations that predict the existence of the 0_6^+ state in ^{16}O located at 15.1 MeV as a very good candidate for the equivalence of the Hoyle state in ^{12}C, a high resolution measurement of ^{16}O spectrum in coincidence with the ^{16}O decay products was proposed using a (p,t) reaction at 200 MeV and 0^o. The decay products of the excited ^{16}O recoil nucleus were detected by means of Double Sided Silicon Detectors and the outgoing tritons were identified in the K600 magnetic spectrometer focal plane. Data were collected with targets containing ^{18}O, ^{16}O, ^{12}C and ^{7}Li. First results on precise measurement of energy spectra of the corresponding recoil nuclei using the K600 as the master trigger and extracted cross sections will be discussed.

Poster1 / 134

xygen adsorption on (110) surfaces of Pyrolusite MnO_2 and Anatase TiO_2

Author: Ms. MAENETJA, khomotso [1]

Co-Authors: Mr. MANGWEJANE, Seshupo [1]; Prof. NGOEPE, Phuti [1]

[1] *University Of Limpopo*

Corresponding Author: khomotso.maenetja@gmail.com

Recent studies have employed manganese dioxide (MnO_2) catalysts to improve the efficiency of Li-air batteries, while other studies have revealed that the Li/O_2 cell can be recharged with high efficiency without a catalyst using an appropriate porous carbon electrode. Interestingly, charge voltages of these cells are similar to those of the MnO_2, while both of these exhibits higher charge voltages than the cobalt-catalyzed cells. However, it has been observed that in the absence of a catalyst the recharge occurs at about high voltage, a large hysteresis between charge and discharge voltages. Ab initio planewave pseudopotential method will be used to investigate the interaction of the oxygen molecule with the (110) surfaces of MnO_2, in particular tendencies of oxygen reduction. Their surface and adsorption energies were determined together with the distances between O-O of the oxygen molecule, in the vertical and horizontal orientation, the metal and oxygen molecule before and after relaxation. We found that manganese dioxide is more effective and gave lowest adsorption energies, and reduces oxygen molecule better than titanium dioxide. However the horizontal orientation of the oxygen molecule is more favourable in terms of oxygen reduction than the vertical orientation.

NPRP / 135

Fine structure of the Isoscalar Giant Quadrupole Resonance and 2^+ level densities in spherical to deformed nuclei across the isotope chain $^{142,144,146,148,150}Nd$ using the (p,p') reaction

Author: Mr. KUREBA, Chamunorwa Oscar [1]

Co-Authors: Dr. FOURIE, Dirk [2]; Ms. HEILMAN, Anna-maria [3]; Mr. JINGO, Maxwell [1]; Mr. KRUGMANN, Andreas [3]; Dr. MABIALA, Justin [4]; Mr. MIRA, Joel [2]; Dr. MURRAY, Sean [2]; Prof. VON NEUMANN-COSEL, Peter [3]; Dr. NEVELING, Retief [2]; Dr. NEWMAN, Richard [2]; Dr. PAPKA, Paul [2]; Prof. SIDERAS-HADDAD, Elias [1]; Dr. SMIT, Frederick [2]; Dr. STEYN, Deon [2]; Mr. SWARTZ, Jacobus [4]; Prof. TAMII, Atsushi [5]; Dr. USMAN, Iyabo [2]; Dr. BUTHELEZI, Zinhle [2]; Prof. CARTER, John [1]; Dr. CONRADIE, Lowry [2]; Prof. FEARICK, Roger [6]; Dr. FÖRTSCH, Siegfried [2]

[1] *University of the Witwatersrand*

[2] *iThemba LABS*

[3] *Technische Universität Darmstadt, Germany*

[4] *University of Stellenbosch*

[5] *ReseOsaka University, Japan*

[6] *University of Cape Town*

Corresponding Author: cokureba@gmail.com

A systematic experimental investigation of the phenomenon of fine structure, with emphasis on the region of the Isoscalar Giant Quadrupole Resonance (ISGQR), in nuclei across stable even-even neodymium isotopes has been performed. Measurements were made using the K600 Magnetic Spectrometer of iThemba Laboratory for Accelerator Based Sciences, a facility which is situated at Faure near Cape Town, South Africa. Unique high energy-resolution inelastic proton scattering experiments were performed at an incident proton energy of E_p = 200 MeV on targets $^{142,144,146,148,150}Nd$. Nuclei with mass number A ≈ 150 and neutron number N ≈ 90 are of special interest since they occupy that region of the nuclide chart wherein the onset of permanent prolate deformation occurs. The stable neodymium (Z = 60) isotopes have been chosen in the present study, in order to investigate the effects accompanying the onset of deformation, on the excitation energy spectra in the ISGQR region ($10 \le E_x \le 25$ MeV), since they extend from the semi-magic N = 82 nucleus (^{142}Nd) to the permanently deformed N = 90 (^{150}Nd) nucleus. An important further step is to test the effect that the transition from spherical to deformed nuclei has on level densities. Experimental details, data extraction and analysis techniques, together with preliminary results will be presented.

NPRP / 136

Determining the impact of anthropogenic activities on the environment by using In Situ gamma ray measurements.

Dr. BEZUIDENHOUT, Jacques [1]

[1] *Stellenboch University*

Corresponding Author: jab@ma2.sun.ac.za

Saldanha Bay on the West Coast of South Africa is surrounded by various nature reserves and protected areas which amongst other includes heritage sites like the West Coast Fossil Park. Large parts of these sensitive areas were however exposed to anthropogenic activities, which includes farming and mining as well as training and preparation for war. This article investigates the prospect of determining the impact that anthropogenic activities had on areas via mapping of primordial radioactive isotopes. For this purpose In Situ gamma ray data were obtained from selected locations around Saldanha Bay. The variation in radioactive isotope concentrations is compared to historical data of anthropogenic activities.

Education / 137

Four–year program students expectations and reactions

Ms. DALE, Denise [1]

[1] *University of Pretoria*

Corresponding Author: denise.dale@up.ac.za

An Investigation of students' expectations when they are accepted to study at the University of Pretoria, how they study for physics and their reactions after the first semester test. We find that most students are shocked after their first semester test, because they expected to obtain high marks and don't, or the other way around.

Poster1 / 138

Computational study of some tin dioxide phases

Author: Mr. NTIMANE, NDUMA [1]

Co-Authors: Dr. MOSUANG, THUTO [1]; Prof. RAMMUTLA, ERASMUS [1]

[1] *UNIVERSITY OF LIMPOPO*

Corresponding Author: ntimanejn@webmail.co.za

Rutile and anatase structured tin dioxide ceramics have been intensively studied in recent years because of their potential in sensing and fuel cells.The present work uses classical molecular dynamics simulations focused on the structure and possible transformation from anatase to rutile tin dioxide.The empirical Buckingham potential has been used to describe the interatomic interactions in tin dioxide.The total energy of the NVE ensemble of the two structures at various temperatures has been calculated in order to determine the transition temperature and pressure.The results obtained showed an energy increase with temperature which was constantly compared with experiments.The radial distribution functions for the two structures suggest the transformations at temperature above 900 degrees celcious in agreement with the experiments.

Applied / 141

Inflammatory response of injured diabetic fibroblasts after low intensity laser irradiation at a wavelength of 830 nm

Author: Ms. SEKHEJANE, Palesa [1]

Co-Authors: Dr. HOURELD, Nicolette [2]; Prof. ABRAHAMSE, Heidi [3]

[1] *DTech Student*

[2] *Researcher*

[3] *Research Center Head*

Corresponding Author: sekhejane@yahoo.com

Diabetes mellitus (DM) is a chronic disease characterized by impeded glucose metabolism and preceded by diabetic ulcers which are chronic due to deteriorated healing process. Hypoxia, decreased fibroblast proliferation and impaired growth factors are amongst root factors that contribute to impaired healing. Photostimulation is a non-invasive treatment that utilizes low intensity laser irradiation (LILI) to provide healing or stimulate appropriate cellular functions. Human skin fibroblast cells (WS1) were used in this study that consisted of four groups viz. normal, normal wounded, diabetic wounded and hypoxic, each with a non-irradiated control. Wounding was simulated by creating a central scratch using a pipette. A diabetic state was induced by growing cells in media that contained excess glucose to a final concentration of 22.56 mM, and for hypoxic insult cells were incubated under anaerobic conditions (0% O2 and 20% CO2) for 4 h. Cells were then irradiated at a wavelength of 830 nm with 5 J/cm2 and incubated for 1 or 24 h. Morphological changes were observed by light microscopy; ELISA and flow cytometry were used to determine interleukin (IL)-1β, IL-6 and tumour necrosis factor (TNF)-α as inflammatory markers; and caspase 3/7 for apoptosis was determined by luminescence. After a 24 h incubation period the wounded area appeared decreased and hypoxic cells had regained normal morphologic features when irradiated, TNF-α and IL-1β had decreased in irradiated samples, whereas IL-6 was increased. Caspase 3/7 had decreased in irradiated samples at both 1 and 24 h. This study demonstrated the beneficial effects of LILI since the results showed significantly reduced inflammatory response in vitro and hastened wound healing particularly under diabetic and hypoxic conditions.

Poster1 / 142

Exploratory investigation of spin density wave behaviour of a $(Cr_{86}Re_{14})_{100-y}V_y$ alloy system

Author: Mrs. JACOBS, Bincy Susan [1]

Co-Authors: Prof. PRINSLOO, Aletta [1]; Dr. SHEPPARD, Charles [1]; Prof. STRYDOM, Andre [1]

[1] *University Of Johannesburg*

Corresponding Author: sjacobs@uj.ac.za

The Cr-Re alloy system was chosen in order to investigate a previous observation of the co-existence of superconductivity and antiferromagnetism, as well as the possibility of a quantum critical point (QCP) in this alloy system. For the initial studies a $Cr_{86}Re_{14}$ mother alloy was doped with V in order to decrease the electron to atom ratio, resulting in a decrease in the Néel temperature (T_N). The preliminary study focused on first obtaining a pure body centered cubic (BCC) $Cr_{86}Re_{14}$ mother alloy, as in this alloy system, a secondary A15 phase may co-exist. X-ray diffraction and electron microprobe analyses of as-cast and annealed samples revealed only BCC structure with good homogeneity and actual Re concentration of 16 ± 1 atomic percent. In order to initiate investigations into the magnetic properties and possible quantum criticality in this system, electrical resistivity and magnetic susceptibility measurements as a function of temperature are reported for $(Cr_{86}Re_{14})_{100-y}V_y$ alloys with y = 0, 5, 7 and 9. Electrical resistivity as a function of temperature for these samples reveal an anomaly on cooling through T_N. The anomaly observed shifts down to lower temperatures as the V concentration is increased. Magnetic susceptibility data supports these observations. These promising results warrant further investigation into this alloy system with the possibility of contributing towards the current interest in quantum criticality in chromium alloy systems.

Education / 143

Contrasts between student and examiner perceptions of the nature of assessment tasks

Author: Mr. CLERK, Douglas [1]

Co-Authors: Dr. NAIDOO, Deena [1]; Dr. SHRIVASTAVA, Sanjiv [1]

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

Corresponding Author: douglas.clerk@wits.ac.za

For several years an on-going study has examined student performance in relation to the types of assessment task encountered in first year physics examinations. The typology used recognises four basic task types: routine operations, novel problems, interpretive questions and bookwork. Thus far it appears that average student performance is strongest for routine operations, variable for bookwork, weak for novel problems and weakest for interpretive questions. The present phase of the study examines the question of whether the students experience a given assessment task in the way the examiner intended – e.g. if a given question was intended by the examiner as a routine operation, do the students experience it as a routine operation or as a novel problem? The answer would appear to depend on the nature and degree of the students' preparation. In addition it seems that no one assessment task fits neatly into a single task category. A student can experience a given task as a mix of several operations, each belonging to one of the four types.

Poster1 / 144

Computational study of hematite(Fe_2O_3) and ilmenite($FeTiO_3$) structures

Author: Mr. MKHONTO, peace prince [1]

Co-Authors: Dr. ACKARMANN, Lutz [1]; Prof. NGOEPE, phuti [1]

[1] *University of Limpopo*

Corresponding Author: peace198829@hotmail.com

We investigate the transformation from hematite to ilmenite structure by solid solution approach using ab initio quantum-mechanical simulation technique. The method uses the Density functional theory with the plane-wave (PW) pseudopotential method within the CASTEP code. We performed full structural relaxation allowing lattice parameters and cell violume to change to their mechanical equilibrium. We found that the transformation process does not change the structure (space group) as observed during geometry optimization. Our calculated properties i.e bond length, cell volume, lattice parameters, bulk modulus and density of states shows that hematite and ilmenite structures have similar property behavior with the lattice parameters corresponding to the experimental value, being large by 0.12%. The bond length from 20% to 50% shows the dominant of the Ti-O bond, in agreement with the experimental value. This bond length behavior is consistent with the density of state. However, we observe that the states overlap from VB to CB in VCA which is not expected from the experimental observations of the hematite and ilmenite crystal structures. The transformation from hematite to ilmenite structure due to doping was observed from 20% atomic titanium.

Poster2 / 145

Polarization Encoded QKD in Fibre

Author: Ms. PILLAY, Sharmini [1]

Co-Authors: Mr. MIRZA, Abdul [1]; Prof. PETRUCCIONE, Francesco [1]

[1] *University of KwaZulu-Natal*

Corresponding Author: 206507614@ukzn.ac.za

Quantum Key Distribution employs the laws of quantum mechanics for the purpose of cryptography. Two parties, called Alice and Bob, are able to create a random key which is used to encrypt a message. QKD is a provably secure method for cryptography because any eavesdropper attempting to anonymously retrieve the key must make measurements, thereby disturbing the system. Using this principle, a high error rate between the two authenticated parties indicates a compromise in the system and the process by which the key is shared is aborted. The quantum channel can be implemented using a free-space link between Alice and Bob, but in many instances, this is not practical for implementations. Fibre optic cables provide an alternative with current technology. In order to implement protocols such as the BB84 protocol, the state of polarization of photons must be maintained between Alice and Bob. This is because the BB84 protocol utilizes the states of polarization of photons as qubits (quantum bits). However, the polarization of light is altered when passed through a fibre. This is due to impurities in the fibre, manufacturing errors or environmental stresses such as heating or movement. This causes refractive differences between polarized states which change the state of polarization. This property is called birefringence. Polarization mode dispersion allows for the state of polarization to be corrected when a photon is transmitted through fibre. If the fibre is fixed, the environmental stresses result in a unique and constant change of polarization [4]. This can be compensated for by rotating each photon appropriately before being measured and each length of fibre will require its own unique adjustment. If the fibre is subjected to variable conditions, changes in the state of polarization of photons must be monitored and adjustments must be made at suitable time intervals. Using this method, polarization encoded QKD can be implemented in fibre.

CMPMS1 / 147

Blended thin films of tris-(8-hydroxyquinoline) aluminium (Alq_3) embedded in polymethyl methacrylate (PMMA) and polystyrene (PS).

Author: Ms. DUVENHAGE, Mart-Mari [1]

Co-Authors: Prof. SWART, Hendrik [1]; Prof. NTWAEABORWA, Martin [1]

[1] *University of the Free State*

Corresponding Author: duvenhagem@ufs.ac.za

Alq_3 is widely used in organic light emitting diodes (OLEDs) as emission and electron transport layer. During the fabrication of OLEDs the current trend is to use solution-processing; however, Alq_3 must be vacuum deposited. One possible way to overcome this problem is to use different polymers containing the Alq3. In this study blended thin films of Alq_3 embedded in PMMA and PS matrices at different molar concentration ranging from 0.5% to 15% was investigated. The photoluminescence (PL) characteristics of the blended films of Alq_3:PMMA and Alq_3:PS was obtained. This was done by exposure of the films to 335 nm light. Emission peaks were obtained at 520 nm and 517 nm for the Alq_3:PMMA and Alq_3:PS films, respectively. The measurements were repeated for a period of one month, with one week intervals between measurements, to confirm the results and also to see if there is any decrease in luminescence intensity over time. Degradation in emission was observed during this period. Absorption measurements were performed on the blended and unblended films to investigate the effect of the polymer matrix. The x-ray diffraction (XRD) spectra confirmed the amorphous nature of the blended films. Atomic force microscopy (AFM) measurements showed that smooth uniform films had formed.

LOS / 148

Compression of highly charged electron pulses for single shot femtosecond time-resolved electron diffraction experiments

Authors: Mr. ERASMUS, Nicolas [1]; Mr. KASSIER, Gunther [1]

Co-Authors: Ms. HAUPT, Kerstin [1]; Ms. BOSHOFF, Ilana [1]; Prof. ROHWER, Erich [1]; Prof. SCHWOERER, Heinrich [1]

[1] *Stellenbosch University*

Corresponding Author: nerasmus@sun.ac.za

Obtaining single shot electron diffraction patterns is highly desirable when dealing with samples that are either destroyed or display irreversible structural changes upon photo-excitation. Such single shot measurements demand highly charged pulses that contain in the order of $10^5 - 10^6$ electrons. Maintaining femtosecond pulse duration in the presence of the inevitably large Coulomb forces inside such electron bunches is currently a major challenge in the field of ultrafast electron diffraction. One of the suggested solutions is to recompress the pulses. Conventional RF cavity compressors have been successfully constructed and implemented, but factors such as their bulkiness, high cost and difficulty of manufacturing constitute a limit to this approach. Here we present an alternative compressor concept based upon a radio frequency cavity shunted by a pair of gallium arsenide photoconductive semiconductor switches (PCSS). The PCSS's are triggered by two synchronous femtosecond laser pulses, resulting in a low jitter 5 GHz oscillation of the cavity. We report here results from our prototype device, which has achieved compression of an electron pulse containing 40 000e^-/pulse from a 14ps down to a 500fs duration, as confirmed by measurements from our in-house developed femtosecond streak camera. We believe that our electron bunch compressor device will be easier to implement and much more cost effective than traditional RF cavities.

Poster1 / 149

The annealing effects on Pt-Mo coating mophology

Mr. KHUMALO, Zakhelumuzi [1]

[1] *ithemba LABS*

Corresponding Author: zakhele@tlabs.ac.za

The study of annealing effects on platinum binary systems has both the fundamental and applied aspects. It is due to the fact that the formation of ordered domains increases the strength and surface hardness and could also have an impact on surface activity and chemical properties. The changes of mechanical, physical and chemical properties caused by annealing could be of significant importance for application of platinum systems as catalysis, gas sensors, fuel cells, glass industry, electronics and biomedicine. The Pt-Mo coatings used in this study were deposited by electron beam and sputtering methods. In order to study annealing effects the Pt-Mo coated systems were subjected to heat treatment at elevated temperatures for different annealing periods. Several complimentary techniques such as X-ray Diffraction (XRD), Rutherford Backscattering Spectroscopy (RBS), Particle Induced X-ray Emission (PIXE), and Scanning Electron Microscopy (SEM) were used for coatings characterisation.

LOS / 150

2 μm Ho doped amplifiers

Author: Dr. STRAUSS, Hencharl Johan [1]

Co-Authors: Dr. ESSER, Matthew Jan Daniel [1]; Mr. JACOBS, Cobus [1]; Dr. BOLLIG, Christoph [1]; Mr. KOEN, Wayne [1]; Mr. COLLETT, Oliver John Philip [1]; Mr. NYANGAZA, Kwanele [1]; Mr. PREUSSLER, Dieter Rainer [1]

[1] *CSIR (National Laser Centre)*

Corresponding Author: hstrauss@csir.co.za

Lasers and amplifiers emitting 2μm single-frequency pulses are used for spectroscopy, remote sensing, and defence applications. The laser sources group at the CSIR National Laser Centre has developed a number of 2μm lasers and amplifiers over the course of five years. We report on three of these, all of which achieved record breaking output energies. To generate the high energy 2μm pulses, we developed a 70mJ single-frequency, Q-switched Ho:YLF ring MOPA. Both the ring laser and pre-amplifier were pumped by a single commercial 80W, 1940nm, Tm:fibre laser from IPG. The seed laser system delivered up to 73mJ per pulse at 50Hz, with a pulse duration of ~365ns in a diffraction limited beam. This system set two world records: it delivered the highest energy from a Ho doped laser, pumped with one Tm:fibre laser, and it was also the highest single-frequency singly-doped Ho:YLF laser. In order to scale these pulse energies even further, we developed a Tm:YLF pumped slab amplifier system. Amplified single-frequency pulses of up to 210mJ were generated from a 43mm long Brewster cut Ho:YLF and a 20mm long Ho:LuLF slab crystal. However, numerical simulations indicated that longer Ho doped crystals between 80 to 120mm in length would perform significantly better. A new Ho:YLF slab amplifier was therefore built which consisted of two 50mm long crystals placed close together in series in a double seed pass configuration. This amplifier delivered >330mJ of single-frequency pulses and a small signal gain in excess of 40. This is the highest reported single-frequency 2μm energy from a Ho:YLF slab MOPA system. The high-energy 2μm pulses were then used to pump a 4μm molecular HBr MOPA, which will also be reported at this conference.

Applied / 151

Effect of Low Intensity Laser Irradiation (LILI) and Epidermal Growth Factor (EGF) on Adult Human Adipose Derived Stem Cells (hADSCs)

Author: Mr. MVULA, Bernard [1]

Co-Author: Prof. ABRAHAMSE, Heidi [2]

[1] *Doctoral Student*

[2] *SupervisorI*

Corresponding Author: bernardmvula@yahoo.com

The study investigated the effects of low intensity laser radiation (LILI) and epidermal growth factor (EGF) on adult adipose derived stem cells (hADSCs) isolated from human adipose tissue. Isolated cells were cultured in complete Dulbeco's Modified Eagle Medium (DMEM) containing 10% featal bovine serum (FBS), EGF and antibiotics and incubated at 37°C in 85% humidified atmosphere of 5% CO2. Semi-confluent monolayers of ADSCs were exposed to low intensity laser at 5 J/cm2 using 636 nm diode laser. Cell viability and proliferation were monitored using adenosine triphosphate (ATP) luminescence and optical density at 0, 24 and 48 h post irradiation. Application of low intensity laser irradiation and EGF on human ADSCs at 5 J/cm2 increased the viability and proliferation of these cells. Therefore low intensity laser therapy would probably enhance differentiation and proliferation of stem cells in vitro and these cells could be used in reconstructive surgery and tissue engineering.

NPRP / 152

Fine Structure of the Isovector Giant Dipole Resonance: a survey with (p,p') scattering at zero degrees

Author: Mr. JINGO, Maxwell [1]

Co-Authors: Prof. CARTER, John [1]; Dr. NEVELING, Retief [2]; Prof. SIDERAS-HADDAD, Elias [1]; Dr. SMIT, Fredrick [2]; Dr. FORTSCH, Siegfried [2]; Dr. BUTHELEZI, Zinhle [2]; Mr. MIRA, Joel [3]; Dr. USMAN, Iyabo [2]; Dr. MURRAY, Sean [2]; Prof. FEARICK, Roger [4]; Ms. HEILMANN, Anna-Maria [5]; Prof. TAMII, Atsushi [6]; Dr. PAPKA, Paul [7]; Ms. POLTORATSKA, Iryna [5]; Prof. VON NEUMANN-COSEL, Peter [5]; Dr. FOURIE, Dirk [2]; Dr. NEWMAN, Richard [2]; Dr. CONRADIE, Lowry [2]; Mr. SWARTZ, Jacobus [7]; Mr. KUREBA, Chamunorwa [8]

[1] *University of the Witwatersrand, South Africa*

[2] *iThemba LABS, Cape Town, South Africa*

[3] *iThemba LABS, Cape Town, University of Stellenbosch*

[4] *University of Cape Town, South Africa*

[5] *Institut fur Kernphysik, Technische Universitat Darmstadt, Germany*

[6] *Research Center for Nuclear Physics, Osaka University, Japan*

[7] *iThemba LABS, Cape Town, University of Stellenbosch, South Africa*

[8] *University of Witwatersrand*

Corresponding Author: mjingo@gmail.com

A survey of the fine structure phenomenon of the Isovector Giant Dipole Resonance (IVGDR) was investigated, using the newly commissioned Zero-degree Facility of the K = 600 magnetic spectrometer of iThemba LABS. Measurements were performed for inelastic proton scattering at an incident energy of 200 MeV for targets ranging from ^{27}Al to ^{208}Pb. Targets of areal density of 1 – 2 mg/cm^2 gave an energy resolution of 45 keV Full Width at Half Maximum (FWHM) after utilising the faint-beam dispersion-matching technique. A reasonable background subtraction procedure allowed for the extraction of excitation energy spectra with low background. The data from the survey promise to give a unique insight into the competition of the various damping mechanisms contributing to the decay of the IVGDR. Furthermore, level densities of $J^{\pi} = 1^{-}$ states can be extracted in a model-independent way, which serves as an important input to models applied in astrophysics. Finally, this survey will simultaneously provide bench-marks on the capabilities and limitations of the new Zero-degree Facility important for planning of the future experimental work. The experimental techniques, experimental results and preliminary theoretical calculations for the measurement of 0^{o} proton scattering will be presented.

CMPMS1 / 153

The electric field gradient in mercuric chloride

Dr. KEARTLAND, Jonathan [1]

[1] *University of the Witwatersrand*

Corresponding Author: jonathan.keartland@wits.ac.za

The temperature dependence of the ^{35}Cl quadrupolar resonance frequency has been measured in a high purity sample of mercuric chloride ($HgCl_2$) over the temperature range 4 K - 460 K. The results allow the temperature dependence of the electric field gradient (efg) at the two inequivalent sites of the chlorine atoms to be determined. Several models were considered to describe the experimental observations, including both librational and vibrational modes. The Bayer model for librational modes provides a satisfactory description of the changes in the efg over the entire temperature range, when the temperature variation of the lattice modes is taken into account, while the other mechanisms considered provide less convincing descriptions. A single librational mode with a wavenumber of approximately 26 cm^{-1} can account for the variation of the electric field gradient over the temperature range investigated. Our conclusions are consistent with the results of optical spectroscopy investigations.

Poster2 / 154

X-ray Timing and Spectral Analysis of the Propeller Driven Pulsar-like White Dwarf AE Aquarii

Author: Mr. ORURU, Bosco [1]

Co-Author: Prof. MEINTJES, Pieter Johannes [1]

[1] *University of the Free State*

Corresponding Author: orurub.sci@ufs.ac.za

The highly transient multi-wavelength system AE Aqr consists of a fast rotating highly magnetic WD, accreting mass from a K3-5 secondary companion. This magnetic CV has a characteristic orbital period of 9.88 h, and is in a propeller state. The turbulent interaction between the fast spinning WD magnetosphere and the accretion flow is believed to play a crucial role in the multi-wavelength emission in the system. We have analysed the system's X-ray lightcurves and spectra from data observed with Chandra and Swift-XRT, and the results of this study show that the X-ray characteristics are unique. In this paper, the results of the analysis will be discussed, with the view to propose suitable models for the X-ray emission mechanisms.

Applied / 155

Remote detection of light organic elements using PET

Author: Mr. COOK, Martin [1]

Co-Authors: Prof. CONNELL, Simon [1]; Mr. BALLESTRERO, Sergio [1]; Mr. MOTLOUNG, Setumo [1]; Mr. CHINAKA, Eric [1]; Mr. BORNMAN, Faan [2]

[1] *University of Johannesburg*

[2] *Multotec*

Corresponding Author: cookish@gmail.com

We look at the use of Positron Emission Tomography to detect light organic elements in two different contexts, namely to locate diamonds within partially crushed kimberlite (Mineral PET), and to locate buried land mines. Light organic elements such as carbon have traditionally proved difficult to locate, and currently mines crush rock down to a fine size, and then employ manual sorting methods to find diamonds. If diamond bearing rocks could be identified before the final crush, up to 98% of the electricity and water used for crushing could be saved, and larger diamonds preserved. The proposed technique is to use bremsstrahlung from a 40 MeV electron source to excite the giant dipole resonance in target nuclei, which have a large branching ratio to decay by emission of a neutron, forming PET isotopes. Such isotopes release positrons, which annihilate to create back-to-back 511 keV gamma rays. A 3D density map of possible sources allows the identification of hotspots. Complications arise from having to account for the excitation of many different nuclei, and having to distinguish diamond from homogeneously distributed carbon. In order to be industrially feasible, small diamonds need to be located, requiring significant advances in detection and image processing. We will look at simulations of the process, imaging algorithms, quantifying radiation doses and detector technologies. Land mines are a huge global problem. 2009 estimates place the number of buried land mines at over 100 million, covering approximately 3 000 square kilometers of land worldwide. Between 1999 and 2008, these have lead to 73 576 mine casualties in 119 countries. Overall demining programme costs in third world environments are typically one to two million dollars per square kilometer of cleared land. Advances in land mine technology mean that mines can contain little or no metal, making demining an expensive, slow and dangerous activity. Most common elements in explosives are PET emitters, including Oxygen, Carbon, Nitrogen and Flourine, raising the possibility that PET could provide an effective method of mine detection.

Poster1 / 156

Spin-density-wave behaviour of the $(Cr_{100-x}Al_x)_{95}Mo_5$ alloy system

Author: Mr. MUCHONO, Blessed [1]

Co-Authors: Prof. PRINSLOO, Aletta [1]; Dr. SHEPPARD, Charles [1]; Prof. ALBERTS, Herman [1]; Prof. STRYDOM, Andre [1]

[1] *University of Johannesburg*

Corresponding Author: muchonoblessed@gmail.com

Previous studies in our laboratory on the $(Cr_{100-x}Al_x)_{95}Mo_5$ alloy system through electrical resistivity and magnetoelastic measurements suggest that spin-density-wave (SDW) antiferromagnetism is fully suppressed down to 4 K in the concentration range $2.0 \leq x \leq 5.0$ at.% Al. The current interest in quantum criticality in Cr and Cr alloy systems warrants further detailed investigation into this aspect. In this regard we report results of electrical resistivity, Seebeck coefficient and Sommerfeld electronic specific heat coefficient (obtained from specific heat measurements) for an extended alloy range $0 \leq x \leq 8.1$ at.% Al. The Seebeck coefficient turns out to be a more sensitive parameter than electrical resistivity in obtaining magnetic phase transition temperatures for this alloy system, particularly for the commensurate (C) SDW phase region $x \geq 5.0$ at.% Al. The electrical resistivity and Seebeck coefficient data depicts total suppression of AFM down to 2 K for $1.5 \leq x \leq 5.3$ at.% Al. The results of Sommerfeld electronic specific heat coefficient confirms this finding, showing a sharp increase in the incommensurate (I) SDW phase up to $x \approx 1.5$ at.% Al, roughly leveling off in the paramagnetic range $2.0 \leq x \leq 4.6$ at.% Al, followed by a slow decreasing trend in the CSDW phase $x \geq 5.0$ at.% Al. From the present study it appears that both points ($x \approx 1.5$ at.% Al, $T = 0$ K) and ($x \approx 5.0$ at.% Al, $T = 0$ K) are possible quantum critical points on the magnetic phase diagram of the $(Cr_{100-x}Al_x)_{95}Mo_5$ alloy system. It is then rather unique to have both ISDW-P and P-CSDW quantum critical points existing in the same alloy system.

APSS / 157

A Comparison of the THINGS HI and HERACLES CO Velocity Dispersion in Nearby Galaxies

Mr. MOGOTSI, Keoikantse Moses [1]

[1] *UCT*

Corresponding Author: moses.mog@gmail.com

In this project data from The HI Nearby Galaxy Survey (THINGS) and from the HERA CO Extragalactic Line Survey (HERACLES) is being used to compare the HI (neutral hydrogen) and CO dispersions in nearby galaxies in order to see if they are related. This is important in improving star formation laws (as they currently only use HI dispersions, but stars form from molecular gas) and to better understand turbulence in galaxies. Preliminary analysis indicates that the HI has higher velocity dispersions than the CO.

LOS / 158

Demonstration of a wavelength tuneable mid-IR molecular laser

Author: Mr. KOEN, Wayne [1]

Co-Authors: Dr. STRAUSS, Hencharl [1]; Dr. ESSER, Daniel [1]; Mr. JACOBS, Cobus [1]; Dr. BOTHA, Lourens [1]

[1] *CSIR National Laser Centre*

Corresponding Author: wkoen@csir.co.za

To our knowledge, we have demonstrated the first optically pumped tunable HBr oscillator lasing on both the P- and the R-branches. Through the implementation of an intra-cavity diffractive grating, we could tune the wavelength over a range of 538 nm from 3872 nm to 4410 nm. A single-frequency Ho:YLF ring laser and amplifier system was used as pump source. The oscillator was pumped in a double pass configuration with 50 mJ, 2064 nm pulses at a repetition rate of 50 Hz. The HBr was kept at 52 mBar, 20 degrees Celsius in a 510 mm tube. The resonator cavity consisted of a flat output coupler mirror with a reflectivity of R=80% at 4 µm, and a high-reflective coating at 2 µm. The input coupler mirror had a concave curvature of 5 m and was coated to be highly reflective at 4 µm and highly transmissive at 2 µm to allow pumping of the HBr. The input coupler mirror was slightly tilted to reflect light unto a flat mirror which in turn reflected unto the diffractive grating which was blazed at 5 µm. The diffractive holographic grating therefore acted as the backreflector mirror, and the wavelength could be selected by rotating the grating. Lasing was demonstrated on eight lines of the P-branch with wavelengths ranging from 4102 nm to 4410 nm, and five lines of the R-branch ranging from 3872 nm to 3999 nm. The highest output energy for the given pump power was 1.1 mJ at 4131 nm.

Education / 159

Foundation Provision: Any Difference in Students' Performance?

Author: Ms. SONDEZI-MHLUNGU, Buyi [1]

Co-Author: Mr. MOLEFE, Paul [1]

[1] *University of Johannesburg*

Corresponding Author: bmhlungu@uj.ac.za

Science, Engineering and Technology (SET) have become essential in the development of the country in all its facets. It has been observed over the past few years that students entering university for degree studies in their respective fields experience considerable level of difficulty. Inadequate understanding of basic mathematics and physics concepts has been identified as a critical deficiency characterizing the performance of SET first year students. As a norm, the intake is usually based on Grade 12 results. Admission to mainstream (three year) programme or a four year extended programme is determined on the basis of M-Scores by various respective institutions. Analysis of students' performance in the four year programme at the University of Johannesburg painted a bleak picture and this led to the introduction of the Foundation Provision Programme (PFP) as a precursor to the normal first year curriculum. This programme serves to adequately develop the basic or foundational competencies necessary for students to embark on successful first year physics studies and beyond. The sample in this study comprised a group of freshmen from Grade 12 registered for various degrees in Science , Engineering and Optometry. All these groups receive physics tuition in one lecture class. The Foundation Provision Programme was implemented for the first time at the University of Johannesburg in 2010 and the results obtained were compared to the results of students' performance obtained from previous years.

APSS / 160

CMB Tensor Anisotropies in f(R) Gravity

Author: Mr. BOURHROUS, Hassan [1]

Co-Authors: Dr. DE LA CRUZ-DOMBRIZ, Alvaro [2]; Prof. DUNSBY, Peter [1]

[1] *University of Cape Town*

[2] *University of Cape Town/Universidad Complutense de Madrid*

Corresponding Author: hassan.bourhrous@uct.ac.za

The cosmic microwave background (CMB) carries information from the last scattering surface that puts constraints on the multitude of proposed cosmological models and the gravity theories they are based on. Amongst such theories are the f(R) theories of gravity which have become an interesting endeavour to correct for the degeneracies of the concordance model. We present a description of CMB anisotropies generated by tensor perturbations in f(R) theories of gravity. The power spectra of the observables TT and EE in the special case of $f(R)=R^n$ are computed using a modified version of CAMB.

CMPMS2 / 161

Magnetic properties of carbon nanospheres at low temperatures

Author: Mr. DUBAZANE, Makhosonke [1]

Co-Authors: Dr. KEARTLAND, Jonathan [1]; Mr. MISHGINA, Yosief [1]

[1] *University of the Witwatersrand*

Corresponding Author: jonathan.keartland@wits.ac.za

The magnetic and electrical properties of nitrogen doped carbon nanospheres can be probed using Electron Magnetic Resonance (EMR) techniques. Previous Raman spectroscopy studies show that both the pristine and doped spheres are graphitic in character. However, XRD measurement showed that these spheres consist of graphitic crystallites embedded in an amorphous phase. Previous ESR measurements showed large peak on nitrogen doped spheres, implying that the nitrogen occupies substitutional sites in graphitic lattice. The EMR measurements clearly showed large Curie-type paramagnetism at low temperatures for all the samples investigated. The EMR peak-to-peak linewidth have provided evidence of the phonon bottleneck effect in one of the sample investigated, meaning to say that there is a strong interaction between localized and conduction electrons. The broadening of linewidth may be manifested by a Korringa type interaction whereby the spin-lattice relaxation time T_1 is inversely proportional to the temperature. The sample with the highest concentration of nitrogen behaves very differently from the other samples studied in th temperature range 77 K to 300 K, and this behaviour is not well understood at present. This may involve contributions from electron scattering with stationary nitrogen impurities, and therefore different spin relaxation mechanisms which are related to the Elliot and Yafet mechanisms.

Poster2 / 162

Atomic processes in gaseous nebulae

Ms. PROZESKY, Andri [1]

[1] *Unisa*

Corresponding Author: prozeskya@gmail.com

The atomic physics relevant to gaseous nebulae is critically examined using modeling software with particular emphasis on recombination spectral lines that occur in the radio regime. The spectral line intensities that we observe from nebulae can be deduced if we know the population structure of the bound electrons in the gas under non-thermal equilibrium conditions. The population structure of hydrogen is solved for various environments using a capture-collision-cascade model. The validity of assuming Case B of Baker & Menzel (1938) when modeling astronomical nebulae is investigated. It is known that Case B is appropriate for levels with small principle quantum numbers ($n < 40$), but this assumption should be re-examined for high energy levels which are relevant to radio recombination lines. The effect of an ambient radiation field on the population structure is examined and processes that are stimulated by a radiation field are included in the model. This is done as a preliminary investigation to extend the model to a full photoionization code that will be geometry-dependent and include an external radiation field as well as the diffuse field that is emitted by the nebula itself.

Poster1 / 163

Minimization of optically active structural defects in MOCVD grown ZnO films using oxygen and NO

Author: Dr. DANGBEGNON, Kouadio Julien [1]

Co-Authors: Mr. TALLA, Kharouna [1]; Prof. BOTHA, Johannes [1]

[1] *Nelson Mandela Metropolitan University*

Corresponding Author: dangbegnon01@gmail.com

The optical and structural properties of ZnO grown with a mixture of oxygen and nitric oxide as oxidants are investigated. With R defined as the ratio of oxygen to nitric oxide molar flow rates, samples grown with $R \geq 1$ (i.e. a higher low rate of oxygen compared to nitric oxide) reveal a 3D growth mode with columns perpendicular to the substrate, while for $R < 1$ a preferential 2D growth mode is observed. The low temperature photoluminescence studies show that the columnar growth observed for $R \geq 1$ coincides with an increase in intensity of the transitions around 3.31 eV arising from structural defects whereas this emission is quenched for $R < 1$. The disappearance of the transition at 3.31 eV is followed by the emergence of a transition at ~3.356 eV, which is assigned to an acceptor bound exciton related to nitrogen. Furthermore, this transition is not visible in the oxygen-rich regime, due to the high density of structural defects in the samples. This work aims to show the importance in minimizing structural defects in order to achieve acceptor bound exciton emission in ZnO doped with nitrogen and possibly stable p-type ZnO.

Applied / 164

On the Thermal and Electrical Properties of Low Concentrator Photovoltaic (LCPV) Modules

Author: Mr. GERBER, Jacques [1]

Co-Authors: Prof. VAN DYK, Ernest [2]; Dr. VORSTER, Frederik [2]

[1] *Nelson Mandela Metropolitan University*

[2] *NMMU*

Corresponding Author: jacquesdgerber@gmail.com

Efficient thermal management of low concentrator photovoltaic (LCPV) modules ensures that the maximum power capabilities of the LCPV system are harnessed, and may substantially prolong the operating lifetime of the photovoltaic (PV) cells. A general understanding of the thermal transfer properties of PV modules is thus necessary to effectively design, construct, and implement viable LCPV systems. A basic thermal model based on one-dimensional heat transfer was developed and includes various energy dissipation mechanisms, such as convection and radiation. Panel fans were used to simulate air flow across the surface of the PV module and temperature measurements of the front and back surface of the PV module were recorded to analyse energy dissipation in accordance with the basic thermal model. Initial results indicate that 50% of the incoming irradiance is dissipated through convection and radiation. Optical losses will also be incurred through reflection from the surface of the PV module. The basic thermal model manages to account for most of the energy incident on a PV module, and thus effectively illustrates the principle of energy conservation within the PV system.

Applied / 165

Miniaturization of electrostatic ion engine through ionization/acceleration coupling: corona model

Author: Mr. TCHONANG POKAHA, Marius [1]

Co-Author: Dr. FERRER, Phil [1]

[1] *Wits University*

Corresponding Author: mariust82@gmail.com

Electrostatic ion propulsion systems resist miniaturization due to constraints imposed by the size of the discharge chamber. We introduce a thruster concept where the same field is responsible for both ionization of the neutrals and acceleration of the ions, by letting the neutral propellant gas escape into a high field region through a thin, hollow needle at high electric potential. The ionization mechanism is thus reminiscent of corona ionization. Although the thruster only ionizes a small fraction of the neutral gas, the ions nevertheless impart a great deal of momentum to the plume, creating an ion wind. We propose a model to estimate the electric behavior of the system, and two further models for the obtained thrust. A comparison with experimental data shows that the models capture the dominant physical effects and give a reasonable description of the system. Apart from being about a thousand times less massive than conventional systems, the thruster, which is at the proof-of-concept stage, performed quite well yielding around 0.3 mN/Watt during initial tests. The thruster small size and simplicity are advantageous in many situations, such as for satellite station keeping and deep space probes.

Poster1 / 167

Vanadium dioxide based on nano-devices for photonic apllications

Mr. MADIBA, itani given [1]

[1] *university of western cape*

Corresponding Author: itanibravo@webmail.co.za

Vanadium dioxide falls into the category of smart thermochromic materials, one where the property of the material changes due to the effect of temperature. High quality pure thermochromic thin films of vanadium dioxide were prepared by using two physical methods, Rf-reactive sputtering and pulsed laser deposition methods. These deposition methods were used to study the effect of deposition temperature on vanadium dioxide thin films microstructure, electrical and optical properties. The deposition conditions (oxygen pressure, substrate-target distance, substrate temperature and etc) on both methods were carefully optimized for the quality of VO2 thin films on a glass substrate, with a substrate temperature ranging from 350-600 degrees celcius. All the vo2 thin films prepared by Pulse laser deposition technique and Rf- reactive sputtering were characterized by X-ray diffraction technique, observed to be crystallized showing the first peak at 27.87 degrees celcius which corresponds to the (011) plane and the monoclinic structure of VO2. This peak indicates the existence of Vanadium dioxide. Thermochromic properties of VO2 thin films were investigated by measuring the optical and electrical properties below and above the critical temperature using the UV/VIS technique. T he atomic force microscopy was also used to investigate the surface roughness of all the VO2 thin films. RBS was used for quantitative analysis of composition, thickness and depth profiles of VO2 thin films and it was conducted using a 2 MeV beam of alpha particles, other techniques as well as TEM, SEM, FTIR were also employed to investigate the morphology, composition, and crystallographic information on VO2 thin films.

Poster2 / 168

Current Status of Ultrafast Electron Diffraction at the Laser Research Institute

Author: Ms. BOSHOFF, Ilana [1]

Co-Authors: Ms. HAUPT, Kerstin [1]; Mr. ERASMUS, Nicolas [1]; Dr. KASSIER, Gunther [1]; Prof. ROHWER, Erich [1]; Prof. SCHWOERER, Heinrich [1]

[1] *University of Stellenbosch (Laser Research Institute)*

Corresponding Author: iboshoff@sun.ac.za

We will show the changes and improvements made to the Ultrafast Electron Diffraction setup which led us to doing the first time-resolved experiments. We have implemented beam tracking and correction systems in both the pump and probe beams, ensuring that we keep spatial overlap during a measurement. By using a different cathode and metal coating we were able to improve the electron efficiency. These improvements enable us to do measurements of up to 20 hours without losing the electron signal. Preciously a commercial 8-bit Nikon camera was used to gather data. We have switched to a 16-bit EHD CCD Camera to increase the amount of information we get from one data point. Previous problems concerning the background were solved by reducing the electron energy and applying a small voltage to the sample holder to prevent photo electrons from reaching the detector. A big challenge in UED is the preparation of thin (<100nm) samples. We will show the techniques we use to overcome this problem.

Applied / 169

Optical design of low concentration photovoltaic modules

Author: Mr. BENECKE, Mario [1]

Co-Authors: Prof. VAN DYK, Ernest [1]; Dr. VORSTER, Frederik [1]

[1] *Nelson Mandela Metropolitan University*

Corresponding Author: mario.benecke@gmail.com

The benefit of concentrating sunlight onto solar cells is that expensive solar cell material can be reduced and replaced with relatively inexpensive optical elements, which has the potential to reduce the cost of solar energy. In low concentration photovoltaics (LCPV), solar cells are subjected to higher irradiance levels. The electrical output, and hence efficiency of a LCPV module is dependent on the amount of irradiance, temperature and more importantly the uniformity of illumination across the solar cells. This paper discusses the design and characterization of the optical subsystem of a LCPV concentrator. By optimizing the aperture area of the LCPV concentrator while still maintaining a uniform illumination intensity across the solar cells, the module's electrical performance can be maximized. In the study a mathematical model was developed to design and evaluate suitable optical elements for LCPV application. This model was based on a facetted reflector that was designed to meet a predetermined set of boundary conditions. Initial evaluation of an experimental LCPV concentrator, based on this type of design, will be discussed in this paper. Results from the model illustrate the angles and positions of receiver and reflectors for maximum geometric concentration ratio as well as the best illumination profile across the receiver.

Poster2 / 171

Efficiency Dependence of Tm3+ -Doped Silica Triple-Clad Fiber Laser

Author: Mr. NDEBEKA, Wilfrid [1]

Co-Authors: Mr. HEIDT, Alexander [2]; Prof. SCHWOERER, Heinrich [2]; Prof. ROHWER, Erich [2]

[1] *MSc Student*

[2] *University of Stellenbosch (Laser Research Institute)*

Corresponding Author: ndebeka@sun.ac.za

We present measurements of the slope efficiency of a Tm3+ -doped silica triple-clad fiber laser emitting at 2.02 µm using different cooling techniques. The maximum slope efficiency of 53.6 % was obtained at a temperature of 25o C with a maximum output power of 5 W for 19 W of absorbed power at the pump wavelength of 800 nm and 9.9 W threshold. In a slightly different setup, the output power could be increased to 10 W for an absorbed pump power of 32 W.

NPRP / 172

Higgs Searches with the ATLAS Detector Using Data Collected in 2010 at the LHC

Dr. ASSAMAGAN, Ketevi Adikle [1]

[1] *Brookhaven National Laboratory*

Corresponding Author: ketevi@bnl.gov

Experiments at the Large Hadron Collider (LHC) aim to address fundamental questions in particle physics such as the origin of mass for elementary particles, the matter/anti-matter asymmetry in the universe, the nature of Dark Matter, the state of matter in the early universe, etc. The ATLAS detector is one of the four major detectors being exploited at the LHC to shed some light on the questions. The Higgs boson is a hypothesized particle responsible for the elementary particle masses. In this talk, we will discuss the search strategies of the Higgs boson with the ATLAS detector at the LHC. In particular, we will present results based on the ATLAS data collected in 2010.

Theoretical / 173

A comparison of purification schemes for treating the idempotency condition on the density matrix in electronic structure calculations

Prof. HOFFMAN, Matthiam [1]

[1] *UFS*

Corresponding Author: hoffmamj@ufs.ac.za

During the last 15 years there has been considerable interest in density matrix based methods for electronic structure calculations. The "difficult" problem of ensuring idempotency conservation of the density matrix through an appropriate purification scheme as well as the use of the "nearsightedness" and associated sparsity of the density matrix to achieve linear scaling with system size has been discussed by various authors. In this study a density matrix based fictitious electron dynamics method for calculating electronic structure is used in a model nanoparticle calculation. This method uses an equation of motion that implicitly ensures the idempotency constraint on the density matrix. The effectiveness of this method compared to conventional purification schemes is discussed. Important properties of the density matrix and its sub matrices, including its sparsity and conditions for effective linear independence of a column sub matrix of the density matrix are discussed and illustrated within the context of this model system. It is shown how the full density matrix can be reconstructed through a fast QR factorization of a column sub matrix using a Choleski factorization of its principal sub matrix.

Education / 174

On the Possibility of Visualizing and Minimizing Student Disappointment

Author: Ms. THOMAS, Anitta [1]

Co-Author: Prof. BOTHA, André [1]

[1] *UNISA*

Corresponding Author: thomaa@unisa.ac.za

In recent years student satisfaction surveys have become increasingly popular in universities. Whether this gain in popularity is because students themselves know best when they are learning, or whether it is because universities merely wish to ensure that they have satisfied customers, is still a matter of debate. Nevertheless, the importance of student satisfaction surveys in universities is undeniable, and consequently it is of interest to understand the most important contributing factors to student satisfaction, or equivalently to student disappointment. By induction, based on our own teaching experience, we have made the following bold postulate: Students will be least disappointed in courses where they perform equally well in all aspects of the course that are assessed. Conversely, students will be most disappointed in courses where they perform very differently in two or more assessments of the course. In science courses, for example, there are typically four different assessments: a practical, three or four assignments, a midterm exam, and a final exam. Although the above hypothesis remains untested in this preliminary work, some of its consequences will be explored through the visualisation of assessment data gathered at the University of Victoria, Canada. In this talk a new way of visualizing and understanding the various components of the assessment data will be presented. The visualisation is constructed to be consistent with the above hypothesis. A concrete example of how the visualization may be used in a modern university setting, the problem of adjusting marks is considered. Such mark adjustments are apparently necessary to increase throughput rates. In this case it is shown that the visualization may be used to achieve an optimized adjustment which both increases the throughput rate and at the same time minimizes student disappointment, assuming the hypothesis is correct.

Poster2 / 175

Femtosecond amplifier pulse characterization: FROG and shaper-assisted techniques

Author: Mr. HENDRIKS, Attie [1]

Co-Authors: Dr. DU PLESSIS, Anton [2]; Dr. UYS, Herman [3]; Dr. BOTHA, Lourens [2]; Ms. BOTHA, Nicolene [4]

[1] *SAIP member*

[2] *Supervisor*

[3] *Project manager*

[4] *Co-worker*

Corresponding Author: ahendriks@csir.co.za

We present pulse characterization of various amplified shaped pulses, using second harmonic autocorrelation, frequency resolved optical gating (FROG), as well as their analogue techniques using only the pulse shaper and no moving parts in the experimental setup. This involves creating double pulse seperations using the pulse shaper only and recording the resulting SHG autocorrelation and FROG signals. Pulse shaper assisted characterization is presented in detail for our setup which includes an acousto-optic programmable dispersive filter (Dazzler) coupled with a Matlab program incorporating pulse energy stabilization to compensate for shaper efficiency changes.

Poster1 / 176

Ion sputtering yield coefficients from In thin films bombarded by different energy Ar^+ ions

Author: Mr. MADITO, Moshawe [1]

Co-Authors: Prof. SWART, Hendrik [2]; Prof. TERBLANS, Koos [2]

[1] *Student*

[2] *University*

Corresponding Author: maditomj@ufs.ac.za

Noble gas ion sputtering combined with Auger analysis has been applied extensively to determine the elemental composition as function of sputtering depth. Data from these depth profiles have been used to determine the sputter yield coefficients (S) of elements that are of fundamental interests in many fields, such as in: sample preparations particularly were the sputter ion source is applied, surface cleaning (the surface is usually cleaned by cyclic ion bombardment and annealing), and understanding the theoretical studies of ion sputtering, etc. Many published data on the Auger-ion (Ar^+) sputtering of indium (In) focused on In compounds like indium nitride (InN), indium phosphide (InP) etc. In this study, the focus is on metal In films that were grown by electron beam evaporation on silica substrates. The APPH's (Auger peak to peak heights) were measured while the In films were subjected to different energy Ar^+ ion sputtering. The Ar^+ ion energy was varied from 0.5 to 4.0 keV. The normal to the film surfaces was kept at a tilt angle of 30^o with respect to the direction of the incident electron beam. The sputter yield coefficients (S) of the In films were determined as 4.5, 6.4, 10.6, 11.5 and 10.7 atoms/ion for the Ar^+ energies 0.5, 1.0, 2.0, 3.0 and 4.0 keV respectively.

Poster1 / 177

AES and XRD study of In/Cu thin films deposited onto SiO_2 by electron beam evaporation

Author: Mr. MADITO, Moshawe [1]

Co-Authors: Prof. SWART, Hendrik [2]; Prof. TERBLANS, Koos [2]

[1] *Student*

[2] *University*

Corresponding Author: maditomj@ufs.ac.za

In order to investigate the diffusion of indium (In) when an In thin film is coated with a copper (Cu) thin film, thin In/Cu films were grown on a silicon dioxide (SiO_2) substrate. Both the In and the Cu layers were grown by electron beam evaporation. The temperature during evaporation of the films ranged between 27 and 38 ^oC. The In films (500 Å) were coated with Cu films (500 Å and 1000 Å). The films were characterized with X-ray diffraction (XRD) and Auger electron spectroscopy (AES). The In/Cu layers interdiffused during evaporation and formed intermetallic $CuIn_2$ and $Cu_{11}In_9$ phases. The In layer completely reacted with the Cu layers during the deposition process. The In layer was effectively coated with a Cu layer (1000 Å). The In (500 Å)/Cu (1000 Å) films were annealed at temperatures ranging between 150 and 300 ^oC for times varying between 25 and 121 min. For annealed films the diffraction data demonstrated peaks only for Cu and $Cu_{11}In_9$ and AES depth profiles pointed out the stability of the $Cu_{11}In_9$ and In diffusion to the surface of the film. The results of this work provide insight towards the In doping of Cu crystals at temperatures higher than the melting point of In (156.6 ^oC).

Applied / 178

Ionizing Radiation as Imaging Tool in Coal Characetrization and Gasification Research

Author: Mr. HOFFMAN, Jakobus [1]

Co-Authors: Prof. CAMPBELL, Quentin [2]; Mr. DE BEER, Frikkie [1]

[1] *Necsa*

[2] *North West University*

Corresponding Author: jakobus.hoffman@necsa.co.za

Around 70 million tones of coal are burned annually in power stations whilst around 50 million tones of coal are converted to chemicals in the petrochemical sector in the same period of time. Researchers, nationally and internationally, aim to optimize the processes to extract the most energy from the limited coal reserves. One such petrochemical process that is of significance to South Africa is gasification, since many industrially important chemicals and fuels are produced through the gasification process of coal. The process of gasification is influenced by many factors including temperature, pressure, coal composition, coal size, etc. and an understanding of each of these factors is crucial to optimize and manage a gasifier. The primary ways in which information is obtained on these factors are usually destructive experimental methods that are applied to powders and small particles. Powders and very small particles are not representative of the mined coal since it usually represents either average or homogeneous coal structures. It is therefore beneficial to conduct research on coal in order to study the coal structure and processes to beneficiate coal in a non-destructive fashion. One such technique is micro-focus X-ray Computed Tomography (CT) which enables the researcher to visualize and quantify the coal composition and spatial distribution of constituents and voids (cleats and fractures). Armed with this knowledge the scientist can investigate and optimize conversion processes such as gasification as well as other physical process (methane extraction and carbon dioxide adsorption). This presentation deals with the characterization of coal and the investigating of the first stages of gasification in a non-destructive manner. Coal particles with two distinct coal macerals (organic components) were investigated and the information obtained was compared to data from a thermo gravimetric analyzer (TGA). The main objective of this study was therefore to obtain a better understanding of gasification through a non-destructive analytical technique.

LOS / 179

The mean focal length of an aberrated lens

Author: Mr. MAFUSIRE, Cosmas [1]

Co-Author: Prof. FORBES, Andrew [1]

[1] *CSIR National Laser Centre*

Corresponding Author: cmafusire@csir.co.za

We outline an approach for the calculation of the mean focal length of an aberrated lens, and provide closed form solutions that show that the focal length of the lens is dependent on the presence of defocus, x-astigmatism and spherical aberration. The results are applicable to Gaussian beams in the presence of arbitrary sized apertures. The theoretical results are confirmed experimentally, showing excellent agreement. As the final results are in algebraic form, the theory may readily be applied in the laboratory if the aberration coefficients of the lens are known.

LOS / 180

Tracking a quantum wavefunction in the presence of noise

Author: Dr. UYS, Hermann [1]

Co-Author: Prof. KONRAD, Thomas [2]

[1] *National Laser Centre, CSIR*

[2] *UKZN*

Corresponding Author: huys@csir.co.za

We simulate real-time quantum state estimation due to a sequence of so-called "unsharp" measurements applied to a two-level system undergoing Rabi oscillations. These measurements allow an experimentalist to extract information about the system without destroying the quantum state. They can be realized physically through the use of auxilary quantum states in addition to the quantum state of interest. Here we demonstrate that high fidelity state estimation is possible even in the presence of significant dephasing and amplitude noise, thus allowing the quantum state to be monitored long beyond the coherence time set by the noise in the absence of measurements.

CMPMS1 / 181

The Magnetocaloric Effect in Ferromagnetic PrSi: Evidence of a Novel Magnetic Gound State and Higher Order Exchange Interactions

Author: Mr. SNYMAN, Jasper Snyman [1]

Co-Author: Prof. STRYDOM, Andre [1]

[1] *University of Johannesburg*

Corresponding Author: jaspersnyman@gmail.com

The discovery of the giant magnetocaloric effect (MCE) in $Gd_5Si_2Ge_2$, a member of the substitution series $Gd_5Si_{4-x}Ge_x$ has generated significant interest into MCE phenomena in rare earth intermetalic compounds. Much recent effort has gone into determining how the MCE in such systems is influenced by the many salient features associated with rare earth magnetism. Here the MCE in polycrystalline ferromagnetic PrSi is determined from specific heat measurements. While the magnitude of the MCE in PrSi is found to be modest when compared to other binary systems, the power of MCE analyses in probing electronic and ground-state properties in magnetic systems is emphasized in this work. We forward a description in terms of a novel magnetic ground state for the 4f -electrons associated with the Pr^{3+} -ions in this particular compound. It is found that the MCE in this system can be accurately reproduced by modeling the system as a modified Ising-type ferromagnet with the addition of a significant higher order exchange term and assuming that the ground state of the 4f-electrons is the unperturbed 9-fold degenerate free-ion spin-orbit coupled ground state multiplet. Such a ground state would imply that the usual splitting of the degenerate energy levels of the free ion multiplet by the crystalline electric field is absent in this system, which in turn implies that significant multipolar interactions may be responsible for the higher order exchange terms present in the magnetic Hamiltonian.

Poster2 / 182

An automated temperature control model for a well-mixed biomass reactor

Author: Mr. PAGONA, FELIX [1]

Co-Author: Dr. MAKAKA, GOLDEN [2]

[1] *PHYSICS DEPARTMENT, UNIVERSITY OF FORT HARE*

[2] *PHYSICS DEPARTMENT*

Corresponding Author: felixpagona@gmail.com

A mathematical model for temperature control in a continuously stirred tank reactor is developed. The startegy used involves a coil immersed in a coolant which proves to provide sufficient heat removal by controlling the coolant flow rate in exponential mode. The approach shows that specific ranges of exponents for the coolant flow rate must be used for the reactor to operate optimally.

Poster1 / 183

Crystalline Electric Field Effects in $PrNiGe_2$

Author: Mr. SNYMAN, Jasper Snyman [1]

Co-Author: Prof. STRYDOM, Andre [1]

[1] *University of Johannesburg*

Corresponding Author: jaspersnyman@gmail.com

Within the confines of the standard model of rare earth magnetism, the high temperature magnetic properties of rare earth ions in a crystalline environment are identical to the magnetic behaviour of free tri-positive rare earth ions. At low temperatures deviations from free-ion behaviour occur due to the action of an anisotropic crystalline electric field (CEF). For Pr^{3+}-ions in a low symmetry crystalline environment it is expected that the 9-fold degeneracy of the spin orbit coupled ground state multiplet associated with the free tri-positive ion should be completely uplifted by the CEF yielding a non-magnetic singlet ground state for the Pr^{3+} 4f-electrons. $PrNiGe_2$ is known to order ferromagnetically despite the fact that the Pr^{3+} ions occupy the low-symmetry m2m sites in the CeNiSi2-type structure. This has prompted the current study into the ground state properties of $PrNiGe_2$. The structure of the CEF-split energy levels in this system could be determined from specific heat measurements. The analyses point to the formation of a pseudo-doublet ground state in the system, and we forward a conceptual explanation of the observed magnetic order in $PrNiGe_2$ in terms a fortuitous merging of electronic singlet levels into a local level dispensation of higher degeneracy.

CMPMS2 / 184

Light scattering studies of boron carbide films grown by laser ablation: thin-film surface quality and elasticity

Author: Dr. MATHE, Bhekumusa [1]

Co-Authors: Prof. COMINS, Darrel [1]; Prof. SCHONING, Frederich [1]

[1] *University of the Witwatersrand*

Corresponding Author: bhekumusa.mathe@wits.ac.za

Covalently bonded solids based on boron, carbon, or nitrogen are the hardest materials, and B4C is the third hardest after diamond and cubic boron nitride. Thin films of boron carbide were formed by pulsed laser deposition at room temperature and at higher temperatures up to 800 o C using a sintered B4C target. Whilst the nature of the particulates embedded in the films and the composition and bonding states of the films is known to vary depending on the laser fluence, it is of considered interest in this study to understand how the surface quality, microstructure and tensile properties of B4C would depend on substrate temperature. The deposition parameters such as the laser intensity, vacuum, supporting gas conditions, target-substrate distance, would be controlled such that only substrate temperature is used to modify the film properties and composition. Raman scattering studies and AFM measurements would be used to probe the microstructure and bonding of the film as the substrate temperature is varied, whilst Brillouin scattering measurements would be used examine the elasticity changes.

LOS / 185

Radiometric studies of South African Water bodies

Author: Mr. RAMKILOWAN, Arshath [1]

Co-Authors: Dr. LYSKO, Meena [1]; Dr. CHETTY, Naven [2]

[1] *CSIR*

[2] *University of KwaZulu-Natal*

Corresponding Author: aramkilowan@csir.co.za

Maintaining, monitoring and safeguarding South Africa's oceans and dams is a multifaceted project requiring the skills and expertise from several scientific domains-.The radiometric study and spectral characterization through in situ measurements of these water systems is critical to such a project. The objective is to develop and subsequently test 2 prototype radiometers for their reliability and efficacy, then pending accurate results, the manufacturing of several low cost radiometers. These radiometers will be deployed at strategic locations in oceans and dams around South Africa to monitor eutrophication levels. By closely observing the eutrophication stages of these water bodies an early warning system for detecting the initial stages of algal blooms is formed. This is of interest not only to oceanographers and biologists but also the military. An additional benefit of the prototype radiometers is that they provide means of validating ocean colour data obtained from satellites. As a result, the data captured from decades earlier can be used with true confidence; such data can be directly linked to climate studies including global warming and global cooling.

Education / 186

How do the features of experiments influence the experience of first year physics students?

Author: Mr. VAN DER MERWE, Johan [1]

Co-Author: Dr. BEZUIDENHOUT, Jacques [1]

[1] *Military Academy*

Corresponding Author: jpvdm@ma2.sun.ac.za

The Faculty of Military Science of Stellenbosch University presents an Algebra-based Physics course to first year students. The practical component comprises of a range of experiments that differ significantly in characteristics. Questionnaires are yearly completed by the students to evaluate the theoretical and practical components of this course. This paper will explore some of the results of these surveys, focusing especially on the experience of the student with regards to the features of experiments that are presented.

Poster1 / 187

The Magnetocaloric Effect in CeAuGe: Scaling Behaviour in the Vicinity of a Ferromagnetic Phase Transition

Author: Mr. SNYMAN, Jasper Snyman [1]

Co-Authors: Mrs. SONDEZI-MHLUNGU, Buyisizwe [1]; Prof. STRYDOM, Andre [1]

[1] *University of Johannesburg*

Corresponding Author: jaspersnyman@gmail.com

The magnetocaloric effect (MCE) may become strongly enhanced in systems exhibiting a second order magnetic phase transition due to critical behaviour of the order parameter in close proximity of the transition region. Recently it has been shown that, analogous to the order parameter, the MCE shows scaling behaviour with the applied magnetic field along the critical isotherm. It has been argued that this behaviour should be indicative of the universality class of the system. Using ferromagnetic CeAuGe as a model system with high crystallographic and atomic order, we have determined the MCE from specific heat measurements in various applied fields. In the low field limit we observe scaling behaviour reminiscent of a mean field ferromagnet. However, in progressively larger applied fields the MCE in CeAuGe significantly exceeds that of the mean field reference system, indicating that the refrigeration capacity of CeAuGe is significantly larger than that of a model mean field ferromagnet. Our results are contextualized in terms of a more general amenability of local-moment magnetic compositions as model systems for magnetic refrigeration.

CMPMS1 / 188

Low voltage electron beam induced degradation and surface chemical changes of $Zn_3(PO_4)_2$:Tb phosphor

Author: Dr. NAGPURE, I M [1]

Co-Authors: Prof. SWART, H C [1]; Dr. PITALE, Shreyas S [1]; Dr. COETZEE, Liza [1]; Prof. NTWAEABORWA, O M [1]; Prof. TERBLANS, J J [1]

[1] *University of The Free State*

Corresponding Author: indrajitnagpure@yahoo.co.in

The investigation of low voltage electron induced cathodoluminescence (CL) degradation of $Zn_3(PO_4)_2$:Tb phosphor has been extended for possible application in low voltage field emission displays (FED). There are two important reasons for studying phosphate based phosphors. These are their chemical, thermal stability and variation in emission colour, which is influenced by the site occupied by the light emitting cations. The CL degradation phenomenon under low voltage electron beam irradiation of $Zn_3(PO_4)_2$ has however not been reported so far. The primary objective of this study was to investigate the correlation between the CL emission intensity, CL degradation behaviour and the changes on the surface chemistry from the $Zn_3(PO_4)_2$:Tb phosphor after prolonged electron beam exposure. The $Zn_3(PO_4)_2$:Tb^{3+} phosphors was synthesized by a sol-gel combustion method. The surface chemical reactions and influence on the CL intensity induced by a prolonged electron beam bombardment were monitored using in situ Auger electron spectroscopy (AES) combined with CL spectroscopy. The chemical state of the surface before and after prolonged electron exposure of $Zn_3(PO_4)_2$:Tb^{3+} phosphor to electron beam was determined using X-ray photoelectron spectroscopy (XPS). The bluish green CL emission that were obtained with minor emission peaks at 380, 420, 440 nm were due to the transition from excited level $^5D_3 \rightarrow {}^7F_6$, $^7F_5$, and $^7F_4$ levels of Tb^{3+} ions, while the peaks at 490, 542, 584 and 620 nm were due to $^5D_4 \rightarrow {}^7F_{6,5,4,3}$ transitions when the powders were irradiated with a 2 keV and 10 uA electron beam. AES data suggested that the Tb^{3+} CL intensity decreases with an increase in the electron dose rate. The XPS data suggested that a thermodynamically stable ZnO and P_2O_5 layer formed on the surface as a result of the electron stimulated surface chemical reactions (ESSCRs). The continues growth of this layer is contributing to the continues CL degradation of the $Zn_3(PO_4)_2$:Tb phosphor.

APSS / 189

NON-SPECIALIST: Cosmic-ray modulation studies – why Parker needed Dirac and Kolmogorov

Prof. BURGER, Renier [1]

[1] *North-West University*

Corresponding Author: adri.burger@nwu.ac.za

In 1958, Eugene Parker predicted that the outer parts of the Sun's atmosphere, the solar corona, must be expanding in the form of a supersonic solar wind. This was confirmed by the Mariner 2 spacecraft in 1962. On 16 December 2004, the Voyager 1 spacecraft crossed the heliospheric termination shock, where the flow becomes subsonic, and began exploring the heliosheath. In August 2007, Voyager 2 also crossed the termination shock. The plasma properties of the heliosheath differ greatly from those of the heliosphere inside of the termination shock and particle transport beyond the termination shock is not yet fully understood. Different approximations of the cosmic-ray transport equation, originally derived by Parker in 1965, have been used for decades to study cosmic-ray modulation in the region inside of the termination shock, the focus of this presentation. Cosmic rays that reach Earth are subject to diffusion, convection, adiabatic energy changes, and gradient- and curvature drift due to the non-uniform heliospheric magnetic field. The consequence is that cosmic-ray intensities at Earth are lower than the interstellar value and is referred to as modulation. The turbulent heliospheric magnetic field is frozen into the supersonic solar wind. Inside of the termination shock the two hemispheres with oppositely directed magnetic field is separated by the so-called wavy neutral sheet, across which the magnetic field changes direction. We discuss how modulation studies have progressed from using simple spherically symmetric solutions of Parker's transport equation, to the current situation where in order to properly account for diffusion and drift, complex turbulence transport models are required as well as detailed knowledge of the form of turbulence energy spectra, the latter which include the so-called inertial range derived by Kolmogorov in 1941. Turning to plasma physics, we show that what appear to be two very different kinds of drift motion, along and away from the neutral sheet, actually follow from the standard expression for gradient- and curvature drift, provided that the particle distribution is nearly isotropic. In the course of this derivation one is confronted by a Dirac delta function that must be replaced by something physically acceptable without changing the physics involved. We also discuss why we can study the drift coefficient which determines drift velocity, while using a uniform background magnetic field that obviously does not cause large-scale drifts.

NPRP / 190

Comparison of thermal and structural Properties of HRT nuclear fuel Composite and nuclear graded graphite

Author: Ms. MUROVHI, phathutshedzo [1]

Co-Author: Dr. MANYALA, Ncholu [2]

[1] *university of pretoria*

[2] *University of Pretoria*

Corresponding Author: murovhip@ul.ac.za

Graphite composite comprising of 64 wt% of natural graphite, 16 wt% of synthetic graphite and 20 wt% of phenolic resin binder heat treated at 1800 0C have been used to encapsulate the TRISO coated fuel particles in the PBMR and considered to serve in the initial state of neutron moderation as well as heat conduction. The structural and thermal properties of the pristine and irradiated samples will be compared to IG110 nuclear graphite so as to check its degree of applicability in the nuclear reactor. The structure and disorder of both materials is investigated using X-ray diffraction (XRD) and Raman spectroscopy, while Low and high temperature thermal and electrical properties is investigated using physical property measuring system (PPMS) and laser flash analyser (LFA) respectively.

APSS / 191

Solar-cycle dependent relationship between cosmic-ray intensity and the heliospheric current sheet tilt angle

Author: Mr. MOLOTO, KATLEGO [1]

Co-Author: Prof. BURGER, ADRI [1]

[1] *NORTH WEST UNIVERSITY*

Corresponding Author: katlego.daniel@gmail.com

We investigate cosmic-ray intensities as measured by neutron monitors as function of the corresponding heliospheric current sheet tilt angle. Three solar cycles with three changes in solar magnetic polarity are examined. The results are compared to predictions of cosmic-ray modulation models that include drift effects. The intensity-tilt plots produce open loops with clockwise rotations for solar cycles 21 and 23 and with anticlockwise rotation for solar cycle 22, as predicted by drift models. However, the observed intensity-tilt loops for cycles 21 and 23 are larger than the loop for cycle 22 contrary to the drift model predictions. To explain this difference we use the time dependence of the tilt angle and show that the loops then become very similar. We show that from this renormalization, the approximate time it takes for particles to travel from the termination shock to Earth can be estimated, and that the time is consistent with model predictions.

Poster2 / 192

Analysis of aberrations generated in aerodynamic random media using computational fluid dynamics

Author: Mr. MAFUSIRE, Cosmas [1]

Co-Author: Prof. FORBES, Andrew [1]

[1] *CSIR National Laser Centre*

Corresponding Author: cmafusire@csir.co.za

Media generated by random mixing of hot and cold gases can be of great importance for laser beam propagation. However, it is not always possible to represent the media's behaviour using simple formulation. This opens the door for the use of numerical methods. We show that, for aerodynamic media, we can use computational fluid dynamics (CFD) software to acquire density distribution data to characterize both local and overall behaviour of the media. Using the Gladstone-Dale law, we acquired refractive index distribution which we use to calculate Zernike coefficients from the respective local phase values at various sections of the media. We show that once we have this data, we can simulate the propagation of laser beams of various shapes in such media. We apply the method to analyse a spinning pipe gas lens (SPGL) which is a horizontal pipe whose walls are heated rotated along its axis. We show that the results from the model agree with the SPGL experimental results.

LOS / 193

Phase calibration of the Shack-Hartmann wavefront sensor using a phase-only spatial light modulator

Author: Mr. MAFUSIRE, Cosmas [1]

Co-Author: Prof. FORBES, Andrew [1]

[1] *CSIR National Laser Centre*

Corresponding Author: cmafusire@csir.co.za

The phase measurements of a Shack-Hartmann wavefront sensor are calibrated. The process involves creating holograms of known amounts of individual phase aberrations on a spatial light modulator and reflects an aberration free laser beam off of the modulator’s liquid crystal display thereby giving the beam that aberration. The beam is then relayed onto the sensor for direct measurement. The results show that the method is accurate to the extent that the results accurately replicate the response of the wavelength calibration of the spatial light modulator.

Poster1 / 194

Electrical Resistivity and magnetic properties of (Ce1□xTbx) Pt2Si2 (0 □ x □ 1)

Author: Mr. MAHLUBI, zwelithini [1]

Co-Authors: Prof. TCHOULA TCHOKONTE, Moise Bertin [2]; Prof. DU PLESSIS, Paul de Villiers [3]; Prof. KACZOROWSKI, Dariuzs [4]; Prof. DOYLE, Terry [5]

[1] *University of the western cape*

[2] *1) Department of Physics, University of the Western Cape, Private Bag X17, Bellville 7535, South Africa.*

[3] *2) Department of Physics, University of Johannesburg, P.O.Box 524, Auckland Pack 2006, South Africa.*

[4] *4) Institute of Low Temperature and Structure Research, Polish Academy of Sciences, PO Box 1410, 50-950 Wroclaw, Poland.*

[5] *5) Material Research Group, iThemba LABS, PO Box 722, Somerset West 7129, South Africa.*

Corresponding Author: zmahlubi@uwc.ac.za

Measurements of X-rays diffraction (XRD), electrical resistivity □(T), magnetic susceptibility □(T), and magnetization □(μ0H) are repeated for the pseudo-ternary alloy (Ce1□xTbx) Pt2Si2. XRD results for all the compositions of (Ce1□xTbx) Pt2Si2 system indicate a tetragonal CaBe2Ge2-type structure. □(T) results indicate evolution from coherent Kondo lattice to incoherent single ion Kondo scattering with increase in Tb content up to x=0.8, and followed by a metallic behavior above x = 0.8. □(T) data at high temperatures follow the Currie-Weiss relation for all alloy compositions and give effective moment value μeff which increases gradually from value of 2.54 μB for Ce3+- ion to the expected values of 9.72 μB for Tb3+ -ion. The alloys compositions in the concentration range of 0.7 □ x □1 exhibit antiferromagnetism and the low temperature □(T) data were used to find the Neel temperature TN as a function of x. □(μ0H) data are presented for all investigated compositions.

Poster1 / 195

The Surface Orientation Dependence of the Pre-Exponential Factors Extracted from the Segregation Profiles of a Cu(111/110) Bi-crystal

Author: Mr. JAFTA, Charl [1]

Co-Authors: Prof. ROOS, Wiets [2]; Prof. TERBLANS, Jacobus [2]; Dr. ASANTE, Joseph [3]; Prof. OZOEMENA, Kenneth [1]

[1] *Energy and Processes Unit, CSIR*

[2] *Physics Department, University of the Free State*

[3] *Physics Department, Tshwane University of Technology*

Corresponding Author: jaftacj@ufs.ac.za

Previous experimental investigations have only shown, without explanation, that the pre-exponential factor (D_0), in the diffusion coefficient of Sb segregating in Cu, is dependent on the surface orientation of a crystal. In this study, the surface concentration of Sb in a Sb doped Cu(111/110) bi-crystal was measured using a method combining AES and linear temperature heating. Segregation parameters, including the D_0's are extracted from the experimental data of surface concentration versus temperature using the modified Darken model. The difference in the two pre-exponential factors D_0 (Sb in Cu(111)) and D_0 (Sb in Cu(110)) is explained thermodynamically in terms of entropy change ΔS that is calculated, for the first time, for a Cu(111/110) bi-crystal.

Poster2 / 196

Generation of a Laguerre-Gaussian TEM01 mode in a monolithic microchip laser

Author: Mr. NAIDOO, Darryl [1]

Co-Authors: Prof. FORBES, Andrew [1]; Prof. AÏT-AMEUR, Kamel [2]

[1] *Council for Scientific and Industrial Research*

[2] *CIMAP—ENSICAEN*

Corresponding Author: dnaidoo3@csir.co.za

We explore a method in the selection of a specific higher-order mode through judicious shaping of the pump light to create a high modal overlap with the desired mode. To demonstrate this principle, we create a donut-shaped pump profile in the focal plane of a converging lens by use of a beam shaping element. This pump profile is used to longitudinally pump a monolithic microchip laser and a plano-concave resonator cavity where we achieve a TEM01 output with powers of ~12 mW and ~14 mW at slope efficiencies of 17% and 21% respectively. In both cases the modal purity is high with a beam quality factor of ~2. Diffractive pump shaping of this form is advantageous as it allows for high pump intensity even with low pumping powers, thus ensuring sufficient gain is achieved for laser oscillation.

LOS / 197

Decomposition of the field within an apertured plano-concave resonator

Author: Mr. NAIDOO, Darryl [1]

Co-Authors: Prof. FORBES, Andrew [1]; Prof. AÏT-AMEUR, Kamel [2]

[1] *Council for Scientific and Industrial Research*

[2] *CIMAP—ENSICAEN*

Corresponding Author: dnaidoo3@csir.co.za

A method of experimentally decomposing a field within an apertured plano-concave resonator cavity into a forward propagating field (plane to concave) and a backward propagating field (concave to plane) is presented. The use of an intra-cavity aperture which is a simple method of laser beam shaping is a means of mode selection as higher-order modes are actively discriminated. This apertured cavity is modelled by two fundamental resonator theories, namely, Fox-Li analysis and Laguerre-Gaussian decomposition where they are used in the determination of the respective beam profiles at a specific plane. These theories traditionally differ from one another for an apertured cavity where the Gaussian beam within the cavity is truncated. A preliminary set-up is characterized for Gaussian propagation in an attempt to verify that the cavity is viable and accurate. A comparison of experimental data with the theories is presented.

Poster1 / 198

Low temperature synthesis and characterization of ZnO nanoparticles using Polyvinylpyrrolidone (PVP)

Author: Ms. TSHABALALA, Modiehi Amelia [1]

Co-Authors: Prof. DEJENE, Francis [1]; Prof. SWART, Hendrik [1]

[1] *University of the Free State*

Corresponding Author: tshabalalama@qwa.ufs.ac.za

ZnO and PVP capped ZnO nanoparticles were synthesised using the sol-gel method at low temperature with ethanol as a solvent, zinc acetate as a precursor and methanol as the cleaning agent. The influence of temperature on the morphology, structure and the optical properties of the ZnO nanoparticles were investigated. The effect of addition different molar masses of the PVP during the synthesis on the ZnO emission peaks was systematically monitored. Polyvinyl pyrrolidone (PVP) is utilized to cap ZnO nanorods from a zinc acetate precursor at low temperature, since the PVP can be easily removed by burning the solid products. The photoluminescence (PL) characterization of the ZnO nanostructures exhibited a broad emission in the visible range with maximum peaks at 449 and/or 530nm, this was influenced by the addition of different molar masses of the PVP. The scanning electron microscopy (SEM) images of ZnO and PVP capped ZnO has showed the presence of the agglomerated ZnO particles which could be due to the agglomeration of the smaller particles. The x-ray diffraction (XRD) spectra for ZnO nanoparticles show the entire peaks corresponding to the various planes of wurtzite ZnO, indicating a single phase. The absorption edges of these ZnO nanoparticles are shifted by additions of PVP polymer. The absorption spectra of the ZnO showed slight shifts with reference to the various molar masses of PVP.

Theoretical / 199

The Giant Graviton on AdS4xCP3

Author: Dr. PRINSLOO, Andrea [1]

Co-Authors: Mr. GIOVANNONI, Dino [2]; Dr. MURUGAN, Jeff [2]

[1] *NITheP, Stellenbosch University*

[2] *University of Cape Town*

Corresponding Author: andyprinsloo@sun.ac.za

A new correspondence between type IIA string theory on AdS4×CP3 and an N=6 Super Chern-Simons-matter theory was proposed by Aharony, Bergman, Jafferis and Maldacena (ABJM) in 2008. We construct the D4-brane giant graviton, extended and moving in the complex projective space, which is dual to a subdeterminant operator in ABJM theory. This dynamically stable configuration factorizes at maximum size into two topologically stable D4-branes (each wrapped on a different CP2 cycle) dual to ABJM dibaryons. We also mention our more recent results obtained from an analysis of small fluctuations around this CP3 giant graviton.

Theoretical / 200

Decoherence-assisted transport in a dimer system

Authors: Dr. SINAYSKIY, Ilya [1]; Ms. MARAIS, Adriana [1]

Co-Authors: Prof. PETRUCCIONE, Francesco [1]; Prof. EKERT, Artur [2]

[1] *UKZN and NiTheP*

[2] *Mathematical Institute, University of Oxford and Centre for Quantum Technologies, National University of Singapore*

Corresponding Author: adrianamarais@gmail.com

The transfer of energy and information in quantum networks plays an important role in both quantum communication and quantum computation. The quantum system inevitably interacts with the surrounding environment, and such interaction leads to dissipation and decoherence, which are processes typically associated with a destruction of quantum coherence in the system. However, recently evidence of surprisingly long-lived quantum coherence has been identified in conjugate polymers and in photosynthetic light harvesting complexes. Here, the dynamics of a dimer under the influence of decoherence are studied. An exact analytical expression for the transition probability in the dimer system is obtained for different situations, i.e., for the dimer coupled to two independent environments, and coupled to two correlated environments, both in a spin star configuration. In all cases considered, it is shown that there exist well-defined ranges of parameters for which decoherent interaction with the environment assists energy transfer in the dimer system. In particular, it is found that correlated environments can assist energy transfer more efficiently than separate baths. This simple and analytically solvable model for energy transfer in a dimer system is easily extendible to more complex quantum networks, and more complex environmental models.

Applied / 201

The Unique Capabilities of Radiation Beam Lines at Necsa as Probes

Author: Mr. DE BEER, Frikkie [1]

Co-Author: Dr. NOTHNAGEL, Gawie [1]

[1] *Necsa*

Corresponding Author: frikkie.debeer@necsa.co.za

The concept of radiation, in the scientific and analytical environment is normally not understood and has being neglected and not considered as analytical probe due to the lack of knowledge of the general public and researchers about its potential as analytical probe, the misunderstanding of the possible "danger' in the utilization thereof and the "unavailability" of facilities in South Africa for researchers to utilize. Gamma-rays, neutrons and X-ray's have not any significance for a researcher unless they are controlled and directed in beams with considerable intensity. These collimated beams have major potential in revealing the "unknown" information normally hidden within the objects under investigation e.g. nuclear materials, museum artifacts', precious fossils, concrete, etc. This paper is an introduction to the unique properties of neutron- and X-ray radiation beams in general. The capabilities of these beams as analytical probes are discussed with special attention to the beam line facilities located at Necsa. The availability of these beam lines to be utilized by post graduate students and researchers will be highlighted.

NPRP / 202

Capabilities of Accelerator Beam Lines in Research and Development at Necsa

Author: Mr. DANIELS, Graham [1]

Co-Authors: Dr. FRANKLYN, Chris [1]; Dr. NOTHNAGEL, Gawie [1]

[1] *Necsa*

Corresponding Author: graham.daniels@necsa.co.za

P-LABS at Necsa consists of two linear particle accelerator facilities; a Van de Graaff with terminal potential up to 4 MV and two radio frequency quadrapole (RFQ) accelerator systems that can accelerate D+ ions to 3.7 - 5.1 MeV (or protons to 1.8 – 2.5 MeV). Depending on the beam target used these accelerators can produce fast neutrons (and associated gamma rays) at a rate of 10^6 - 10^12 n/cm^2/s. One can utilize the high penetrative nature of the fast neutrons as well its ability to distinguish between different elements, to conduct radiography and tomography on samples. These fast neutrons can also be used to conduct time of flight analysis. One can also utilize the associated gamma rays together with the fast neutrons for material identification and non destructive testing including identification of threat material within cargo. Utilization of the Monte Carlo Neutral Particle code (MCNP) is also done to simulate the facility and experiments beforehand. Some of the techniques currently being investigated will be presented here.

Poster1 / 203

Synthesis and Characterization of $CaAl_2 0_4$:Tb^{3+} Phosphor using Solution – Combustion Method.

Author: Ms. FOKA, Kewele Emily [1]

Co-Authors: Prof. DEJENE, Francis [2]; Prof. SWART, Hendrik [2]

[1] *University of the Fee Stae*

[2] *University of the Free State*

Corresponding Author: fokake@qwa.ufs.ac.za

Presently Ca $Al_x O_y$:Tb green phosphors are mainly prepared by the solid-state process which is more feasible than others in terms of operation and large-scale production. However, the raw materials are usually not mixed well and very high temperature is needed to synthesize the final powder using the solid-state process. In order to solve these problems, Terbium ion doped calcium aluminate (Ca $Al_x O_y$:Tb^{3+} green phosphors were obtained at low temperatures (500ºC) by the solution - combustion of corresponding metal nitrate–urea solution mixtures, over a time of 5 min. The morphology and structural properties were characterized by scanning electron microscopy (SEM) and X-ray diffraction (XRD), SEM shows that the particles are irregular shape and are aggregated and the structural analysis revealed the presence of monoclinic $CaAl_4O_7$ at optimized fuel to nitrate molar ratio. The characteristic luminescence properties were investigated using emission spectra. It was found that the oxidizer: fuel molar ratios showed greatly influence not only on morphology, but also on their PL spectra. The photoluminescence (PL) excitation spectrum was characterized by a dominant broad band centered on 239 nm. Intense emission bands were observed at 489 nm, 544 nm, 587 nm and 622 nm originating from the $^5D_4$ to ^7F_J transition and other bands were observed at 379, 417 and 438nm originating from $^5D_3$ to ^7F_J transition, which correspond to the crystal field splitting components of the Tb^{3+} 4f states in Ca $Al_4 O_7$. The effects of doping concentration of Tb^{3+} on luminescence lifetimes and intensities were also investigated. The samples with Tb concentration of 1.0 mole % exhibited the highest luminescence enhancement and longer luminescence lifetimes.

Poster1 / 204

Use of raman spectroscopy to study fatigue type processes in polycrystalline diamond (PCD)

Author: Mr. VHARETA, Maxwell [1]

Co-Authors: Prof. COMINS, Darrel [1]; Dr. ERASMUS, Rudolph [1]

[1] *University of the Witwatersrand*

Corresponding Author: maxwell.vhareta@students.wits.ac.za

Polycrystalline diamond (PCD) cylindrical cutters used in oil well drilling are susceptible to fracture due to the hostile environment of randomly occurring high impact loads. These cutters commonly consist of a PCD layer sintered onto a cobalt-tungsten carbide (Co-WC) substrate. The fact that the cutters fail after repeated use gives rise to the possibility of fatigue type processes in diamond. The study of stress fields and their relative geometries thus become crucial in the quest to have extended lives for these cutters. Since the diamond Raman line reveals both the nature and magnitude of the stress present in the material this technique was employed in this work. Room temperature measurements show a general compressive stress field on the PCD before being fatigued using a ball on three balls test rig and it then gradually deteriorates to a residual tensile stress field. Whereas a general compressive stress is desirable in the PCD layer as it inhibits the propagation of cracks, on the contrary tensile stresses facilitate formation of cracks leading to catastrophic failure of the cutters.

LOS / 205

Accurately and precisely determining the strength of an optical trap

Author: Ms. ISMAIL, Yaseera [1]

Co-Author: Dr. FORBES, Andrew [1]

[1] *CSIR-National Laser Centre*

Corresponding Author: yismail@csir.co.za

Since its inception, optical trapping has found its place in the field of physics, biology and recently in micro-fluidics. To a physicist, this technique opens up avenues to carry out force measurement with utmost accuracy and precision on the micro-scale level. This is attained by measuring the magnitude of the trapping force required to restrain a trapped particle to its equilibrium position. Here three such methods will be discussed in light of their relevance to the current optical system in the laboratory. The most direct method carried out was the drag force method, by keeping the particle fixed while accurately controlling the movement of the automated stage we were able to measure the magnitude of the force applied to a particle in order to release it from the trap. Alternatively, since trapped particles are submerged in liquid medium, any thermal fluctuation within the medium would lead to the trapped particle displacing from its equilibrium position. Under this condition, the particle is said to behave as a simple harmonic oscillator. By measuring the variation of the trapped particle with respect to its equilibrium position we were able determine the trap stiffness using the Equipartition theorem. Lastly, we discuss the Allan variance method. Since most systems contain some form of noise, the Allan variance method was used to eliminate any form of white noise that could exist to accurately and precisely determine the trapping force using CMOS technology. Most scientific programs can be used to determine the Allan variance; we used Labview as a platform for the analysis. An overview of all the methods mentioned will be discussed in detail to give an understanding of the most accurate and precise method of calibrating an optical trap.

LOS / 206

Time-domain Terahertz Spectroscopy: Principles and applications

Author: Dr. NEETHLING, Pieter [1]

Co-Authors: Dr. STEENKAMP, Christine [1]; Prof. ROHWER, Erich [1]; Ms. NUMAN, Nagla [1]

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

Corresponding Author: pietern@sun.ac.za

Time-domain terahertz (TD-THz) spectroscopy has emerged as a valuable tool for studying material properties in the THz region of the electromagnetic spectrum. Many classes of materials exhibit characteristic absorption signatures in this previously unstudied portion of the electromagnetic spectrum. This opens up the possibility for non-destructive and non-invasive testing and analysis of materials which previously have proven difficult. Time domain T Hz spectroscopy entails measuring the electric field of the generated THz pulse in the time domain, and extracting the spectral information from the pulse through a Fourier Transform. Two main mechanisms for generating short, broadband THz pulses have emerged namely optical rectification in a nonlinear crystal of a femtosecond laser pulse and THz generation from a photo-conductive antenna (PCA). Recently, a photo-conductive antenna TD-THz setup has been established at the Laser Research Institute, University of Stellenbosch. This presentation will focus on the basic principles of operation and on the layout of the setup as well as the possible applications envisaged using the setup.

Applied / 207

Application of Dual Energy X-ray Radiography/Tomography on Nuclear and Related Materials

Author: Mr. NDANDULENI, Takalani [1]

Co-Author: Dr. DE BEER, Frikkie [2]

[1] *University of Johannesburg*

[2] *Necsa*

Corresponding Author: 802017520@student.uj.ac.za

This study investigates the principle and capabilities of Dual Energy X-Ray Radiography/Tomography when applied on nuclear and related materials. The dual-energy X-ray technique is a significant improvement to X-ray imaging systems and gives additional information on the composition of the object being imaged. Within this technique, two radiographs are obtained at two distinct X-ray energies and are combined (divided, subtracted) to give detailed information about the material features with improvement of the image contrast. X-rays for this research, will be generated with a new 225 kV microfocus X-ray system to be commissioned by June 2011 at the Nuclear Energy Cooperation of South Africa (Necsa). This system will be able to generate different peak energy X-rays at different anode target materials at very small focal spot sizes in order to obtain high-resolution images. Different X-ray filters will be utilized to shape the energy of the X-ray beam for high energy X-rays to interact with the material. This presentation focuses on the principles of X-ray generation with different anode materials and the utilization thereof in radiographs and tomograms.

Applied / 208

Monitoring a grid-assist photovoltaic system

Author: Mr. ALISTOUN, Warren [1]

Co-Authors: Dr. VORSTER, Frederik [1]; Prof. VAN DYK, Ernest [1]

[1] *NMMU*

Corresponding Author: warrenalistoun@yahoo.com

Recent developments in electricity regulatory environment and the possible inclusion of small, kW-scale, photovoltaic (PV) systems in the feed-in tariff framework has led to an increased interest in these systems. In South Africa, grid reliability issues are not fully mitigated by employing a straight grid-tie PV system, with users sometimes wanting some battery backup for load-shed periods at night. In this study a system comprising a PV array, maximum power point tracker, a battery bank and inverter was monitored using a custom-build data acquisition system. The monitored parameters include; environmental conditions, DC and AC power, and energy flow within the system. This paper will discuss the influence of environmental parameters and load requirements on the performance of the system. Issues such as soiling and other loss mechanisms are also discussed.

LOS / 209

Validation of a numerical simulation to study the decoherence of quantum orbital angular momentum entanglement due to atmospheric turbulence

Author: Mr. HAMADOU IBRAHIM, Alpha [1]

Co-Authors: Dr. ROUX, Filippus [1]; Prof. KONRAD, Thomas [2]

[1] *CSIR, National Laser Center*

[2] *University of Kwazulu-Natal*

Corresponding Author: aibrahim@csir.co.za

The orbital angular momentum (OAM) state of light has been the object of much interest within the quantum information community lately mainly because it can be used to implement higher dimensional entanglement. Unfortunately, the OAM cannot be used for quantum communication through optical fibers in use today because these fibers support only modes with zero OAM values. One can alternatively use free-space communication. However, one needs to understand how atmospheric turbulence affects quantum entanglement. In recent years, numerical simulation has become a very important and successful approach for solving complex problems and to gain more insight into scientific phenomena. In this work, we present a numerical simulation to study the decoherence of quantum entanglement between a pair of qubits due to atmospheric turbulence. The qubits are photons entangled in their OAM mode. The photons propagate in a turbulent atmosphere modeled by a series of consecutive phase screens based on the Kolmogorov theory of turbulence and the concurrence is used as entanglement measure. We validate our simulation scheme with the formula derived in "Nature Physics 4 99 - 102 (2008)" stating that the entanglement reduction under a one-sided noisy channel is independent of the initial state and completely determined by the channels action on a maximally entangled state.

CMPMS2 / 210

The radioactive ion beam facility project at iThemba Labs and its potencial uses for materials research

Author: Prof. PINEDA-VARGAS, Carlos [1]

Co-Author: Dr. BARK, Rob [1]

[1] *iThemba LABS*

Corresponding Author: pineda@tlabs.ac.za

An introduction to the new development project on the implementation of a radioactive ion beam (RIB) facility at iThemba LABS will be presented. In particular with relation to the uses of the RIB for the application of research in condense matter and materials research. Some leading examples by international laboratories using radioactive nuclei as probes to enhance the understanding of structural and/or electronic/magnetic lattice environment in materials (metals, insulators or semiconductors) will be also presented. The main procedures of such investigations are implantation induced lattice damage and its annealing behavior, the lattice site of the implanted ion after annealing, the interaction between impurities or impurities and intrinsic defects, the electronic and optical properties of the implanted species and the identification of defects and impurities. The understanding and the control of diffusion profiles of intrinsic and extrinsic defects particularly in semiconductors is significantly enhanced using radioactive tracer diffusion.

Education / 211

Aspects of DC circuits: a fine grained investigation of student conceptions

Author: Mr. JOHN, Ignatius [1]

Co-Author: Prof. ALLIE, Saalih [2]

[1] *CPUT*

[2] *UCT*

Corresponding Author: johni@cput.ac.za

This is the second part of our study, where we are analysing the reasons and explanations behind each answer of each student. In the first part of our study (2010) using an open circuit (battery, single wire, resistive element) in which the resistive element (resistor, heating element, light bulb) and the words ("current', "charge flow") are inter-changed in an electrically equivalent circuit and the students answers were found to be influenced by the different elements and words.

CMPMS2 / 212

Tungsten Oxide Nanostructures synthesized by Laser Pyrolysis

Author: Mr. GOVENDER, Malcolm [1]

Co-Authors: Prof. SIDERAS-HADDAD, Elias [2]; Prof. FORBES, Andrew [1]; Mr. ERASMUS, Rudolph [2]; Dr. MWAKIKUNGA, Bonex [1]; Mr. SHIKWAMBANA, Lerato [1]

[1] *CSIR*

[2] *University of the Witwatersrand*

Corresponding Author: mgovender2@csir.co.za

Laser pyrolysis has been used to synthesize tungsten oxide (WO3-x) nanostructures, and here we report on the production of six-sided nanostars. The proposed mechanism used to explain the growth of the stars is the concentration difference and gradient mechanism which speculates that a high local concentration of one reactant mixed with a low concentration of another reactant under ambient conditions, and the high concentration favoured the thermodynamic conditions for crystal growth and the low concentration resulted in a diffusion-controlled kinetic environment for growth of hierarchical structures. Apart from precursor concentration, further analysis was carried out to determine the influence of varying laser wavelengths and power densities in such experiments. The laser wavelength was varied between 9.22-10.82 m at a fixed power density of 51.2 W/cm2, and the laser power density was varied between 17-110 W/cm2 at a fixed wavelength of 10.6 m. Annealing the samples at 450oC in argon atmosphere for 17 hours appeared to be an essential step for further growth of nanostructures. Particle size and morphology were determined by scanning and transmission electron microscopy and the chemical composition was determined by x-ray diffraction studies in conjunction with Raman spectroscopy and energy dispersive x-ray spectroscopy to confirm the tungsten oxide phase as a function of the laser parameters.

Poster1 / 213

Optical properties of $SrGa_2S_4:Ce^{3+}$ films prepared by pulsed reactive cross laser beam ablation method (PRCLA)

Author: Ms. MOLEME, Pulane [1]

Co-Authors: Prof. NTWAEABORWA, Martin [2]; Prof. SWART, Hendrik [2]

[1] *200922*

[2] *University of the Free State*

Corresponding Author: molemepa@ufs.ac.za

$SrGa_2S_4:Ce^{3+}$ thin films are promising for full colour thin-film electroluminescent (EL) and field emission displays (FED's) because of its good optical properties. These films were previously prepared using several different techniques such as sputtering (RF), molecular beam epitaxy (MBE), reactive multi-source deposition (MSD), metal-organic chemical vapour deposition (MOCVD), deposition from binary vapours (DBV) and Pulsed Laser Deposition (PLD). In the present study, Ce doped $SrGa_2S_4$ thin films were prepared for the first time using pulsed reactive cross laser ablation (PRCLA) technique. Characterization of the films was carried out with scanning electron microscopy (SEM), atomic force microscopy (AFM) and x-ray diffraction (XRD). Cathodoluminescence (CL) and photoluminescence (PL) measurements were taken with a S2000 Ocean Optics Spectrometer and a Varian Cary Eclipse Fluorescence Spectrophotometer respectively. The substrate temperature, number of pulses and the working pressure are the parameters that were varied during the preparation of the thin films. A single-phase $SrGa_2S_4$ layer with high crystallinity was obtained at the growth temperature of 400^{o}C. XRD patterns also showed that the properties of the films are relatively sensitive to substrate temperature. PL showed one broad band that can fit two Gaussian peaks according to the two Ce^{3+} emission peaks which are known to originate from radiative transitions from 5d (T_{2g}) $\rightarrow$ 4f ($^2F_{5/2}$) and from 5d (T_{2g}) $\rightarrow$ 4f (($^2F_{7/2}$) respectively. CL showed two broad emission peaks around 441nm and 478nm which are due to Ce^{3+} transitions. The AFM images of the films prepared had a rough surface, which became smooth after annealing in vacuum at 700^{o}C temperature. Non-uniformity in particles of the films and rough surface were observed from the SEM images.

Poster2 / 214

Magneto-optical trap - First step towards BEC

Author: Ms. SEMONYO, Malehlohonolo [1]

Co-Authors: Dr. REHN, Magnus [1]; Prof. PETRUCCIONE, Francesco [1]

[1] *University of KwaZulu-Natal*

Corresponding Author: semonyo@ukzn.ac.za

The experimental demonstration of Bose-Einstein Condensation (BEC) is one of the most exciting developments of recent years. It has enabled researchers to study a macroscopic quantum object with well controllable parameters. This has sparked a lasting flurry of experiments covering an enormous range of fields, which have made significant contributions to our understanding of atomic and molecular physics, precision metrology and future technologies in quantum optics and quantum information science. The success of these experiments has led to the award of several Nobel Prizes in recent years. The first step in the construction of an experiment for realizing a Bose-Einstein condensation is obtaining an appropriate reservoir of cold atoms with sub-microKelvin temperatures. In our experiment, we cooled and trapped Rubidium atoms by using a combination of lasers and magnetic fields known as a magneto-optical trap (MOT) [2]. The MOT will be used as a reliable and robust source of cold atoms that will be cooled further to create a BEC. We report here on the construction of the MOT, in particular we describe the absorption saturation spectroscopy used for locking the lasers, the type of lasers used as well as the construction of the magnetic coils needed for generating the field used for spatial trapping of the atoms. We also describe the design and construction of the glass cell we used as the vacuum chamber and finally report on our main objective of realizing a BEC through evaporative cooling.

Theoretical / 215

Entanglement dynamics in an oscillating bipartite Gaussian state coupled to reservoirs with different temperatures

Author: Dr. GHESQUIERE, Anne [1]

Co-Authors: Dr. SINAYSKIY, Ilya [1]; Prof. PETRUCCIONE, Francesco [1]

[1] *National Institute for Theoretical Physics*

Corresponding Author: aghesquiere@stp.dias.ie

An entangled bipartite Gaussian state is coupled to two thermal reservoirs, one for each particle. A harmonic oscillation is allowed between the two particles. The reservoirs are assumed to have different temperatures and to be coupled to the particles with different coupling strengths. This allows for a realistic situation where a bipartite state may be shared between two parties who "keep" their part in different environments. A master equation, previously derived in the non-rotating wave approximation, is solved for the system. The effects of a variation in the bath temperature on the entanglement, as well as that of the variation in coupling strengths are shown. For high temperatures, the entanglement vanishes if the coupling strength is large, whereas for low temperatures, the effect is reversed and it survives longest for a stronger coupling strength. The stationary dynamics of the system is also examined.

CMPMS2 / 216

Thermal damage study on diamond tools at varying laser heating power and temperature by Raman spectroscopy

Author: Ms. MASINA, Bathusile [1]

Co-Authors: Prof. FORBES, Andrew [1]; Dr. MWAKIKUNGA, Bonex [2]; Dr. BODKIN, Richard [3]

[1] *CSIR-National Laser Centre*

[2] *CSIR National Centre for Nano-structured materials*

[3] *Element Six (Production) (Pty) Ltd*

Corresponding Author: bmasina@csir.co.za

Diamond tools are generally made of sintered polycrystalline diamond (PCD) on a hard metal tungsten carbide (WC-Co) substrate during the High Pressure High Temperature (HPHT) process. The diamond tools are used widely as cutting and drilling tools due to their unique combination of superior properties. However, there are several issues that need to be resolved about the diamond tools. At present it is known that diamond tools degrade with time as it is normally used at high temperatures, but what is not known is the damage mechanism and how the degradation varies as a function of temperature. In this study, we have made use of a laser based system to raise the temperature of the diamond tool and measure the diamond tool temperature. A study of the thermal damage on the diamond tool with respect to the laser heating power and temperature has been carried out using Raman spectroscopy; to determine the structure and composition of the resulting diamond tool. We have shown the radical changes on the diamond tool as the laser heating power and temperature increases.

CMPMS1 / 217

Isochronal annealing of argon ion bombarded GaAs with Raman and surface Brillouin scattering

Author: Mr. JAKATA, Kudakwashe [1]

Co-Authors: Dr. WAMWANGI, Daniel [2]; Mr. SUMANYA, Clemence [3]; Dr. MATHE, Bhekemusa [3]; Mr. ERASMUS, Rudolph [3]; Prof. COMINS, Darrell [3]; Dr. NAIDOO, Shunmugam [3]

[1] *University of the Witwatersrand*

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

[3] *DST/NRF Centre of Excellence in Strong Materials, School of Physics, University of the Witwatersrand*

Corresponding Author: kudakwashe.jakata@students.wits.ac.za

Semiconductors are important because of their numerous technological applications. As such, there have been a number of investigations on the recrystallization of amorphous GaAs. We present results of the isochronal annealing of an ∼ 140nm amorphous layer of GaAs on a crystalline substrate produced by bombarding with 100 KeV argon ions with a fluence of 5×1015 ions/cm2. Raman measurements were taken at room temperature which was the base temperature. Sharp peaks characteristic of polycrystalline GaAs were observed at 600o C. Similar experiments have also been carried out with the technique of Brillouin scattering (SBS). SBS is a laser based technique used to study the acoustic phonons and elastic properties of materials. SBS spectra were collected using a 514.5 nm laser in a backscattering arrangement and analysed using a Fabry-P`erot interferometer supplied by Sandercock. Changes in the elastic properties during the isochronal anneal were observed at temperatures below 400o C, in agreement with results previously obtained. The differences in the Raman spectroscopy and SBS results may be explained by the differences in the two techniques.

Poster1 / 218

Graphene Coatings:Snythesi/Physical-Chemical Investigations

Authors: Mr. NYANGIWE, Nangamso Nathaniel [1]; Prof. MALIK, Maaza [2]

Co-Author: Prof. MOISE, Tchokonte [3]

[1] *iTemba LABS and University of the Western Cape*

[2] *iTemba LABS*

[3] *University of the Western Cape*

Corresponding Author: nnnyangiwe@webmail.co.za

The main aim of this project is to synthesize, isolate, identify and characterize graphene, defined as a one-atom layer of hexagonally bonded carbon atoms using mechanical exfoliation method. Moreover, this technique is based on pulling apart the layers of a piece of highly oriented pyrolytic graphite(HOPG) and transfer layers from the graphite onto a SiO2 substrate. Graphene is the first truly 2D dimensional material and has a number of remarkable mechanical and electrical properties. It is substantially stronger than steel, and it is very stretchable. The thermal and electrical conductivity is very high and it can be used as a flexible conductor. Graphene is a zero-gap semiconductor and has a novel electron structure, with its conduction and valence bands meeting at the Dirac point. This characteristic enables the electron conduction by shifting the Fermi level with applied field.

APSS / 219

Pc3 pulsations during low density events

Author: Mr. LOTZ, Stefan [1]

Co-Authors: Dr. MCKINNELL, Lee-Anne [2]; Dr. SUTCLIFFE, Peter [3]

[1] *SANSA: Rhodes University*

[2] *SANSA: Space Science Directorate; Dept. of Physics and Electronics, Rhodes University*

[3] *SANSA: Space Science Directorate*

Corresponding Author: slotz@hmo.ac.za

We study the generation of Pc3 geomagnetic pulsations (22 – 100 mHz) measured at Tihany, Hungary during intervals of very low solar wind (SW) proton density (low density events - LDE's) when Np ~ 1/cc. We know the main SW based drivers of Pc3's are SW velocity and interplanetary magnetic field (IMF) direction. However, it is observed that under very low SW density pulsation activity measured on the ground is paused, regardless of otherwise favourable conditions. A simple statistical study is performed to show the dependence of pulsation activity on Np, and we estimate a threshold Np, below which pulsations cease. Furthermore we use the growth rate of the ion beam instability, that generates the ULF waves upstream of the bow shock (which drive Pc3's), to explain the observed dependence of Pc3 pulsations on solar wind density.

Education / 220

The South African Physics Olympiad, SAPhO

Mr. RIJSDIJK, Case [1]

[1] *SAAO (retd)/ASSA*

Corresponding Author: particles@mweb.co.za

With the current success of physics and astronomy and their technological support bases in South Africa, there is a need to identify and nurture talent in physics. It is clear that the current South African schooling system has little chance of doing this, and thus it becomes imperative that alternative means are found to grow local talent. This need was identified by the International Physics Review Panel, recommendation 4.1.4, but there has been very little progress since the International Year of Physics in 2005, when the first Physics Olympiad was held. A possible way forward will be outlined, what is needed and how it will be implemented will be discussed. A brief look will also be taken at the future potential of SAPhO including the formation of a Pan African Physics Olympiad, PAPhO, as a potential precursor to participation in the IPhO. Some concluding remarks on the challenges facing formation of the SAPhO will also be addressed, including possible solutions and necessary mechanisms that will need to be in place.

Poster2 / 221

Identification of isotopes using time differential, event-by-event gamma spectroscopy

Author: Mr. COOK, Martin [1]

Co-Authors: Prof. CONNELL, Simon [1]; Mr. BALLESTRERO, Sergio [1]; Mr. MOTLOUNG, Setumo [1]; Mr. CHINAKA, Eric [1]; Mr. BORNMAN, Faan [2]

[1] *University of Johannesburg*

[2] *Multotec*

Corresponding Author: cookish@gmail.com

In the context of activation studies, in order to uniquely identify an isotope via gamma spectroscopy, both the lifetime and the energy of the emitted gamma rays are required. Traditional detectors collect only integral data, losing information about the timing of individual events. This makes lifetime analysis a manually intensive task, as data points must be obtained by cycling the target in front of the detectors for well defined times at well defined intervals. Lifetime accuracy is limited by the manual details of this cycling procedure. A gamma spectroscopy system based on event-by-event acquisition implemented on the VME standard offers the advantage of recording time-stamped energy data for each event. The system described is capable of both coincident and single photon detection - enabling in addition the identification of PET isotopes amongst the other nuclides. The data can then be analyzed offline in a time differential manner, to provide both the gamma-line energy and lifetime. If necessary, the lifetime analysis can accommodate correlated and uncorrelated multiple lifetimes. One detection run will therefore yield complete information about both the energies and lifetimes of all isotopes present, allowing for unique isotope identification. This poster outlines this technique, then goes on to show results from its application to the study of isotopes excited when an electron beam is incident on high Z targets. These experiments were conducted in the context of obtaining activation data for a diamond sorting technique based on positron emission tomography.

CMPMS1 / 222

Tuning Carbon Nanotubes for Application in Photovoltaic Devices

Author: Mr. BEPETE, George [1]

Co-Authors: Mr. KOTANE, Lesias [1]; Dr. WAMWANGI, Daniel [1]; Prof. COVILLE, Neil [1]; Dr. CHIGUVARE, Zivayi [1]

[1] *University of the Witwatersrand*

Corresponding Author: zchiguvare@polytechnic.edu.na

Control of diameter, length and level of nitrogen doping in synthesis of nitrogen doped carbon nanotubes (N-CNTs) can be achieved by careful selection of catalyst, precursor mixture and chemical vapour deposition (CVD) synthesis temperature. Solutions of ethanol and acetonitrile (20% acetonitrile) were pyrolysed over a Fe/Al/MgO catalyst in a CVD reactor at temperatures from 700 OC to 1000 OC. The products were characterised by TGA, TEM and Raman spectroscopy. N-CNTs with well graphitised morphology, small diameter, and narrow diameter distribution were obtained at CVD temperatures from 850 OC to 900 OC. Below 800 OC the N-CNTs with large seized diameters were formed and above 900 OC the product yield became very low and the carbon nanotubes were malformed with wide diameter distribution. By pyrolysing precursor mixtures of acetonitrile and alcohols (methanol, ethanol, propanol, butanol, pentanol, hexanol, heptanol and octanol) we found out that short, 500 nm in length N-CNTs were obtained by the pyrolysis of long chain alcohols, (heptanol and octanol) and acetonitrile solution whilst longer N-CNTs were formed from pyrolysis of earlier alcohols (methanol, ethanol and propanol). Short and thin carbon nanotubes can be useful in carbon based nanoelectronics and photovoltaic devices since there is less entanglement of N-CNTs which will result in good dispersion of carbon nanotubes in solutions and polymer matrix. Preliminary results of the devices made from N-CNTs will be presented.

Poster1 / 223

Magnetic and strong correlation effect in CeT2Al8 (T=Fe,Co)

Author: Mr. GHOSH, SARIT KUMAR [1]

Co-Author: Prof. STRYDOM, Andre Michael [1]

[1] *UNIVERSITY OF JOHANNESBURG*

Corresponding Author: saritghosh@gmail.com

We present specific heat, electrical resistivity, susceptibility, and thermopower measurements on the two novel intermetallic compounds $CeFe_2Al_8$ and $CeCo_2Al_8$. They form in an orthorhombic crystal structure of space group Pbam. In the unit cell representation Ce atom occupies only one lattice site,having Ce-Ce interatomic distance of 4.03Å. Magnetic susceptibility of $CeFe_2Al_8$ in the range of 1.9K - 400K yields an effective paramagnetic moment value of $3.89\mu_B$ together with prevailing antiferromagnetic interaction through Weiss temperature Θ=-745.8K. The overall temperature dependence suggests valence instability in this compound and we model the appearance of broad peak around T=230K in the susceptibility to a $T^2 \ln T$ dependence attributed to an intermediate valent state. On the other hand for $CeCo_2Al_8$ the local moment state is depicted through an effective moment close to the free Ce^{3+} ion value. No long-range magnetic ordering is found in either of the two compounds down to 1.9K. The magnetic contribution of electrical resistivity on $CeFe_2Al_8$ and $CeCo_2Al_8$ compounds follows $-\ln T$ behavior at intermediate temperatures which is typical of incoherent Kondo interactions between conduction electrons and magnetic Ce ions. A Fermi liquid behavior in resistivity measurement is observed in $CeFe_2Al_8$ compound towards the ground state,whereas clear deviations from standard Fermi liquid behavior are indicative of strong electronic correlation effects in $CeCo_2Al_8$. At 2K the electronic specific heat of this compound reaches γ =0.106J/mol-K^2,and exhibits a $-\ln T$ divergence towards $T \rightarrow 0$. We explain this behavior in terms of quantum criticality that stems from low-lying magnetic ordering effects. In studies of the thermoelectric power,a maximum is reached at T=140K(S=24μV/K) and T=30K(S=23μV/K) for $CeFe_2Al_8$ and $CeCo_2Al_8$ compounds respectively. We propose a description for this behavior in terms of formation of fine structure in the electronic density of states near the Fermi energy(E_F).

Education / 224

Pre knowledge of physics 1 students on vectors

Author: Mrs. MHLONGO, Motlalepula Rebecca [1]

Co-Authors: Mr. MOLOI, Alfred [1]; Dr. SITHOLE, Enoch [1]

[1] *University of Limpopo*

Corresponding Author: mrebecca@ul.ac.za

The purpose of this study was to investigate the pre-knowledge of the Physics I students on vectors. The study was conducted on 234 Physics I students from the University of Limpopo (Medunsa campus). The sample was divided into four groups, where the first group (n = 119) did their grade 12 in 2010, the second group (n = 46) did their grade 12 prior 2010, the third group (n = 42) did Foundation Physics in 2010 and the fourth group (n = 27) were those repeating Physics I. An ex post facto research design was chosen for the study whereby all the groups were given a vector test at the beginning. The test was divided into three questions, testing definitions, classifications, drawing and interpretations of graphs. Results showed a less difference between average percentage of the groups whereby the group before 2010 (47.4%), foundation group (47.3%), the repeaters (44.3%) and those who did grade 12 in 2010 (44.1%).

CMPMS2 / 225

Non-linear Fowler-Nordheim plots in thin film polymer-fullerene composite devices: Transition from electron-only to hole-only conduction

Dr. CHIGUVARE, Zivayi [1]

[1] *University of the Witwatersrand*

Corresponding Author: zchiguvare@polytechnic.edu.na

We studied charge injection and transport mechanisms in blends of poly(3-hexylthiophene) (P3HT) and [6,6]-phenyl C61-butyric acid methylester (PCBM), by analysing dark, temperature dependent current-voltage characteristics of the P3HT:PCBM blend thin films sandwiched between aluminium electrodes in a MIM configuration. We present a general method of interpreting Fowler - Nordheim plots of metal/semiconductor/metal devices with pronounced non-linear characteristics by dividing them into several regions based on physical origins. We show that by applying appropriate electric fields it is possible to switch from electron-only conduction to hole-only conduction in a single Al/P3HT:PCBM/Al device. We affirm that electrons can be selectively transported through the lowest unoccupied molecular orbital of PCBM at low applied voltages and low temperatures; and alternatively holes can be transported through the highest occupied molecular orbital of P3HT at higher applied voltages and high temperature, within a single device.

Poster1 / 226

Computational study of some tin dioxide phases.

Author: Dr. MOSUANG, Thuto [1]

Co-Authors: Mr. NTIMANE, James [1]; Prof. RAMMUTLA, Erasmus [1]

[1] *University of Limpopo*

Corresponding Author: thuto.mosuang@ul.ac.za

Rutile and anatase structured tin dioxide ceramics have been intensively studied in recent years because of their potential in sensing and fuel cells. The present work uses classical molecular dynamics simulations focused on the structure and possible transformation from anatase to rutile tin dioxide. The empirical Buckingham potential has been used to describe the interatomic interactions in tin dioxide. The total energy of the NVE ensemble of the two structures at various temperatures has been calculated in order to determine the transition temperature and pressure. The results obtained showed an energy increase with temperature which was constantly compared with experiments. The radial distribution functions for the two structures suggest the transformations at temperature above 900 °C in agreement with the experiments.

Education / 227

Lightning

Mr. RIJSDIJK, Case [1]

[1] *SAAO (retd)/ASSA*

Corresponding Author: particles@mweb.co.za

Every year over a hundred people die unnecessarily from lighting in South Africa. Recent reporting and correspondence in the media clearly indicated a total lack of knowledge on the part of the public, from Ministerial level down, about the causes and effects of lightning. Much work has been done by organizations such as the CSIR and SA Weather Bureau, and there are several commercial concerns addressing this problem in both urban and wealthy rural areas such as game lodges and other tourist resorts. Recently it has been reported that the Department of Science and Technology, DST, has initiated a progamme to install lightning conductors in rural areas. The SAIP can, and should be, playing a leading role in addressing this problem and this presentation will discuss an assortment of possible ways that the SAIP can assist in sustaining remedial efforts in rural areas.

Poster1 / 228

Synthesis and characterization of PbS nanorods using the chemical bath deposition method

Authors: Mr. KOAO, Lehlohonolo [1]; Prof. DEJENE, Francis [1]

Co-Author: Prof. SWART, Hendrik [2]

[1] *UFS (Qwa Qwa Campus)*

[2] *UFS*

Corresponding Author: koaolf@qwa.ufs.ac.za

Crystalline lead sulfide (PbS) nanorods were synthesized by chemical bath deposition (CBD) method using the mixed aqueous solutions of lead acetate, thiourea and ammonium solution. The lead acetate concentrations were varied in the deposition process to determine the effect thereof. The temperature of the bath was maintained at 80°C. The final yields were characterized for structural, morphology and optical properties. The X-ray diffraction (XRD) spectra of the PbS nanorods correspond to the various planes of cubic PbS. A single phase was obtained. The average particle sizes calculated using the XRD spectra were found to be 14±0.5 nm for particles stirred for 10 minutes and 16±0.5 nm for samples stirred for 5 minutes respectively. When the concentration of lead acetate was increased the particle size also increased. Scanning electron microscopy (SEM) micrographs depict nanorod structures for a high mol concentration of lead acetate and a spherical shape for a low mol percentage. Energy dispersive X-ray (EDS) analyses confirm the presence of all the expected elements. The solid powder nanorods show good optical properties with high absorptions in the UV and visible regions. The band gap energies were estimated to be 1.69 to 1.84 eV which are higher than the bulk PbS band gap of 0.37 eV. The absorption edge and the band gap energies of these PbS nanorods have shifted depending on the ionic strength of the precursors.

CMPMS1 / 229

Nitrogen-vacancy in diamond for Solid-state quantum computing

Author: Mr. ZULU, Bheki [1]

Co-Author: Prof. PETRUCCIONE, Francesco [2]

[1] *Student*

[2] *South African Research Chair*

Corresponding Author: zulu@tlabs.ac.za

Ever since the inception of the quantum computing idea, many technologies for its realization have been tried. The fundamental intention is to implement and manipulate a two-dimensional quantum mechanical unit of information that is termed a quantum bit (qubit). In this context during the past decade, solid-state fluorescing defects have drawn huge interest. The promising candidates for solid-state qubits are nitrogen-vacancy (NV) centers in diamonds due to their individual addressability, optical spin polarization and spin coherence time of milliseconds at room-temperature. Here, an on-going study on enhancing NV centres creation and NV electronic spin coherence times is reported. The vacancies in diamond crystal samples are created using Van der Graaf accelerator and then the samples are annealed at elevated temperatures to form NV centres. Sample measurements in terms of detecting the defects and their concentrations and electron spin coherence times are performed using techniques such as Raman spectroscopy, absorption spectrum, photoluminescence and confocal microscopy equipped with Electronic spin resonance (ESR).

Poster2 / 230

The Effects Of High Atomic Material On Photon Beams At The Interface

Dr. SITHOLE, Enoch [1]

[1] *University of Limpopo*

Corresponding Author: mesithole@ul.ac.za

The purpose of this work was to study the dose enhancement factor (DEF) by high-Z material in water phantom, irradiated by photon beams. Two energies, 6 and 15 MeV generated by Varian linear accelerator were used. Monte Carlo technique (EGSnrc code) was used in this study. The source model was validated against measured data. The effect of photon beam quality, atomic number (Z) and the material thickness in the water phantom were studied. Calculations for a variety of materials and photon beams showed that dose enhancement factor increase with Z; decrease with decreasing material thickness; and decrease with decreasing incident photon beam energy.

Education / 231

The Pinhole Camera: A fascinating optical device for physics freshmen.

Authors: Mr. MOTSOENENG, John [1]; Mr. MAPASHA, Edwin [1]

Co-Author: Dr. MOJI, Cable [1]

[1] *University of Pretoria*

Corresponding Author: qhobosheane.motsoeneng@up.ac.za

A simple pinhole camera was used to demonstrate to students that light travels in a straight line. The one to one correspondence between a point on the object and a point on the image was used to explain why the image was upside down and reversed from left to right.

Education / 232

Forces: A difficult area for the students

Authors: Mr. MAPASHA, Edwin [1]; Mr. MOTSOENENG, John [1]

Co-Author: Dr. MOJI, Cable [1]

[1] *University of Pretoria*

Corresponding Author: sengere@webmail.co.za

The investigation reflects on the causes of unsatisfactory students' performance on the section involving forces during tests. It has been realized that more often than not students tend to be excited after undertaking a test on forces. However, subsequent feedback usually paints a different picture and this has become a worrying trend. The results of the investigation in this regard seem to suggest that students have inadequate understanding of sizes, directions and points of actions on the body. In addition, students also appear to encounter difficulties in distinguishing between the pushing and the pulling interactions.

Education / 233

Visualizing Physics: Good Vibrations

Mr. FISH, Derek [1]

[1] *University of Zululand*

Corresponding Author: thefish@iafrica.com

This talk forms part of the author's Masters investigation into perceptions of Physics in school visitors to Unizul Science Centre. Visitors typically fall into three distinct groups with very different needs and responses. Those coming from: rural schools, township schools and urban schools. In this study, pupils were exposed to an interactive Science Show: Good Vibrations, presenting the basics of sound and waves through musical instruments. They were then asked to respond to questions requiring both written and graphical answers. From these, conclusions are drawn as to the ability of these pupils to understand sound both visually and conceptually. These conclusions will be used to inform best practice when dealing with different groups of visitors with different needs.

CMPMS2 / 234

Carbon-Nickel Oxide Nanocomposite coatings: Preparation and characterization

Author: Mr. TILE, Ngcali [1]

Co-Authors: Dr. RORO, Kittessa [2]; Mr. YALISI, Brian [1]; Dr. ROBERTS, Ted [2]; Prof. FORBES, Andrew [1]

[1] *CSIR NLC, School of Physics University of KwaZulu Natal*

[2] *CSIR NLC*

Corresponding Author: ntile@csir.co.za

Nanocomposite materials have wide range of applications in solar energy conversion. In this work, C-NiO nanocomposite coatings are prepared using sol-gel synthesis and deposited on aluminium substrates using a spin coater. The coatings are prepared from alcoholic sols based on Ni-acetate using diethalonamine as a chelating agent and polyethylene glycol (PEG) as organic template. Sucrose is used as a carbon source. Sols with different PEG and sucrose concentrations are prepared and coated on aluminium substrates. The effect of heat temperature on the properties is also investigated. The optical and structural changes of the nanocomposite coatings are characterized by UV-Vis, FTIR, thermal emissometer, Raman, and SEM techniques. It has been shown that the solar absorption increases with increasing the heating temperature in the temperature range 300 – 550 °C due to the increase in carbon content in the composite material. Preliminary durability studies on these samples will also be presented

LOS / 235

Comparison of phase-dependent only and complete Laguerre-Gaussian beams using modal decomposition

Author: Ms. MCLAREN, Melanie [1]

Co-Authors: Prof. FORBES, Andrew [1]; Dr. ROUX, Stef [1]

[1] *CSIR*

Corresponding Author: mmclaren@csir.co.za

Laguerre-Gaussian (LG) beams possess many interesting properties, one of which is that they carry orbital angular momentum, an extrinsic component of angular momentum, when the electric field or mode has an azimuthal angular dependence of exp(il⊠), where l is the azimuthal mode index. These beams are easily generated using spatial light modulators (SLMs), where a Gaussian beam incident on an SLM is shaped according to a predetermined phase pattern. For LG beams, this phase pattern has typically only included the azimuthally dependent phase component of the field, ignoring the amplitude and radial components present in the full LG expression. Although this approximation has yielded azimuthal modes which compare well with theory, it excites higher order transverse modes. We show both theoretically and experimentally, using a method of modal decomposition, that higher order transverse modes are excited. The results were compared to the full LG expression, where no higher order modes were seen. This is of particular interest regarding the orbital angular momentum carried by these beams.

Applied / 236

Application of Electroluminescence and Thermal Imaging in Defect Identification in Photovoltaic Modules

Author: Ms. CROZIER, Jacqui [1]

Co-Authors: Prof. VAN DYK, Ernest [1]; Dr. VORSTER, Frederik [1]

[1] *NMMU*

Corresponding Author: crozier.jacqui@gmail.com

In order for solar energy to become an alternative to traditional fossil fuel energy it is important that defects in photovoltaic (PV) modules can be easily identified. Typically a module is characterised by measuring the current-voltage (I-V) characteristics under standard test conditions. In addition to this electroluminescence (EL) and thermal imaging can be used to identify the location of defects in the module. A cooled Si CCD camera is used to detect the EL emitted from a forward biased PV module. The intensity of this light is related to the minority carrier concentration and the emitted EL thus provides a visual representation of defects in the cell. Infrared imaging can be used to identify irregular heating patterns which are indicative of defective cells or contacts. In this study we used both techniques in conjunction to assess the defects present in a 36 cell custom-made single crystalline silicon module. Defects that were identified in this study showed that areas around the contacts appeared very bright in EL images and this corresponded with hot areas in the infrared images. These results show that the electrical contacts in these areas are poor.

Poster1 / 237

Low-lying magnetism in heavy-fermion CeRh2Sn2

Prof. STRYDOM, Andre [1]

[1] *University of Johannesburg*

Corresponding Author: amstrydom@uj.ac.za

The existence of the ternary intermetallic compound $CeRh_2Sn_2$ has been known since the crystallographic report of Selsane et al on the CeM_2Sn_2 family of compounds in which M is a d−electron element. The crystal structure is well ordered and the sole magnetic species, Ce, occupies a unique symmetry site in the unit cell. Subsequent studies into these compounds revealed a general trend of magnetic ordering at very low temperatures. CeRh2Sn2 was found to order antiferromagnetic through a peculiar smeared out transition around T_N=0.4 K. Most significantly though was the giant electronic specific heat witnessed in the Sommerfield coefficient C_p(T)/T which was found to develop in this compound even well above the magnetic ordering temperature. The behaviour of this system was explained in the framework of a heavy-electron quasiparticle state forming out of the many-body Kondo interaction between localized magnetic moments of Ce ions and the conduction electrons. This results in an exceedingly high electronic density of states at the Fermi energy EF. In this work we present a detailed study of specific heat, magnetic susceptibility, and electrical resistivity of $CeRh_2Sn_2$ in order to map the field stability of salient cooperative effects. The magnetic ordering is found to be instable to fields beyond about 0.5 T. At the same time, applied magnetic fields displace the huge 4f-electron entropy towards higher temperatures. Further evidence for the importance of the Kondo effect in $CeRh_2Sn_2$ will be discussed.

CMPMS1 / 238

Brillouin scattering study of TiC hard films

Author: Mr. SUMANYA, Clemence [1]

Co-Authors: Dr. WAMWANGI, Daniel [1]; Mr. JAKATA, Kudakwashe [1]; Dr. MATHE, Bhekumusa [1]; Prof. COMINS, Darrell [1]; Prof. EVERY, Arthur [2]

[1] *DST/NRF Centre of Excellence in Strong Materials*

[2] *Materials Physics Research Institute, University of the Witwatersrand*

Corresponding Author: clemence.sumanya@students.wits.ac.za

The dispersion relation of surface acoustic waves in TiC thin hard films of various thicknesses on silicon and silicon carbide substrate is studied using Surface Brillouin scattering. Simulations of surface Brillouin scattering (SBS) spectra of TiC thin hard films on silicon and SiC substrates have been carried out over a range of film thickness from 5nm to 1000nm. The simulations are based on the elastodynamic Green's function method that predicts the surface displacement amplitudes of acoustic phonons. These simulations provide information essential to understand and analyze experimental data emerging from SBS experiments. There are striking differences in both the simulated and experimental SBS spectra depending on the respective elastic properties of the film and the substrate. In fast on slow situations (TiC on Silicon), the Rayleigh mode is accompanied by broadened resonances; in slow on fast situations (TiC on SiC), several orders of Sezawa modes are observed together with the Rayleigh mode and sharper resonances. The velocity dispersion of the modes as a function of the product of surface wavevector and thickness (k//d) has also been simulated and obtained experimentally, allowing the elastic constants of the films to be determined.

Theoretical / 239

Open Quantum Random Walks

Author: Dr. SINAYSKIY, Ilya [1]

Co-Author: Prof. PETRUCCIONE, Francesco [1]

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

Corresponding Author: ilsinay@gmail.com

Quantum Random Walks have been introduced almost 20 years by Y. Aharonov et al. [Phys. Rev. A, 48(2):1687–1690, 1993] and have found wide applications in quantum computing. As is often the case in quantum theory, Quantum Walks differ strongly from classical random walks. In joint work of S. Attal, C. Sabot, F. Petruccione and I. Sinayskiy the concept of Open Quantum Random Walks was introduced, by taking into account dissipation and decoherence that occur in open quantum systems. The connection to classical and unitary random is discussed as well as the potential of Open Quantum Random Walks for quantum computing and efficient quantum transport.

CMPMS1 / 240

Pulsed laser deposition of multiwall carbon nanotube/NiO nanocomposite thin films

Author: Mr. YALISI, Brian [1]

Co-Authors: Dr. RORO, Kittessa [2]; Prof. FORBES, Andrew [2]; Mr. TILE, Ngcali [3]; Dr. ROBERTS, Ted [2]

[1] *CSIR, UKZN*

[2] *CSIR*

[3] *CSIR,UKZN*

Corresponding Author: byalisi@csir.co.za

In this work, we report on the fabrication of multiwall carbon nanotubes (MWCNT)/NiO nanocomposite thin films by the pulsed laser deposition technique on to aluminium substrates. Samples were prepared with different MWCNT content, and varying substrate temperatures. Structural and optical properties were investigated by scanning electron microscopy, x-ray diffraction, Raman spectroscopy, UV-Vis spectroscopy and the thermal emissometer. The morphological and structural changes induced by laser beam will also be presented.

NPRP / 241

A search for the 5 alpha condensate state in 20Ne

Author: Mr. SWARTZ, Cobus [1]

Co-Authors: Dr. SMIT, Ricky [2]; Dr. PAPKA, Paul [3]; Dr. NEVELING, Retief [2]; Prof. FREER, Martin [4]

[1] *Stellenbosch University & iThemba LABS*

[2] *iThemba LABS*

[3] *Stellenbosch University*

[4] *University of Birmingham*

Corresponding Author: cobus.swartz@gmail.com

Quantum condensation of alpha particles is believed to occur in cluster states of the self-conjugate alpha nuclei 12C and 16O. This phenomenon is similar to the Bose-Einstein condensation observed through the laser cooling of atoms such as Rb or Na. A state of this nature, which must be of 0+ character, is expected to exist just above the 5 alpha decay threshold in 20Ne. In this region, only high spin states Jiπ≥4+ are known. This is mainly due to the types of reactions usually used to populate states in this nucleus. Alpha-particle inelastic scattering will be performed close to zero degrees with the K600 magnetic spectrometer at iThemba LABS. This will provide a sensitive probe for states of the 0+ character which may be associated with the 5 alpha particle condensate state, while enhancing the L = 0 angular momentum peaks. Additionally, measurements will be made at two larger angles in order to demonstrate the L = 0 character.

Theoretical / 242

Derivation of the master equation for a particle in an external field which is subject to continuous measurement.

Author: Mr. GARAPO, Kevin [1]

Co-Author: Prof. KONRAD, Thomas [1]

[1] *Centre for Quantum Technology, University of Kwazulu-Natal.*

Corresponding Author: 209523532@ukzn.ac.za

The theory of continuous measurement provides a tool to monitor the evolution of the wave function of a single quantum system in real time. We derive the master equation in the non-selective regime for the dynamics of the wave function of a particle in an external potential which is subject to continuous measurement of position. In the derivation we view continuous measurement as the limit of a sequence of unsharp position measurements. Unsharp position measurements are described by generalised measurement observables, or in mathematical terms, positive operator valued measures (POVM) rather than the standard von Neumann projection operators which are a special class of the sub-class of POVM's called projection valued measures (PVM). We discuss a method which introduces a commutative algebra for non-commuting operators in order to carry out the summation of the corresponding measurement operators. In addition we reveal the stochastic Ito equations for the selective regime of measurement.

Theoretical / 243

Designing reservoirs for 1/t decoherence process in Jaynes-Cummings model

Author: Dr. GIRALDI, Filippo [1]

Co-Author: Prof. PETRUCCIONE, Francesco [1]

[1] *University of KwaZulu-Natal*

Corresponding Author: filgi@libero.it

Decoherence indicates the process that a quantum system undergoes through the interaction with an external environment. The central issue and one of the greatest challenges in Nanotechnology and Quantum Information Processing is the way to control or delay the destructive effect of the environment on qubit coherence. For this reason, a qubit interacting with a reservoir of bosons (external environment), described by a Jaynes-Cummings model, is considered. The decoherence process corresponding to Lorentzian type distributions of field modes results in exponential like relaxations. At this stage we adopt the engineering reservoir approach as the way of delaying the decoherence process. A special class of reservoirs of field modes is designed in order to obtain a decoherence process resulting, over estimated long time scales, in inverse power laws with powers decreasing continuously to unity according to the choice of the particular reservoir. The designed reservoirs exhibit a photonic band gap coinciding with the qubit transition frequency and are piecewise similar to those usually adopted in Quantum Optics, i.e., sub-ohmic at low frequencies and inverse power laws at high frequencies. Initially, the reservoir is assumed to be in the vacuum state and is unentangled from the qubit versing in a generic state. The exact dynamics results to be described by series of Fox H-functions. The simple form of the designed reservoir can be accessible experimentally.

Poster1 / 244

Low Temperature Synthesis of ZnO nanoparticles and Nanorods via Wet Chemistry Route

Author: Ms. MBULE, Pontsho Sylvia [1]

Co-Authors: Prof. O.M NTWAEABORWA, Martin [2]; Prof. SWART, Hendrik [2]

[1] *University of the Free State*

[2] *UFS*

Corresponding Author: mbuleps@ufs.ac.za

A wet chemistry route is an essential method used today to synthesize high quality ZnO nanoparticles and nanorods. It is a novel low cost method to produce nanoparticles and nanorods with relatively high dispersivity. In this study optical properties and morphology of the nanoparticles and nanorods were investigated. The X-ray diffraction (XRD) patterns of both nanoparticles and nanorods revealed the hexagonal wurtzite structure, the diffraction peaks matched well with the JCPDS (card no 80-0075) standard data. The transmission electron microscopy (TEM) revealed the nanoparticles and nanorods with different diameters and lengths. The optical absorption and photoluminescence (PL) were also obtained and it was demonstrated that the PL exhibited a strong near-band-edge emission (UV) and weak visible emission bands. The PL intensity increased with increasing precursor concentration (0.1M-1.5M) and was quenched at higher concentrations, which may be attributed to concentration quenching effects. The fourier transform infrared spectroscopy (FTIR) was used to determine the distinct stretching mode frequencies. The ZnO nanoparticles and nanorods were investigated for possible applications in transparent electrodes in solar cells and gas sensors.

Poster1 / 245

Low-temperature magnetic ordering in Ce6Pd12In5

Prof. STRYDOM, Andre [1]

[1] *University of Johannesburg*

Corresponding Author: amstrydom@uj.ac.za

The novel ternary intermetallic compound $Ce_6Pd_{12}In_5$ forms in a well-defined atomic stoichiometry with a hexagonal crystal structure (space group $P6_3/mcm$) and a unique atom in each of the crystallographic sites available in this space group. The bonding lengths are comparatively short and suggest strong interaction especially between Ce and Pd atoms. In this work we report on our findings of the first studies into the physical properties of $Ce_6Pd_{12}In_5$. A key finding is the occurrence of long-range ferromagnetic-like order below TC =1.6 K, where the specific turns into a lambda-like anomaly peaking at C_p = 8 J/(mol Ce K). The electrical resistivity hints at a low-lying Kondo scale in this compound. The magnetic susceptibility shows well-defined Curie-Weiss behaviour over an extended temperature range with an effective magnetic moment value that is indicative of conduction-electron hybridization effects on the Ce localized moment. The 4f–electron derived magnetic contributions to the entropy and to the electrical resistivity in $Ce_6Pd_{12}In_5$ are assessed by means of the nonmagnetic counterpart $La_6Pd_{12}In_5$.

Theoretical / 246

Wave-packet scattering off a soliton

Author: Mr. ABDELHADY, Ahmed [1]

Co-Author: Prof. WEIGEL, Herbert [1]

[1] *Stellenbosch University*

Corresponding Author: abdelhady@sun.ac.za

We investigate the scattering of a wave-packet off a soliton in the (1+1) dimensional kink model. We solve the classical, time-dependent field equation numerically subject to the initial condition that the wave-packet is widely separated from the kink soliton at very early times and propagates towards the soliton. After some time the wave-packet interacts with the static soliton and departs from it at later times. At very late times the wave-packet is finally again separated from the soliton. We then extract the scattering matrix from the distorted wave-packet and compare it to the known result from the static scattering calculation. This investigation constitutes a first step towards studying crossing symmetry in soliton models, i.e. in a framework beyond perturbation theory.

Theoretical / 247

Many-boson Quantum Walks on Graphs with Shared Coins

Author: Mr. MUSUMBU, Dibwe Pierrot [1]

Co-Authors: Dr. SINAYSKIY, Ilya [1]; Prof. PETRUCCIONE, Francesco [1]

[1] *University of KwaZulu-Natal*

Corresponding Author: pierrotmus@gmail.com

Quantum walks of particles obeying bose statistics are introduced. In such a quantum walks the conditional shift operation is performed with the single coin tossing for the whole lattice. An explicit form for the transition probabilities in a single step is derived. This allow to describe the evolution of an arbitrary state and an arbitrary number of steps. This model easily embrace the concepts such as the join probability, the counting statistics and the high order correlations. It also presents the computational challenges arising from the exponential increase in the number of basis states entering into the lattice state as a function of the number quantum walkers and the number of steps. Possible solutions are proposed in some applications of the model to quantum walks on finite graphs.

NPRP / 248

Omega Meson electroproduction analysis

Mr. UNWUCHOLA, Doomnull Attah [1]

[1] *University of Johannnesburg*

Corresponding Author: doomnull@gmail.com

This work is part of a program based on the electro-production of baryonic resonances. In part, the physics goals are to assess the relevant degrees of freedom appropriate to describe high momentum transfer exclusive reactions. In particular, the interest is in the region where the four − momentum transfer squared, t ~ Q2 varies beyond the validity of the constituent quark model (CQM), towards the region where one may search for evidence of pQCD. In this work, the differential cross section for p(e,e'ω)p has been studied at a Q2 ≈ 5.5 GeV. We present further analysis including comparison with other data. A significant divergence from an extrapolation of previous data is obvious.

Poster2 / 249

Stellar Masses of Star Forming Galaxies in Galaxy Cluster

Author: Mr. RANDRIAMAMPANDRY, Solohery [1]

Co-Author: Dr. CRAWFORD, Steven [2]

[1] *SAAO/UWC*

[2] *SAAO*

Corresponding Author: solohery@saao.ac.za

We determine the stellar mass of star forming galaxies in the X-ray luminous cluster MS 0451.6-0305 at z ~ 0.54. The stellar masses are estimated from fitting model spectral energy distributions (SEDs) to deep, optical UBRIz observations obtained from WIYN 3.5m telescope and public NIR K-band image from Palomar Observatory telescope. The model SEDs are based on the stellar population synthesis (SPS) model of Bruzual & Charlot (2003) and Conroy et al. (2009) that span a wide range of age, star formation history, initial mass function, metallicity and dust content. We measure stellar masses for galaxies down to $M_* \sim 2\times10^8 M_\odot$. We find a tight correlation between stellar masses derived from the two SPSs. We compare the derived stellar masses to the dynamical masses for a set of 25 star-forming galaxies. The dynamical masses are derived from high resolution, spectroscopic observations of emission lines from the DEIMOS spectrograph on the Keck telescope. A strong correlation is seen between the dynamical and stellar mass for the galaxies; and the star forming galaxies show fairly constant ratio between stellar and dynamical mass. When comparing to the field sample of Guzmán et al. (2003) of luminous compact blue galaxies, we see an excess of low mass galaxies in the cluster.

Poster1 / 250

Thermal transport in the cage-compounds RFe2Al10 (R=Y, Yb)

Author: Prof. STRYDOM, Andre [1]

Co-Author: Mr. PERATHEEPAN, Pararajasingham [1]

[1] *University of Johannesburg*

Corresponding Author: amstrydom@uj.ac.za

Since the first report of the anomalous magnetic and electronic phenomena in $CeRu_2Al_{10}$ this intermetallic class of compounds, incorporating also members with elements Os and Fe in the place of Ru, have attracted considerable interest. N spite of large interatomic distances antiferromagnetic order sets in at TN =27 K in the ru and Os derivatives, with simultaneous energy gap formation in the electronic energy levels. In this work we studied the electronic and thermal transport in two novel members of the 1:2:10 series, YFe_2Al_{10} and $YbFe_2Al_{10}$. These two compounds were synthesized with the purpose of studying the effects of a unit cell volume that is compressed well beyond that of $CeRu_2Al_{10}$ in order to expose the role of Fe-based magnetism in the observed electronic correlations. Here we discuss our results of thermal and electronic transport in the pair of compounds YFe_2Al_{10} and $YbFe_2Al_{10}$. Both exhibit anomalous thermopower behavior and a peak that develops at low temperatures. This is attributed to an enhanced density of states that is achieved through hybridization between conduction electrons and magnetic moments with a localized nature. The thermal conductivity of both compounds shows a weak temperature dependence and especially in the case of YFe_2Al_{10} is the observed behavior amenable to a description in terms of glass-like behavior that most likely results from optical phonon modes which effectively scatter heat-carrying quasiparticles. The electrical resistivity suggests low-lying magnetic cooperative behavior.

Education / 251

The transition from high school Physics to first-year Physics: How well prepared are our students?

Author: Mr. MOLEFE, Paul [1]

Co-Author: Ms. SONDEZI-MHLUNGU, Buyisiwe [1]

[1] *University of Johannesburg*

Corresponding Author: pmolefe@uj.ac.za

Premature withdrawal from university due to academic failure has the potential to present problems to both students and educators. The demand from industry for a larger pool of science and engineering graduates in South Africa is in line with international norms. This state of affairs is compounded by a shrinking pool of good quality school leavers. For the desired growth in graduate numbers to occur, physics educators are required to respond effectively through curriculum reform to optimize success and retention of students at first year level. The research project in this regard aims to investigate the level of preparedness in relation to Physics I students and to identify key success factors in this course. This course is compulsory for most first year science students and is largely perceived as difficult in comparison with other first year courses. More students are pursuing Physical Science at school and consequently study science, engineering and technology at universities (DoE, 2010) and University of Johannesburg is no exception. For many students, the first year at university represents a transition during which a variety of academic and social challenges are encountered. To this end, students' entry-level preparedness was investigated through analysis of their high school examination results, administration of a diagnostic test and first year university assessment results. The results reveal that high school examination results appear not to be the only independent factor characterising students' readiness for first year physics studies at university.

CMPMS2 / 252

Influence of ruthenium on the oxidation behaviour of Cu-CNT nanocomposite interconnect

Author: Mr. SULE, RASIDI [1]

Co-Authors: Dr. OLUBAMBI, Peter Apata [2]; Mrs. ABE, Bolanle Tolulope [3]

[1] *MTech Stuent at TUT*

[2] *Tshwane University of Technology, Chemical & Metallurgy Dept.*

[3] *Tshwane University of Technology, Electrical Engineering Dept.*

Corresponding Author: richysule@yahoo.com

Copper based interconnect are widely used in the electronic industry. They provide the conductive path required to achieve connection from one circuit element to another. However, the application of copper based interconnect is often limited by the oxidation behaviour of copper. At elevated temperature and humidity, the bonding strength of copper interconnect deteriorates due to copper oxide formation on the surface which could result at device failure. Effort is made in this study to investigate the effect of ruthenium incorporation on the oxidation and electronic interconnection characteristic of Cu-CNT nanocomposite synthesized through the powder metallurgical technique. The compacted samples were sintered by conventional sintering method. Oxidation test was performed in tube furnace. The samples were oxidized isothermally at different temperature. Electronics weighed balance with the precision of 0.01mg was employed to investigate the weight gain of the sample due to oxidation. The morphology structure, oxide layer thickness and possible crack on the sintered sample were examined using scanning electron microscope with energy dispersive X-ray spectroscopy (SEM/EDS). Phase identification was performed using an X-ray diffraction spectroscopy (XRD). It could be concluded from the result obtained that minor addition of Ru has a positive effect on the oxidation resistance of Cu-CNT nanocomposite due to formation of a well protected oxide.

Poster2 / 253

Super star clusters in nearby Luminous Infrared Galaxies

Author: Ms. RANDRIAMANAKOTO, Zara [1]

Co-Author: Dr. VAISANEN, Petri [2]

[1] *University of Cape Town*

[2] *South African Astronomical Observatory*

Corresponding Author: zara@saao.ac.za

Apart from the presence of an active AGN, very young and massive super star clusters (SSCs) are likely to be found in local starbursts and interacting luminous infrared galaxies. SSCs are responsible of a high star formation rate (SFR) of the host galaxy. From an on-going deep NIR AO imaging survey, we were able to observe some SSCs hidden by the dusty central regions. To better understand the formation and the evolution of massive star clusters we derived the K-band SSC luminosity functions (LFs) of our sample.

Poster2 / 254

Cross phase modulation induced depolarization of a probe signal and its impact on polarization mode dispersion compensators

Author: Mr. GAMATHAM, Romeo [1]

Co-Authors: Dr. GIBBON, Timothy [1]; Prof. LEICTH, Andrew [1]

[1] *Nelson Mandela Metropolitan University*

Corresponding Author: romeo.gamatham@live.nmmu.ac.za

Nonlinear effects are easily observed in single mode optical fibres because of the fibre small spot size and extreme low loss. At high optical intensities in fibres the refractive index becomes a function of the intensity of the optical signal. This refractive index is known as the Kerr nonlinearity. This leads to the optical Kerr effect where the nonlinear phase shift induced by an intense high power pump changes the characteristics of the probe beam. Cross phase modulation (XPM) refers to a nonlinear effect where a pump beam with high intensity changes the phase of a low power probe beam. In this work, we consider the composite problem of polarization mode dispersion (PMD) and XPM in wavelength division multiplexing (WDM) networks. PMD continues to pose a treat to high speed optical networks hence the need for PMD compensators (PMDCs). PMDCs monitor the link PMD in an indirect manner where a popular monitoring technique tracks the degree of polarization (DOP) of a signal in the link. It can be shown that in a two channel WDM system an intensity modulated pump modulates the state of polarization (SOP) of a probe signal at the pump bit rate. In this work we experimentally demonstrate the depolarization of a probe signal in the presence of an intensity modulated pump signal. The results show that minimum interaction between the pump and probe signal occur when the pump and probe input Stokes vectors are parallel and anti-parallel. Hence the probe signal incurs maximum depolarization when the two signals are arranged in an orthogonal configuration. These results are crucial to PMDC because the source of the DOP degradation may mislead the compensator.

Poster1 / 256

Synthesis and characterization of reproducible stoichiometry of cobalt sulfide nanoparticles using sulphur containing single-source precursors

Author: Mr. SIBOKOZA, Simon Bonginkosi [1]

Co-Authors: Prof. MOLOTO, Makwena Justice [2]; Dr. MOLOTO, Nosipho [3]

[1] *Student at Vaal University of Technology*

[2] *Supervisor*

[3] *Co-supervisor*

Corresponding Author: sbk@webmail.co.za

Cobalt sulphide nanoparticles are one of the most complex and challenging particles to synthesize due to strongly reducibility of the cobalt ion and the oxidizable nature of the sulphide ion. Cobalt sulphide therefore exist in various phases with different compositions including Co4S3, Co9S8, CoS, Co1-xS, Co3S4, Co2S3 and CoS2. Herein, we describe the synthesis of CoxSy nanoparticles; furthermore we interrogate the influence of the reaction conditions on the structure and optical properties of the nanoparticles. CoxSy nanoparticles were synthesized by thermolysis of N, N, N´, N´-tetramethylthiuram disulphide cobalt (II) complex in the presence of stabilizing agent Hexadecylamine (HDA). The advantage of this method is that the bond between the cobalt and sulphur atoms already exist, therefore decomposition of the complex at write conditions will result in the formation of CoxSy nanoparticles. The cobalt sulfide nanoparticles were prepared by varying concentration from the range 5.0 mg to 5.0 g of the CoCl2[(CH3)2NCS2S2CN(CH3)2]2 complex at 130 °C temperature. The effect of temperature was also investigated by varying the temperature from 80 to 250 °C. The nanoparticles were characterised by a combination of absorption spectroscopy, photoluminescence (PL), X-ray diffractometry (XRD) and transmission electron microscopy (TEM).

APSS / 257

Stellar perturbation via Lie derivatives.

Author: Dr. FRESCURA, Fabio [1]

Co-Author: Dr. ENGELBRECHT, Chris [2]

[1] *U Witwatersrand*

[2] *U Johannesburg*

Corresponding Author: fabio.frescura@wits.ac.za

Perturbation theory uses Lagrangian techniques that require vector fields to be compared at finitely separated points. This method can be generalised to the strong gravitational field regime in one of two ways, using either covariant or Lie derivatives. In this paper, I argue that those methods based on the Lie derivative are more useful. The Lie derivative provides a clear picture of how the deformation of the fluid flow takes place. It also provides a natural way to discuss large perturbations. I apply this method to some elementary stability problems in the study of stellar structure.

APSS / 258

On the shape of rotating stars.

Author: Mr. NICOL, Peter [1]

Co-Authors: Dr. ENGELBRECHT, Chris [1]; Dr. FRESCURA, Fabio [2]

[1] *University of Johannesburg*

[2] *U Witwatersrand*

Corresponding Author: nicol3.peter@gmail.com

I adapt a recent work by Zahn et al. on the shape of rapidly rotating stars to explore the degree of oblateness for uniform, differential and shellular rotation of the star. I also discuss the relation of these results to the classical Roche limit.

APSS / 259

What Can We Learn from Phase Alignment of Gamma-ray and Radio Pulsar Light Curves?

Author: Dr. VENTER, Christo [1]

Co-Authors: Dr. JOHNSON, Tyrel [2]; Dr. HARDING, Alice [2]

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

[2] *NASA Goddard Space Flight Center*

Corresponding Author: christo.venter@nwu.ac.za

The Fermi Large Area Telescope (LAT) has revolutionized high-energy (HE) astronomy, and is making enormous contributions particularly to gamma-ray pulsar science. As a result of the many new pulsar discoveries, the gamma-ray pulsar population is now approaching 100. Some very famous millisecond pulsars (MSPs) have also been detected: J1939+2134 (a.k.a. B1937+21), the first MSP ever discovered, as well as J1959+2048 (a.k.a. J1957+20), the first black widow pulsar system. These along with other MSPs such as PSR J0034-0534 and J2214+3000 (and also including the Crab pulsar), are unique among the pulsar population in that they exhibit nearly phase-aligned radio and gamma-ray light curves (LCs). Traditionally, pulsar LCs have been modeled using standard HE models in conjunction with low-altitude conal beam radio models. However, a different approach is needed to account for phase-aligned LCs. We explored two scenarios: one where both the radio and gamma-ray emission originate in the outer magnetosphere, and one where the emission comes from near the polar caps on the stellar surface. We find best-fit LCs using a Markov Chain Monte Carlo technique for the first class of models. The first scenario seems to be somewhat preferred, as is also hinted at by the radio polarization data. This implies that the phase-aligned LCs are possibly of caustic origin produced in the outer magnetosphere, in contrast to the usual lower-altitude conal beam radio models. We lastly constrain the emission altitudes with typical uncertainties of 10% of the light cylinder radius. The modelled pulsars are members of a third gamma-ray MSP subclass, in addition to two others with non-aligned radio and gamma-ray LCs.

Poster2 / 260

Hi-speed Random Number Generator

Mr. OLATINWO, Adedayo [1]

[1] *University of Kwazulu Natal*

Corresponding Author: uncledlatins@yahoo.com

Recently, I . Kanter et al, developed an Ultra fast random bit generator, based on a semiconductor laser, having time delayed self-feedback, which operates reliably at rate up to 300 GB/s. The method uses a high derivative of the digitized laser intensity and generates the random sequence by retaining a number of the least significant bits of the high derivative value. The generator is insensitive to laser operational parameters and eliminate the necessity for all external constraints such as incommensurate sampling rates and laser external cavity round trip time. The randomness of long bit string is verified by standard statistical tests An improved Random Number generator is proposed by making use of Zener noise. At the same time Field programmable Gateway Array for processing the final generated random numbers instead of using the Nth and Least Synthetic Bits (LSBS). All the output from the FPGA will be transferred through USB cable into a connected PC where the random number is interpreted.

Poster1 / 261

Synthesis and photoluminescence properties of Tb^{3+}-cdoped $SrZnAl_2O_4$ nano crystals phosphor prepared via combustion process

Author: Mr. SHAAT, Samy [1]

Co-Authors: Prof. SWART, H.C [1]; Prof. NTWAEABORWA, O.M [1]

[1] *Department of Physics at University of Free State*

Corresponding Author: shaatskk@ufs.ac.za

Tb^{3+}-doped $SrZnAl_2O_4$ nanocrystalline phosphor with good crystallinity were successfully prepared by a combustion method at a relatively low temperature (500^{o}-C), using urea as fuel and metal nitrates as precursors. The effects of Sr and Zn concentrations on the structure and luminescent properties of the material were investigated. In addition, different concentrations of Tb^{3+}- were also used to determine the concentration that gives maximum intensity. The samples obtained were characterized by X-ray diffraction, scanning electron microscopy (SEM) and transmission electron micrograph (TEM), and photoluminescence (PL) properties of doped samples were investigated. The green emission obtained is associated with ^{5}-$D_4 \rightarrow {}^{7}F_5$ transitions of Tb^{3+}- at 543 nm. This emission was shown to increase with the concentration of Tb^{3+}- and it quenched at high concentrations. This was attributed to concentration quenching effects. The $SrZnAl_2O_4$:Tb^{3+}- phosphor was evaluated for possible application in different types of light emitting devices.

Poster1 / 262

Determining the bulk concentration of S in Fe-S: a Auger electron spectroscopy study

Author: Mr. BARNARD, Pieter [1]

Co-Authors: Prof. TERBLANS, Koos [1]; Prof. HOFFMAN, Matie [1]; Dr. ANDERSON, Bruce [2]

[1] *UFS*

[2] *Sasol*

Corresponding Author: barnardep@ufs.ac.za

An Auger electron spectroscopy study was performed in order to determine the bulk concentration of S in Fe-S. A number of studies have been performed that employs AES to study diffusion and segregation in metals. The most common application is the use of the technique to determine the diffusion parameters i.e. activation energy (Q) and the pre-exponential factor (D0). This approach makes use of a known bulk concentration and uses Fick`s semi-infinite solution to extract the diffusion parameters. Our research employs AES to determine the bulk S concentration in Fe-S. With the diffusion parameters obtained from literature and the use of the adapted t1/2 equation, derived from Fick`s semi-infinite solution, the bulk concentration of S was determined. AES measurements were performed at various temperatures for a fixed period of time in order to observe the segregation of S from the bulk of Fe to the surface. These constant temperature measurements were performed at temperatures in the range 200-800 °C where the temperature was increased in increments of 50 °C. A non-linear least square software program was developed to fit the adapted t1/2 equation to the data, in order to extract values for the bulk concentration of S. An average concentration value was calculated for the range of temperatures investigated and compared to concentration values obtain by linear programmed heating performed over the same temperature range with a linear increase in temperature.

Poster1 / 263

Investigation of S diffusion in bulk Fe – a DFT study

Author: Mr. BARNARD, Pieter [1]

Co-Authors: Prof. TERBLANS, Koos [1]; Prof. HOFFMAN, Matie [1]; Dr. ANDERSON, Bruce [2]

[1] *UFS*

[2] *Sasol*

Corresponding Author: barnardep@ufs.ac.za

The diffusion of a dilute S solution in Fe was investigated in order to determine the diffusion path and the energy required, Q, for diffusion in a bulk Fe crystal structure. Different pseudototentials were investigated in order to determine the pseudototential that best describes the ground state of the bulk Fe structure. Pseudototentials that gave a good description of the ground state were subsequently tested to find the appropriate bulk cell size that will give the best description of S diffusion in Fe. This was done by calculating the binding energy of pure Fe and that of S in Fe for different cell sizes and to find the cell size were the binding energy converges. Using the appropriate cell size, an investigation was performed in order to determine the diffusion mechanism of S in Fe. The nudged elastic band method was employed to calculate the minimum energy path of S diffusion in Fe, which gives the energy required for diffusion of S in Fe, namely the activation energy, Q. Activation energies for both interstitial S and substitutional S in the Fe crystal was calculated by the nudged elastic band method in order to determine the most energetically favourable diffusion mechanism for S in bulk Fe.

Poster1 / 264

Ab initio studies on stabilities of products related to Li/S and Li/O batteries

Mr. MASEDI, Cliffton [1]

[1] *University of Limpopo*

Corresponding Author: cliff8701@webmail.co.za

Ab-intio Density Fuctional Theory has been employed to investigate the stabilities of Li< sub >2< /sub >O, Li< sub >2< /sub >S, Li< sub >2< /sub >O< sub >2< /sub > and Li< sub >2< /sub >S< sub >2< /sub > systems. Calculations were carried out utilizing Plane-wave Pseudopotential method within GGA-PBE using VASP CODE. We found good agreement between predicted data and experimental data of lattice parameters . The elastic constant for Li< sub >2< /sub >O, Li< sub >2< /sub >S accord well with experimental results and those of Li< sub >2< /sub >O< sub >2< /sub > and Li< sub >2< /sub >S< sub >2< /sub > are reasonably predicted, and satisfied stability conditions. Phonon dispersion of Li< sub >2< /sub >O and Li< sub >2< /sub >S compare well with those obtained from neutron scattering experiments. We predicted phonon dispersion of Li< sub >2< /sub >O< sub >2< /sub > suggest that the structure is stable, while those of Li< sub >2< /sub >S< sub >2< /sub >< sub >2< /sub > display soft modes along along Γ direction hence suggesting structural instabilities. Furthermore phonon density of states attribute the instability to the vibrations of the sulphur atoms in the ab plane.

Applied / 265

Miniaturization of electrostatic space thrusters using ionization/acceleration coupling in discharge mode

Dr. FERRER, phil [1]

[1] *wits*

Corresponding Author: philippe.ferrer@wits.ac.za

Miniaturization of space prolusion systems has many advantages, both from an economic and performance perspective. One of the most promising propulsion technologies, the gridded electrostatic ion engine, resists miniaturization due to the poor down-scaling characteristics of the ion producing discharge chamber. We investigate a system where the ionization and acceleration mechanisms are coupled, thereby making the same electric field responsible for both. This sidesteps the need of a discharge chamber and allows for design of a much smaller engine. We introduce the concept and present some initial results, commenting on the feasibility of such a design.

LOS / 266

First time resolved diffraction experiments with the Stellenbosch Ultrafast Electron Gun

Author: Ms. HAUPT, Kerstin [1]

Co-Authors: Ms. BOSHOFF, Ilana [1]; Mr. ERASMUS, Nicolas [1]; Dr. KASSIER, Günther [1]; Prof. ROHWER, Erich [1]; Prof. SCHWOERER, Heinrich [1]

[1] *LRI, Stellenbosch University*

Corresponding Author: haupt@sun.ac.za

We observe ultrafast structural dynamics in crystals. For that, we use the 'Pump Probe Technique': The 'Pump' triggers a fast process, the 'Probe' takes a snapshot of it at a specific time. We are interested in observing processes, which happen on a picosecond timescale. That means, the duration of our 'Probe' must be in the order of ~ 100 fs. The only source of a 100 fs short signal, produced and controlled by humans, is a short pulsed Laser. We therefore convert short laser pulses to electron pulses of about the same duration (~ 200 fs). The electrons get diffracted on the atomic structure of the sample and form a pattern on the detector, which is recorded by a 16 bit camera. From the diffraction pattern we can work out the structure of the sample material at that specific time step. By repeating the experiment for different time delays between pump and probe, we gather information about the whole process we want to observe. We will show and discuss our latest measurements on charged density waves in TaSe2.

APSS / 267

On TeV Gamma-rays from Galactic X-ray Binary Systems with H.E.S.S. array

Mr. DAVIDS, Isak Delberth [1]

[1] *North-West University, Potchefstroom Campus*

Corresponding Author: isak.davids@gmail.com

With the birth of the new generation ground-based gamma-ray imaging atmospheric Cherenkov telescope arrays (such as H.E.S.S., MAGIC and VERITAS), there is a growing need to probe X-ray binary stars for very high energy gamma-ray emissions. Since the discovery of the first extra-solar X-ray binary (XRB), namely the Scorpius X-1 in 1962, XRBs are now well-established systems in the realm of X-ray astronomy. Today Scorpius X-1, with X-ray output energy 100 000 times greater than the total radiation of the Sun at all wavelengths, is today known as a microquasar. In order to foster the multi-wavelength campaigns of the day, we selected candidate XRBs from the Galaxy that were observed by H.E.S.S. for purposes of searching for significant TeV gamma-ray emission from these. Paredes (2008) confirmed four XRBs to be candidates that can be listed on the gamma-ray sky map. These were PSR B1259-63, LS I +61 303, LS 5039 and Cygnus X-1. From a survey of 125 known XRBs, Dickinson (2009) reported no conclusive detections of TeV emissions. The present study presents the Cherenkov technique, a briefing on X-ray binaries, known radiation mechanisms, relevant analysis techniques, and report on the preliminary results of Galactic XRBs that do not add any of the candidate XRBs to the envisaged catalogue of TeV gamma-ray binaries. It is an astrophysical hope that the envisaged CTA (Cherenkov Telescope Array), which may be hosted by South Africa, will provide the anticipated discoveries, providing a deep insight of the TeV gamma-ray sky.

APSS / 268

Constraining the Phase Space for Chameleon Dark Energy

Author: Mr. SIKHONDE, Muzikayise [1]

Co-Author: Dr. WELTMAN, Amanda [1]

[1] *University of Cape Town*

Corresponding Author: skhmuz002@gmail.com

A number of solutions to the dark energy problem have been proposed in literature, the simplest is the cosmological constant Λ. But the cosmological constant lacks theoretical explanation for its extremely small value, thus dark energy is more generally modeled as quintessence scalar field rolling down a flat potential. For the quintessence scalar field to be evolving on cosmological scales to day its mass must be of order H_0 , which is the present value of the Hubble constant. A scalar field φ whose mass varies with the background energy density was proposed by Khoury and Weltman(2003). This scalar field can evolve cosmologically while having coupling (β) to different matter fields of order unity. Such a scalar field also couples to photons in the presence of an external magnetic field via the φF^2 interaction, where F stands for the electromagnetic field strength tensor. The chameleon(φ)-photon coupling of this nature causes a conversion of photons to light Chameleon(φ) particles and vice versa. In this work we investigate this effect on pulsars, and we constrain the parameter space of this theory.

Education / 269

Learners' and prospective teachers' productive intuitive conceptions in magnetism

Ms. ERASMUS, Benita [1]

[1] *North-West university*

Corresponding Author: 20311192@nwu.ac.za

During the past decades there has been an increasing interest in alternative conceptions in physics. An alternative conception in science refers to a conception which in some aspects is contradictory to or inconsistent with the concept as intended by the scientists. Research in this domain tries to answer questions such as which misconceptions occur, what are their origins, how extensive are they and what can we do about them? Investigations of conceptual change approaches to remedy learners' alternative conceptions often showed that they are resistant to change. In this study we intend to follow a different approach that focuses more positively on productive intuitive concepts of learners and students, i.e. concepts that may serve as a potential base for further refinement towards the science concept. Students' and learners' initial conceptions are investigated and analyzed for productive resources. A teaching sequence will then be developed based on conceptual refinement of their resources rather than using a cognitive conflict strategy that intends to accomplish conceptual change of alternative conceptions. The study is still in progress and the presentation will discuss the results of interviews conducted with learners in grades 10, 11 and 12 and with prospective teachers enrolled in the first year university physical sciences programme. The learners' and students' intuitive concepts were probed in the field of magnetism. A clinical interview approach was followed with semi-structured open-ended questions. The data was transcribed and coded according to a conceptual development scheme. The results of the interviews will inform the compilation. The subjects in depth understanding of magnetic phenomena's and their positive intuitive concepts were probed and documented. The results of completing the interviews lead to the compilation of a structured questionnaire to investigate the consistency of potential positive intuitive concepts in magnetism. The findings lead to the potential refinement of specific magnetic concepts to the scientifically correct. The results showed deficiencies in the subjects' knowledge in magnetism as well as productive intuitive concepts that can be used for further refinement to a more scientifically correct understanding of magnetic concepts.

Poster1 / 270

Synthesis and photoluminescence studies of $(Ba_{1-x}Sr_x)Al_2O_4:Eu^{2+};Nd^{3+}$ prepared by combustion method

Author: Ms. LEPHOTO, Mantwa Annah [1]

Co-Authors: Prof. NTWAEABORWA, Odireleng Martin [1]; Prof. SWART, Hendrik [1]; Dr. MOTHUDI, Bakang Moses [2]; Dr. BEM, Daniel Barasa [1]

[1] *University of The Free State*

[2] *UNISA*

Corresponding Author: dunkie86@gmail.com

Barium-substituted phosphor powders of $(Ba_{1-x}Sr_x)Al_2O_4:Eu^{2+}$;Nd^{3+} composition were prepared by combustion method at an initiating temperature of 500^0C, using urea as reducer. The powders were then annealed at higher temperatures of 800^0C and 1000^0C for 3 hours. Their crystallinity and phase were characterized by x-ray diffraction (XRD). The x-ray diffraction shows that the crystallinity of $(Ba_{1-x}Sr_x)Al_2O_4:Eu^{2+};Nd^{3+}$ at (x=0) greatly improved after annealing at the higher temperature of 1000^0C and shows the hexagonal structure that closely correspond with the JCPDS data (PDF#17-0306). The morphology of the $(Ba_{1-x}Sr_x)Al_2O_4:Eu^{2+};Nd^{3+}$ composition were investigated using Scanning Electron Microscopy (SEM). The effect of varying the Ba/Sr concentration on the thermoluminescence (TL) glow curves was investigated using the Thermoluminescence Reader (Integral-Pc Based) Nucleonix TL 1009I. Photoluminescence (PL) properties of all phosphor samples were investigated by measuring their emission spectra using a 325nm He-Cd laser. For the as-prepared phosphor samples, the sample with x=0 $(BaAl_2O_4:Eu^{2+};Nd^{3+}$showed a much higher intensity compared to both the sample with x=1 $(SrAl_2O_4:Eu^{2+};Nd^{3+}$and the mixed composition of the two. $(BaAl_2O_4:Eu^{2+};Nd^{3+}$(x=0) and $SrAl_2O_4:Eu^{2+};Nd^{3+}$ (x=1)showed a broad emission at 505nm and 522nm respectively while the mixed composition showed two peaks at 447nm and 517nm. The broad emission peaks attributed to $4f^65d^1$-$4f^{\ 7}$ transitions of Eu^{2+} were obtained. Their phosphorescence was investigated by using the fluorescence Cary eclipse spectrophotometer coupled with a xenon lamp. Phosphorescence show higher luminescence for $(Ba_{1-x}Sr_x)Al_2O_4:Eu^{2+};Nd^{3+}$at (x=0).

Poster2 / 271

Mathematical Modeling of a Concentrator-Diffuser Wind Energy system

Mr. MASUKUME, Peace-Maker [1]

[1] *University of Fort Hare, Department of Physics*

Corresponding Author: pmasukume@gmail.com

Optimization of power output from ducted wind turbines has been the focus of many researchers in recent years. However many have dwelt much on diffusers than concentrators (nozzles) . Diffusers are characterized by flow separation due to deceleration of the fluid and this leads to energy dissipation. On the other hand a concentrator is accompanied by a favourable pressure gradient which stabilizes the boundary layer and thus minimizes energy dissipation. This study presents a mathematical model of a concentrator-Diffuser system which has been developed to optimize the power output of a low speed wind turbine. Optimization of the inclination angles of both the concentrator and the diffuser, ducts exit ratios and the reduction in backpressure were found to augment the mass flow at the rotor due to increased pressure drop and reduction in flow separation. It is illustrated that Power coefficients (Cp) of about 0.65 are achievable.

Education / 272

Using classroom response systems as a tool to enhance interactive engagement and formative assessment in the classroom

Author: Dr. HERBERT, Mark [1]

Co-Authors: Ms. CONANA, Honjiswa [1]; Mr. VOLKWYN, Trevor [1]

[1] *University of the Western Cape*

Corresponding Author: msherbert@uwc.ac.za

Educational technology in the form of classroom response systems (clickers)have become a tool in classroom instruction. In the classroom the clickers are used to promote interactive student engagement and immediate assessment of student understanding. The paper reports on a study using clickers as well as flash cards (a low tech version of the clicker) as a tool to enhance interactive engagement and formative assessment in the Extended Curriculum Programme (ECP) Physics at UWC. The results suggest that clickers may be a useful tool for the instructor to engage students in class discussions and to monitor their understanding and for students to have immediate feedback on their own progress. Overall the students' attitudes towards clickers were positive. They enjoyed the interactive nature of the clickers because of their familiarity with mobile phones and digital media. They also felt the anonymity associated with the assessment results decreased peer pressure.

NPRP / 273

Quasifree alpha cluster knockout studies

Prof. COWLEY, Anthony [1]

[1] *Stellenbosch University*

Corresponding Author: aac@sun.ac.za

Cluster-like structures in the shell-model description of the ground state of nuclei can be conveniently studied by means of knockout reactions. Of these the (p, p alpha) reaction is perhaps the simplest, especially from the viewpoint of the tractability of theoretical calculations used to interpret experimental results. The distorted wave impulse approximation (DWIA) is a versatile theory which is applicable to a knockout reaction. Fortunately its results appear to be reasonably insensitive to uncertainties in the exact ingredients, such as distorting optical potentials, which are obtained from unrelated elastic scattering studies. It will be shown that a number of surprisingly simple approximations in the DWIA hold for alpha-cluster knockout from light nuclei. Furthermore, results for a medium-mass nuclear target such as 40Ca are also consistent with expectation. Extracted spectroscopic factors are in reasonable agreement with shell-model estimates.

Poster2 / 274

Batch anaerobic co-digestion of cow dung and donkey manure

Mr. MUKUMBA, Patrick [1]

[1] *University of Fort Hare*

Corresponding Author: 201013904@ufh.ac.za

Biogas from anaerobic digestion can be a solution to current and future energy needs in South Africa. One option for improving biogas yield of anaerobic digestion of organic matter is co-digestion. Cow dung and donkey manure were co-digested together at different mixing ratios. Total Solids (TS) and volatile solids (VS), ammonia-nitrogen, pH, alkalinity, volatile fatty acids (VFA) and chemical oxygen demand (COD) were determined by using the standard methods of the American Public Health Association (ALPHA). The pressure of the biogas was measured daily by means of a pressure gauge fixed on top on the batch biogas digester. Methane and carbon dioxide contents in the biogas were sensed by non-dispersive infra red sensors. Palladium/Nickel sensors were used for sensing hydrogen and hydrogen sulphide in biogas. Highest biogas yield was obtained for a mixing ratio of 50% cow dung to 50% donkey manure, however lowest biogas yield was obtained from cow dung. For all the substrates the gas yield increased with time and then attains a constant value. However the co-digestion of cow dung and donkey manure attained maximum gas yield on 24th day while for cow dung it was on 28th day and for donkey manure it was on 26th day. Co-digestion of cow dung and donkey manure increased the gas yield by about 43%. Pure samples produced less biogas than co-digested samples. There was a strong positive relationship between gas production and % of co-substrates used (R2 = 0.999). The biogas produced from co-digestion can be a solution to lack of energy in rural areas in Eastern Cape Province of South Africa where plenty of donkeys and cattle are kept.

CMPMS2 / 275

Low-temperature Electrical conductivity and Magneto-resistance of Reduced Graphene Oxide Layers

Author: Mr. MCINTOSH, Ross [1]

Co-Authors: Mr. CHIMOWA, George [1]; Dr. MAMO, Messai [1]; Prof. BHATTACHARYYA, Somnath [1]

[1] *WITS*

Corresponding Author: macbugger@yahoo.com

We report on the electrical transport properties of graphene oxide (GO) and GO reduced using an organic acid (RGO). Two terminal GO and RGO devices were assembled via dielectrophoresis. The current-voltage characteristics of these devices were studied at low temperatures (77 K to 300 K) using a micromanipulated probe station. The I-V characteristics for RGO devices were found to be almost linear, indicating metallic behavior. This is in contrast to reports by other groups who have suggested variable range hopping (both Mott and Efros-Shklovskii) or space charge limited conduction. The density of states at the Fermi level in RGO was found to be an order of magnitude greater than that of GO. This was confirmed by four probe low temperature RT data (3 K to 300 K) which showed a T^2 dependence. Further support for the metallic nature of RGO was confirmed with magnetoresistance data at low temperatures (from 3 K) and fields up to 12 T. We believe reduction with organic acid does not introduce a high defect density, unlike the conventional reducing agent hydrazine. The superb electronic properties of RGO synthesized with this new method could find use in high-speed spintronic and magnetic memory devices.

APSS / 276

The neutron superfluid in the interior of neutron stars.

Author: Mr. KEMP, Garreth [1]

Co-Authors: Dr. ENGELBRECHT, Christian [1]; Dr. FRESCURA, Fabio [2]

[1] *University of Johannesburg*

[2] *University of Witwatersrand*

Corresponding Author: garry@kemp.za.org

In his work on superfluid helium, Feynman gave both qualitative and quantitative descriptions of the excitation spectrum of superfluid helium. I briefly review Feynman's approach to superfluid helium and assess the applicability of this theory to neutron star interiors.

Theoretical / 277

Monte Carlo simulation using GEANT 4 of MuSR

Mr. HARTMAN, Jonathan [1]

[1] *University of Johannesburg*

Corresponding Author: hartman.jonathan2@gmail.com

GEANT 4 is a C++ library developed by CERN to simulate particle physics experiments. However, GEANT 4 can be also be used for other applications that need not have anything to do with particle or high-energy physics. Here we discuss an application of GEANT 4 that simulates the EMU Spectrometer for Muon Spin Relaxation measurements at the ISIS facility in the Rutherford Appleton Laboratory. Both the incident muon and decay positron trajectories are affected. This changes the stopping location of muons for small samples and also the efficiency of the positron detection, in a strongly field dependent way. This leads to a systematic field dependent false asymmetry. The simulation has been performed in support of the interpretation of experiments todetermine the effect on diamond samples doped with muonium, which is a known analogue of the hydrogen atom.

CMPMS1 / 279

Enhanced green emission from UV down-converting Ce^{3+}-Tb^{3+} co -activated $ZnAl_2O_4$ phosphor

Authors: Mr. TSHABALALA, Kamohelo George [1]; Prof. NTWAEABORWA, Odireleng Martin [1]

Co-Authors: Dr. CHO, So-Hye [2]; Dr. PARK, Jung-Ku [2]; Prof. SWART, Hendrick [1]

[1] *University of the Free State*

[2] *Korea Institute of Science and Technology (KIST)*

Corresponding Author: tshabalalakg@ufs.ac.za

Rare–earths (Tb^{3+} or Ce^{3+}) doped zinc aluminate ($ZnAl_2O_4$) nanocrystals were successfully prepared by a modified combustion method using urea (CH_4N_2O, 99–99.5%) as fuel and characterized to investigate down-converted emission by energy transfer from Ce^{3+} to Tb^{3+} . The post-preparation annealing of the samples was carried out in a reducing atmosphere of 4%H_2/96%N_2 mixture at an elevated temperature of 700^0C for 4 hours. This was meant to reduce non-emitting Ce^{4+} to Ce^{3+} and also to improve crystallinity. As confirmed by X-ray diffraction (XRD) data, the materials were highly crystalline and the XRD patterns were consistent with the closed-packed face centered cubic spinel structure of $ZnAl_2O_4$. The photoluminescence excitation and photoluminescence data collected when $ZnAl_2O_4$:Ce^{3+},Tb^{3+} samples, with different concentrations of Ce^{3+} and Tb^{3+} ions, were excited at different wavelengths (230—325nm) showed that green emission of Tb^{3+} was sensitized by Ce^{3+}, i.e. there was energy transfer from Ce^{3+} to Tb^{3+} resulting in improvement of green emission due to the $^5D_4 \rightarrow {}^7F_5$ transitions of Tb^{3+} ions. This study therefore, sets out to discuss the sensitizing effect of Ce^{3+} and the effect of post annealing on the structure of $ZnAl_2O_4$:Ce^{3+},Tb^{3+}. The results indicate the potential of the phosphor powders for applications in luminescent display panels and further development as UV down-converters for improved performance of conventional photovoltaic cells.

Poster1 / 280

Spectroscopic studies of nanofluorides doped with Ln3+ synthesized via thermal decomposition of organic precursors

Author: Dr. GUSOWSKI, Marek [1]

Co-Author: Prof. SWART, Hendrik [1]

[1] *Department of Physics University of the Free State*

Corresponding Author: gusowskima@ufs.ac.za

There has been a growing demand for quantum cutting and upconverting efficient nano luminescent materials during the last decades. Wide band gap luminescent materials, specially the fluoride, are one of the major role players. Due to a number of advantages such as the excellent transparency in theinfrared (IR) to far ultraviolet (UV) range and low-energy phonons as well as low toxicity they have recently gathered considerable attention for their potential applications in bioimaging, disease detection and diagnostics. The same group of materials having downconversion characteristics can be applied for the improvement of solar cell efficiency in the quantum cutting processes. Here, we report on the synthesis and luminescence properties of colloidal double fluorides which belong to the general composition MF-LnF3 co-doped with optically active rare earth ions. During the thermal decomposition of the alkaline metals trifluoroacetate and lanthanide trifluoroacetate precursors NaYF4, KYF4, and KY3F10 samples have been obtained. The noncoordinating, high-boiling solvent octadecene was selected as the growth medium for the nanoparticles. Oleiamine and oleic acid were employed as the surfactant, which attached to the particle surface during the crystal growth and kept the nanoparticles well-separated from each other. Nanocrystals of RE3+ doped in the range of 40 nm were obtained. High Resolution Transmission Electron Microscopy (HRTEM) was used to evaluate the morphology and particle size distribution (PSD) of the prepared nanoparticles. The structural (XRD) and spectroscopic properties of optically active lanthanides doped fluorides have been determined based on the excitation spectra, emission spectra and luminescence decay curves recorded in the UV-Vis spectral regions.

Theoretical / 281

Non-locality without inequality and generalized non-local theory

Dr. CHOUDHARY, Sujit Kumar [1]

[1] *University of KwaZulu-Natal*

Corresponding Author: sujit@imsc.res.in

We find non-local but non-signaling probabilities satisfying the 'nonlocality without inequality' arguments for multiple two-level systems. Maximum probability of success of these arguments are obtained in the framework of a generalized nonlocal theory. Interestingly, for two two-level systems, the probability of success of these arguments converge to a common maximum in this framework. This is in sharp contrast with the quantum case, where for such systems, Cabello's argument succeeds more than that of Hardy's. We also find that the maximum probability of success of Hardy's argument is the same for both the two and three two-level systems in the framework of this more generalized theory.

Poster1 / 282

Thermal and electronic transport studies of the Kondo energy scale in the heavy-fermion system CeCu5-xAlx

Author: Prof. STRYDOM, Andre [1]

Co-Author: Mr. BRITZ, Douglas [1]

[1] *University of Johannesburg*

Corresponding Author: amstrydom@uj.ac.za

The binary compound $CeCu_5$ is an archetypal heavy-fermion Kondo lattice with an antiferromagnetic ground state. Strong hybridization effects between the localized 4f-electron moment and conduction electrons result in incoherent spin scattering in the electronic transport at high temperatures, but with an effective magnetic moment nearly equal to that of the free-ion Ce_{3+} state. Long-range magnetic ordering at T_N = 3.9 K and the Kondo temperature T_K=2.2 K are of similar energy scales, making this system ideally suited to studies of competing magnetic interactions in the strongly correlated electron class of systems. In this work we synthesized a series of pseudo-binary compounds $CeCu_{5-x}Al_x$. The dilution of Cu by Al results in augmenting the electronic density of states close to the Fermi energy, which is also the location of the magnetic and hybridized 4f electron levels resonance. Our studies of the temperature and magnetic field dependencies of thermoelectric power and electrical resistivity in the $CeCu_{5-x}Al_x$ series of compounds will be discussed in terms of comparitive calculations of the Kondo energy scale from data of magnetoresistivity (the single-ion Bethe Ansatz theory) and from the thermoelectric power (phenomenological description in presence of intermediate valency) by means of two different theoretical models.

Applied / 283

Transmission electron microscopy investigation of radiation damage caused by keV implantation in single-crystal diamond.

Author: Mr. NSHINGABIGWI, Emmanuel Korawinga [1]

Co-Authors: Prof. NEETHLING, Jan [2]; Dr. LEVITT, C.M [1]; Dr. NAIDOO, S.R. [1]; Prof. DERRY, T.E [1]

[1] *University of the Witwatersrand*

[2] *Nelson Mandela Metropolitan University*

Corresponding Author: 0413352y@students.wits.ac.za

An understanding of the types of defects produced during the doping/implantation of diamond remains essential for the optimization of high-temperature, high-power electronic applications. Thus this study focuses on investigating the nature of the radiation damage produced during the multi-implantation of carbon ions in synthetic type Ib and natural diamonds, according to the CIRA (Cold-Implantation-Rapid-Annealing) routine. The implanted and annealed diamond samples were characterized using bright field transmission electron microscopy (BFTEM) in conjunction with selected area diffraction (SAD). For low fluence implantations, the damaged diamond retains its crystallinity after annealing at 1600K, while implanting using doses above the amorphisation/graphitization threshold, followed by rapid thermal annealing (RTA) at 1600K, results in a multi-layer of graphite/amorphous carbon close to the surface.

APSS / 284

Validating The Auroral Zone Lower Ionosphere Model

Authors: Mr. AFFUL, MICHAEL [1]; Mrs. MCKINNELL, Lee-Anne [2]

Co-Author: Mrs. MCKINNELL, Lee-Anne [2]

[1] *UNIVERSITY OF CAPE TOWN*

[2] *SANSA, Space Science*

Corresponding Author: michaelafful@gmail.com

The ionosphere is known to behave predictably as a function of solar zenith angle, solar activity and season. In the past, analytical models have been developed to predict the behaviour of the ionosphere according to these parameters. This project aims to validate the IMAZ model, a recently developed empirical model for the lower ionosphere in the auroral zone to predict electron densities in the D-region as well as compare to other existing models designed for the same purpose. Rocket-bourne measurements were used as a database of reliable lower ionosphere data. A response in the lower ionosphere was analysed based on the contribution of some input parameters. The output was the electron density for a given set of inputs at a particular pressure surface as predicted by the IMAZ model. Furthermore, the ability of the IMAZ model to predict accurately within the auroral zone was established and the need for further improvements was presented.

CMPMS2 / 286

Atomistic Simulation Study on Lithiated Manganese Dioxide Nanostructures

Author: Mr. KGATWANE, Kenneth [1]

Co-Authors: Prof. NGOEPE, Phuti [1]; Prof. SAYLE, Dean [2]

[1] *University of Limpopo*

[2] *Cranfield University*

Corresponding Author: kgatwanek@hotmail.com

Nanostructured materials are used to develop lithium-ion batteries with high energy, high-rate capability and excellent cycling stability due to their huge surface area, short distance for mass and charge transport and freedom for volume change. They are capable of reversibly accommodating large amount of Li, on intercalation mesoporous β-MnO_2 can accommodate Li/Mn = 0.92:1 with 81% capacity retention. This is contrast to a very limited amount of Li, that could be intercalated electrochemically into the bulk crystalline MnO_2. The electrochemical properties of MnO2 are governed by the rich and complex microstructure it accommodates and characterisation at the atomistic level is difficult experimentally. Atomistic computer simulations offer a unique platform of exploring structural features at the nanoscale. Simulated amorphisation and recrystallisation technique, involving tens of thousands of atoms, has been successfully used to generate models of various nano-forms of the complex manganese dioxides, which include microstructural details. In the current study, we apply this method to study lithium insertion into the nanospheres, nanosheets, nanorods and nanoporous structures of the binary manganese dioxides. Different Li concentrations (up to Li:Mn = 0.73:1) were inserted into the different nanostructures. Molecular dynamics simulation under the NPT ensemble was performed, in order to allow the system to expand. The variation of mechanical properties and changes of microstructural features with low and high lithium concentration are investigated. The resulting microstructure provides valuable insights into the origins of electrochemical activity which could make it a suitable battery electrode.

CMPMS2 / 287

Stabilities of low and high pressure structures of $CoPO_4$ and $MnPO_4$

Author: Mr. LETHOLE, NDANDULENI LESLEY [1]

Co-Author: Prof. NGOEPE, Phuti Esrom [2]

[1] *SAIP*

[2] *Materials Modeling Centre*

Corresponding Author: letholel@ul.ac.za

Crystals of $LiFePO_4$ and related materials have recently received a lot of attention due to their promising use as cathodes in rechargeable lithium ion batteries. These compounds have been known for good stability and low cost. The Co based compound $LiCoPO_4$, has rapidly become of particular interest as recent measurements found a potential of 4.8 V, while the Mn based compound structure has an equilibrium voltage of 4.1 V, which is compatible with the electrolyte presently used in Li-ion batteries. Before the introduction of amorphisation recrystallisation methods to quaternary $LiMPO_4$ (M=Mn and Co), it will be important to commence with ternaries ($CoPO_4$ and $MnPO_4$), since ternaries are less complex. Hence we investigate the mechanical, optical and structural stabilities of the different polymorphs of $CoPO_4$ and $MnPO_4$, before atomistic simulations, by employing the pseudo-potential planewave calculations within the Local Density Approximation (LDA) and Pardew-Wang Generalized Gradient Approximation (GGA).

CMPMS2 / 288

Computational modelling of Zr-Nb alloys by solid solution approach

Authors: Dr. CHAUKE, Hasani [1]; Ms. CHUMA, Moyahabo [1]

Co-Author: Prof. NGOEPE, Phuti E [1]

[1] *Materials Modelling Centre*

Corresponding Author: hr.chauke@ul.ac.za

We use density functional theory to investigate the structural, elastic properties and energetic stabilities of Zr, Nb and its alloys in the alpha and beta phases, employing pseudopotential plane wave methods within the Pardew-Burke-Ernzerhof Generalized Gradient Approximation (PBE-GGA). The structures were fully optimized in a non-magnetic state, allowing atomic positions, cell volume and shape to change. Lattice parameters for the pure phases gave excellent agreement with the available experimental data. We also found that the phonon dispersions curves display soft-modes for the metastable beta-Zr phase which is lacking on the alpha-Zr and beta-Nb, condition of mechanical stability. The solid solution calculations show that an increase in the Nb contents destabilizes the structures in both the alpha and beta phases. Interestingly, the calculated elastic moduli for Zr-2.3%Nb are in good agreement to the experimental results of Zr-2.5%Nb.

NPRP / 289

Study of di-photon events in the ATLAS detector at the LHC : cross-section measurement and application to Higgs searches in the di-photon channel

Dr. AUROUSSEAU, Mathieu [1]

[1] *University of Johannesburg*

Corresponding Author: mathieu.aurousseau@gmail.com

The measurement of the isolated di-photon cross-section at the LHC is crucial as these events constitute an irreducible background to new physics processes, such as a Higgs boson or graviton decaying to two photons. These events also provide important information for the understanding of QCD processes. The di-photon cross-section has been measured in ATLAS using the full 2010 data sample, corresponding to an integrated luminosity of 37 pb-1. Results as a function of the di-photon invariant mass, transverse momentum and azimuthal separation are presented and compared with NLO theoretical predictions. Focusing on the invariant mass region between 100 and 150 GeV where a light Higgs boson is searched for in the di-photon channel, exclusion limits are set on the Standard Model prediction. The results obtained are already at the level of the results from TeVatron experiments in this channel.

NPRP / 290

Search for Higgs boson to 4 leptons through new gauge bosons

Dr. AUROUSSEAU, Mathieu [1]

[1] *University of Johannesburg*

Corresponding Author: mathieu.aurousseau@gmail.com

The H -> ZZ(*) -> 4leptons channel is one of the most promising channels for a low-mass Higgs boson, as it has both a clean signature and a large branching fraction for Higgs mass below a few hundred GeV. The ATLAS experiment has explored this channel using the LHC collisions data at a center-of-mass energy of 7 TeV, using data-driven background estimation techniques. Some Abelian Hidden Sector models predict the existence of new Higgs and gauge (Z') bosons, weakly coupled to the Standard Model (SM) sector. The decay of the SM Higgs to a pair of Z' bosons is allowed, possibly with a large branching fraction, by the mixing of the Higgs sectors. The decay of the Z' bosons to lepton pairs with a large branching fraction can then be explored in the same way as the standard H -> ZZ(*) -> 4l channel, by relaxing the constraints on the di-lepton invariant mass. Perspectives on this new approach with the ATLAS experiment are presented.

APSS / 291

Constraining Viewing Geometries of Pulsars With Single-Peaked Gamma-ray Profiles Using A Multiwavelength Approach

Author: Dr. SEYFFERT, Albertus [1]

Co-Authors: Dr. VENTER, Christo [1]; Dr. HARDING, Alice [2]; Mr. JOHNSON, Tyrel [2]

[1] *North-West University*

[2] *NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA*

Corresponding Author: 20126999@nwu.ac.za

Since the launch of the Large Area Telescope (LAT) on board the Fermi spacecraft in June 2008, the number of observed gamma-ray pulsars has increased dramatically. A large number of these are also observed at radio frequencies. Weltevrede et al. (2010) derived constraints on the viewing geometries of 6 gamma-ray pulsars exhibiting single-peaked gamma-ray profiles using high-quality radio polarization data. We obtain independent constraints on the viewing geometries by using a geometric emission code to model the Fermi-LAT and radio light curves. We find fits for the magnetic inclination and observer angles by searching the solution space by eye. Our results are generally consistent with those obtained by Weltevrede et al. (2010), although we do find differences in some cases. We will indicate how the gamma-ray and radio pulse shapes as well as their relative phase lags lead to constraints in the solution space. A more rigorous approach, the Monte Carlo Markov Chain technique, is able to statistically find best-fit light curves in addition to constraining several model parameters and estimating errors on these.

Poster1 / 292

Structure-property relationship of sol-gel synthesised zinc-oxide nanoparticles

Author: Ms. PETERSON, Natasha Venita [1]

Co-Authors: Prof. ARENDSE, Christopher [1]; Prof. HILLIE, Thembela [2]; Dr. DHLAMINI, Mokhotjwa [3]

[1] *University of the Western Cape*

[2] *DST/CSIR National Centre for nano-Structured Materials*

[3] *University of South Africa*

Corresponding Author: 2551076@uwc.ac.za

Zinc-oxide nanoparticles are well known for their novel optical and electronic properties for applications in various fields such as solar cells, ultra violet shielding, gas sensors, paint and heat mirrors. We report on the relation between the structure and optical properties of ZnO nanoparticles synthesized via the sol-gel technique, with specific emphasis on the effect of growth and reaction temperatures. High-resolution microscopy techniques, complemented by Raman spectroscopy and x-ray diffraction, confirm that the crystallinity and particle size of ZnO nanoparticles is directly related to the synthesis conditions. Optical absorption and emission spectroscopy show that optical band gap and photoluminescence of the ZnO nanoparticles are intimately related to its structural properties, ascribed to the quantum confinement effect. Photoluminescence spectroscopy confirm the emission peaks in the ultraviolet (380 nm) and visible (500 nm) region; the latter attributed to the presence of the singly ionized oxygen vacancies in the nanoparticle.

Applied / 293

Protein localization and folding mechanisms revealed by molecular dynamics simulations

Author: Dr. GUMBART, James [1]

Co-Authors: Dr. CHIPOT, Christophe [2]; Dr. KLAUS, Schulten [3]

[1] *Argonne National Laboratory*

[2] *Nancy Universite*

[3] *University of Illinois at Urbana-Champaign*

Corresponding Author: gumbart@ks.uiuc.edu

Many nascent proteins, including nearly all membrane and secreted proteins, must traverse a membrane-bound protein-conducting channel prior to their full maturation. This channel, the Sec translocon, is found in all domains of life and possesses the novel ability to direct nascent proteins to the membrane or to the extracellular space, depending on their sequences, often concomitant with their synthesis by the ribosome. By combining atomic structures with cryo-electron microscopy data using the molecular dynamics flexible fitting method, we have developed some of the first views of inactive and active translocons in complex with the ribosome. These views reveal a conserved mode of interaction between translocon and ribosome as well as the roles of specific elements of both in protein localization. We also carried out two-dimensional potential-of-mean-force calculations to explore the structure of the nascent peptide within the translocon environment. The calculations revealed that the translocon exerts a small bias on the peptide towards a helical state. This bias can serve to facilitate, e.g., the insertion of nascent membrane proteins into the otherwise inhospitable lipid bilayer.

Applied / 294

Comparative Efficiency Study of a Solar Trough Receiver: Hot mirror and Selective coating

Author: Ms. CYULINYANA, Marie Chantal [1]

Co-Author: Dr. FERRER, Philippe [2]

[1] *University of the Witwatersrand*

[2] *University of the witwatersrand*

Corresponding Author: 458410@students.wits.ac.za

We consider a solar trough system in which cylindrical parabolic mirrors focus the sun's radiation onto a receiver pipe, heating it. Conventionally, the pipe is enclosed in a glass cover under vacuum and the dominant radiation losses are reduced by the use of a selective coating on the receiver pipe. We study the suitability of applying a 'hot mirror' coating on the glass cover instead, which transmits in the visible but reflects well in the infra-red. We compare the performance of the 'selective' with a 'hot mirror' coating using the results from simulations for a general heat transfer model. It is seen that a hot mirror is a viable alternative, and certainly allows higher temperatures of the working fluid and therefore higher Carnot efficiency. The optimum is a hybrid system, with selective coating applied at the low temperature end of the receiver pipe and the hot mirror being used at higher temperatures.

NPRP / 295

Status of the Electron Cyclotron Resonance Ion Sources (ECRIS) at iThemba Labs

Author: Mr. NTSHANGASE, Sifiso Senzo [1]

Co-Authors: Dr. THOMAE, R.W [1]; Dr. FOURIE, D.T [1]; Dr. CONRADIE, J.L [1]

[1] *iThemba LABS*

Corresponding Author: sifiso@tlabs.ac.za

Heavy ion beams at iThemba LABS have been produced in a 10GHz Minimafos electron cyclotron resonance ion source (ECRIS) for the past two decades. The typical values for the injection and extraction coil current are in the range of 1000A. The operating pressure is about 10-6 mbar depending of the ion produced. The Minimafios ECRIS allow the use of supporting gas like helium, oxygen etc. It accommodate up to from 10KV up to 20KV extraction voltage. For electron enhancement a biased disc at -50V was introduced at the injection side of the plasma chamber. Examples of beams which have been produced using the Minimafios are: H, He, B, C, N, O, Ar, Ne, Al, Si, Cl, Zn, Kr, I, Xe, Li.The increase in demand for new ion species and high intensity beams from the nuclear physics community has led to a decision to procure a new 2nd generation ECRIS. The procured source is a room temperature ECRIS based on the Grenoble Test Source (GTS) design. It uses two microwave frequencies, 14.5GHz and 18GHz to deliver positive ions. It was made to accommodate to oven. The axial field can be varied between 0.5T and 1.2T using three solenoid coils and a radial field of 1.3T achieved by using FeNdB permanent magnet. The source has been assembled and is being commissioned at iThemba LABS. The Hahn-Meitner-Institute (HMI) in Berlin donated their 14.5GHz ECRIS4 to iThemba LABS where it is presently operational. This source consist of a water-cooled plasma chamber (length 18cm, diameter 7cm) surrounded by feNdB permanent magnets which produce a hexapole field of 1T at the wall of the chamber for plasma confinement. Two solenoid coils produce an axial field which confines the plasma axially. The field on axis typically varies from 0.4 to 1.1T. The microwave power is coupled into the source via a wave guide. It generator can deliver up to 2KW of microwave power. Furthermore, iThemba LABS is one of the few laboratories which produce nuclear polarized proton beams using the so-called polarized ion source. In this report the status of the four ion sources will be presented.

Poster1 / 296

Computational study of the effect of polydimethylsiloxane (PDMS) side chain size and spacing on the mobility of the polyethylene oxide (PEO).

Author: Mr. KUBAI, Thomas [1]

Co-Authors: Prof. NGOEPE, P. E. [2]; Dr. ACKERMANN, Lutz [2]

[1] *university of Limpopo*

[2] *University of Limpopo*

Corresponding Author: chanky@webmail.co.za

The effects of side chain size and spacing on the mobility of the PEO backbone have been studied using molecular dynamics (MD) in Forcite code of Materials studio. The systems investigated contain a PEO chain of 186 ethylene oxide (EO) monomers to which side chains of 5, 6, 7, 8 and 9 PDMS monomers have been attached. The separations of the side chains used are 5, 10, 15, 20 and 50 EO monomers. The overall mobility of the polymer host system is found to have minima at side chain size of 6 and 7. A maximum is seen at side chain spacing of 8 and 9. No evident was found to suggest that side chain spacing has an effect on the mobility of the PEO polymer backbone. Furthermore, the point of attachment of the side chain has no effect on the polymer mobility.

Poster2 / 297

The effect of ventilation on the thermal performance of an energy efficient house

Author: Mr. MTHIMUNYE, Thabiso Vincent [1]

Co-Author: Dr. MAKAKA, golden [1]

[1] *ufh*

Corresponding Author: ttvmthimunye@webmail.co.za

An energy efficient passive solar house was designed, constructed and its natural ventilation efficiency monitored. Carbon tracer test was used to measure the ventilation efficiency of each ventilation component. Windows were found to have higher impact on the ventilation rate than doors. The correct operation of the ventilation components was found to be the main contribution factor in natural ventilation.Tracer gas tests were conducted over a period of time to measure actual air change rates. Carbon dioxide was injected into the house and its concentration monitored over time to determine how quickly the gas dissipates through the house's envelope. The west side ventilation components were used to control the indoor environment by regulating the amount of air flowing into the house. A carbon dioxide sensor was placed in the centre of the house at a height of about 0.45 m above the floor. A fan was used to pump the indoor air into the sensor at a rate of about 300 ml/min. To investigate the effects of each of the ventilation component configurations, the ventilation rate tests were done in four configurations. A carbon dioxide sensor connected to a CR1000 data logger and a computer was used to monitor carbon dioxide concentration in the house. results:The tracer gas technique was used to measure the air exchange rate. The average indoor and outdoor temperatures during these tests were, Tin = 20 °C and Tout =17 °C, and an average wind speed of 0.5 m/s blowing from W(600 150)N.when both windows and doors were opens. Results indicate that the concentration decays exponentially to the background concentration within a period of 16 minutes. Assuming that the west window and door are the only paths through which the westerly winds enter the house, then the mass air flow rate through the door and window is approximated.Take the average air density to be 1.2 kg/m3, an average indoor and outdoor pressure difference to be 4 Pa. For wide-open windows and doors, the opening area is the sum of the windows and doors areas, which gives 2.06 m2 and taking the discharge coefficient Cd=0.6 the average mass airflow was found to be approximately 3.83 kg/s.Natural ventilation varies greatly on local factors such as wind speed and temperature which also influence at which occupants open ventilation components.

CMPMS2 / 298

The impurity levels of lanthanide ions in silica

Author: Dr. KROON, R.E. [1]

Co-Authors: Mr. SEED AHMED, H.A.A. [1]; Dr. GUSOWSKI, M.A. [1]

[1] *Physics Dept, University of the Free State*

Corresponding Author: kroonre@ufs.ac.za

Silica is a basic material of technological importance for optics, microelectronics, photonics and fibre optics. Its high absorption edge energy makes its particularly useful for UV applications and it has been used as a host material for a variety of luminescent lanthanide ions due to its chemical stability and non-hygroscopic nature. For lanthanide ions the 4f electron energy levels are shielded from the host environment by the filled outer 5s and 5p orbitals, so that the transitions between these states and therefore the luminescent wavelengths are relatively insensitive to the host. For this reason little attention has been paid until recently to the location of the impurity levels of the lanthanide ions within the energy gaps of their hosts. However, luminescence from some lanthanide ions, e.g. cerium, occurs due to f-d transitions from the unshielded 5d state of which the energy relative to the f-states is therefore host dependent. The absolute positions of the 4f and 5d states relative to the energy gap of the host also affect quenching and charge trapping phenomena and so they are required for proper modeling of phosphor performance. Recently Dorenbos has suggested that the energy levels of any of the 13 divalent lanthanides relative to the band edges of the host can be found using only three parameters. However, obtaining this data for a particular host is not always straightforward e.g. use can be made of the f-d transition energy of cerium, but different values for this parameter in silica have been reported. In this paper a scheme for the energy levels of both the divalent and trivalent lanthanide ions in silica is proposed and compared to the experimental data.

CMPMS1 / 299

Temperature dependent I-V characteristics of Sulphur passivated Au/n-GaSb Schottky barrier diodes

Author: Mr. MURAPE, Davison Munyaradzi [1]

Co-Authors: Prof. BOTHA, Reinhardt [1]; Prof. VENTER, Andre [1]

[1] *NMMU*

Corresponding Author: munyamurape@gmail.com

The current-voltage (I-V) characteristics of sulphur passivated n-GaSb have been studied in the temperature range 80 K - 330 K using Au Schottky barrier diodes (SBDs). The forward I-V characteristics have been analysed assuming that thermionic emission is the dominant current transport mechanism and that the barrier height patchiness takes on a Gaussian distribution. It has been found that sulphur treatment of the GaSb accompanied by prior etching steps lead to a significant improvement in the quality of the SBDs as is evidenced by the improvement in the ideality factor (n), rectification ratio, series resistance (Rs) and the barrier height (Φb) of the device, These improvements were attributed to removal of predominantly Sb-O from the GaSb surface together with passivation of surface states acting as recombination centres. Typical diode parameters obtained at room temperature (300K) were found to be to be 1.12 (n), 19.4Ω (Rs) and 0.52eV (Φb)) The ideality factor was found to diverge from unity whereas the barrier height increased with decrease in temperature. The increase in the ideality factor is attributed to the dominance of field assisted tunnelling over thermionic emission at low temperatures and is particularly severe for high free carrier concentration material. Finally, the surface state densities for sulphurized material were quantified using I-V measurements and compared to that of untreated material.

Education / 300

The Extended Curriculum Programme (ECP) Physics at University of the Western Cape (UWC): Giving students' access to study the physical sciences in higher education, particularly further studies in physics.

Author: Dr. HERBERT, Mark [1]

Co-Authors: Ms. CONANA, Honjiswa [1]; Mr. VOLKWYN, Trevor [1]

[1] *University of the Western Cape*

Corresponding Author: msherbert@uwc.ac.za

This paper addresses what has been done in the Science Faculty at the University of the Western Cape (UWC). The Extended Curriculum Programme (ECP) Physics at UWC centers its focus on giving students access to the studies of the Physical Sciences and improving their success. The paper notes that the incoming students enter university with educational disadvantage backgrounds. For this reason the ECP Physics has undertaken an initiative to address this under-preparedness by aligning with the UWC graduate attributes to produce good quality graduates. Central to addressing the students' under-preparedness, the ECP Physics makes an effort to create a learning environment that is conducive to meaningful learning. In this way, a good foundation is laid for further studies in Physical Sciences. Students are oriented as soon as they come in to the Physics classes about their role and the lectures role in their learning. In the paper, discussion on how the curriculum, learning outcomes, learning activities, assessments of the learning activities and the research into teaching and learning are aligned to the graduate attributes. Data will be collected through a survey questionnaire about how the past and the current students perceive the ECP Physics learning environment and what their experiences are. The challenges that come across throughout the Physics course will be presented and discussed in depth.

LOS / 301

Identification of ultrafast processes in the spectroscopy of ZnPc

Author: Mr. OMBINDA-LEMBOUMBA, Saturnin [1]

Co-Authors: Dr. DU PLESSIS, Anton [1]; Dr. STEENKAMP, Christine [2]; Dr. BOTHA, Lourens [1]; Prof. ROHWER, Erich [2]

[1] *CSIR National Laser Centre*

[2] *Laser Research Institute, Department of physics, University of Stellenbosch, South Africa*

Corresponding Author: sombinda@csir.co.za

The transient absorption of Zinc phthalocyanine (ZnPc) has been studied by femtosecond pump-probe spectroscopy. We present results on the ultrafast spectroscopy of ZnPc, specifically identifying three ultrafast components observed. These are the inertial solvation dynamics (~1.8 ps), the dielectric solvation dynamics (~39 ps) and vibrational relaxation (~2.7 ps) in the electronic excited state. Results using different pump wavelengths, different sample concentrations and different solvents help to clarify the mechanisms behind the observed signals. The red shift of the ground state (Q band) spectra is also discussed.

Applied / 302

Fabrication of MWCNT/NiO nanocomposite thin films for optically selective solar absorbers

Author: Dr. RORO, Kittessa [1]

Co-Authors: Mr. YALISI, Brian [2]; Mr. TILE, Ngali [2]; Dr. MWAKIKUNGA, Bonex [3]; Dr. ROBERTS, Ted [1]; Prof. FORBES, Andrew [1]

[1] *NLC-CSIR*

[2] *CSIR-NLC*

[3] *3DST/CSIR-National Centre for Nano-Structured Materials*

Corresponding Author: kroro@csir.co.za

Carbon nanoparticles embedded in thin NiO layers have shown an increasing interest for application in spectrally selective solar absorbers that can be used for low temperature photothermal applications. It is expected that the size and shape of carbon nanoparticles in the NiO matrix is extremely important in tuning the selectivity of the coatings. In this work, multiwall carbon nanotubes (MWCNT)/NiO composite films of different CNT contents were prepared by sol-gel technique, and their structural and optical properties were investigated by scanning electron microscopy, x-ray diffraction, Raman spectroscopy, UV-Vis spectroscopy and emissometer. Preliminary durability study on these coatings will also be presented. The results demonstrate promising spectrally selective properties indicating that the CNT/NiO composite is an excellent choice for solar water heating applications.

APSS / 304

Strong Gravitational Effects on Pulsar Signals Emanating from Close Compact Binary Systems

Mr. TUCKER, Bevan [1]

[1] *University of the Witwatersrand*

Corresponding Author: tuckersama@gmail.com

The advent of the MeerKAT and SKA radio telescope projects will allow for vastly improved precision in the measurement of pulsar radio frequency emissions. Thus, the propagation of a pulsar's conical radio beam through the strong gravitational field region in the vicinity of a compact object, i.e. black-hole or another neutron star, will probe the metric of spacetime in the high-field regime. This talk outlines the theoretical and associated numerical predictions of General Relativistic effects, such as the Lense-Thirring effect, on such a pulsar signal.

Poster1 / 305

Variation of different compositions of Ti-Pt within the B2 region using solid solution method employed in CASTEP

Author: Ms. MAHLANGU, Rosinah [1]

Co-Authors: Dr. CHAUKE, H.R [1]; Prof. NGOEPE, P.E [1]; Mr. PHASHA, M.J [2]

[1] *University of Limpopo*

[2] *CSIR*

Corresponding Author: rosinahm@ul.ac.za

Different compositions of Ti-Pt were varied within the B2 region i.e. 45-55 at% Pt using solid solution method employed in CASTEP code. The Ti50Pt50 structure was found to be more stable as compared with other different compositions with the heats of formation of -0.8584 eV. We also observed that the more we increase the Ti and decrease the Pt composition, the change of the heats of formation becomes minimal and this was observed on the plotted curves of the heats of formation against the composition range. The elastic properties of the compositions were also calculated.

Applied / 306

Carbon structures generated by carbon ion implantation into FeCr thin films

Author: Dr. WAMWANGI, Daniel [1]

Co-Authors: Dr. NAIDOO, Mervin [1]; Mr. ERASMUS, Rudolph [1]; Prof. COMINS, D [1]

[1] *wits university*

Corresponding Author: daniel.wamwangi@wits.ac.za

We present results on the synthesis of precise and thickness controlled carbon structures using ion implantation into thin films of a typical metal catalyst, for Schottky contacts and spintronic applications. Thin films of FeCr on a silicon substrate was prepared using magnetron sputtering and then implanted with carbon ions at controlled thicknesses close to the surface at elevated temperatures (600C) in an attempt to catalyse the formation of carbon nanotubes. The energy and the dose of the carbon ions to be deposited close to the surface was determined from SRIM simulations. The nature and quality of the carbon nanotubes was probed using Raman, electrical and magnetic measurements.

LOS / 307

Density Functional Calculation of Metal Dithizonates

Author: Mr. OLAOYE, OLUFEMI OPEYEMI [1]

Co-Authors: Mr. BOSMAN, Gurthwin [1]; Prof. SCHWOERER, Heinrich [1]

[1] *STELLENBOSCH UNIVERSITY*

Corresponding Author: olaoye@sun.ac.za

Understanding molecular dynamics on potential energy surfaces has been at the heart of ultrafast transient absorption in the recent years [Philipp K, etal., 2005],[Karel G, etal., 2008]. Based on the on-going experiment at our ultrafast laboratory, we ran density functional calculations on metal dithizonates, starting with their kernel molecule, formaldimine, to validate what we observe experimentally. This we treated in terms of ground state energy, absorption spectrum, vibrational frequency and potential energy surface using two different softwares: Amsterdam Density Functional (ADF) and Gausian(09). The overall results show that B3LYP functional combined with CEP-31G basis set gave the closest results to the experimentally observed data.

Poster2 / 308

Developing a laser ionization test bench for radioactive beams

Author: Mr. MAKHATHINI, Lucky [1]

Co-Authors: Dr. BACK, Rob [2]; Prof. WALTERS, P E [3]; Prof. ROHWER, E G [3]

[1] *University of Zululand, stellenbosch and iThemba labs*

[2] *iThemba Labs*

[3] *University of stellenbosch*

Corresponding Author: makhathinilucky@yahoo.com

Nuclear reactions employed in the production of neutron-rich radioactive beams often produce many species simultaneously. To extract these beams, they must not only be ionized, but ionized selectively, so that only the desired species is extracted. We are developing the laser resonant ionization technique to fulfil these requirements. The method makes use of high power pulsed lasers, making it possible to assume that the ionization probability of atoms entering the laser beam zone will be close to 100%. A test setup-is being developed to ionize stable atoms. In our test bench, a stream of atoms is produced by evaporation. Atoms in the stream are ionized by lasers and transported to an ion detector with the assistance of an electric field. Ionization can be either non-resonant through a continuum of levels or resonant through excitation of an auto-ionizing state. For efficient atom ionization the transition must be saturated at all excitation stages. The condition of saturation means 100% probability of excitation of all atoms in the laser radiation zone in the time shorter than the life time of the level being excited. The lasers that are employed are the excimer laser and dye laser. The excimer laser is used to pump the dye laser and the dye laser is used to tune the wavelength. Instruments such as Fabry-Perot interferometers and diffraction gratings are used to select the wavelength required. The laser beam for ionization is directed to the chamber by means of mirrors and lenses. Separation of ion makes it possible to obtain individual spectra of each ion without the use of mass separator.

LOS / 310

Superresolution beams

Author: Mr. NGCOBO, Sandile [1]

Co-Authors: Prof. FORBES, Andrew [1]; Prof. AIT-AMEUR, Kamel [2]

[1] *CSIR*

[2] *University of Caen*

Corresponding Author: sngcobo@csir.co.za

The transformation of a Gaussian beam into a symmetrical TEMp0 Laguerre Gaussian beam (LGB) intensity distribution which has transverse superresolution properties is very useful in improving the spatial resolution of optical imaging microscopes by making the central diffractive spot smaller than the Airy spot. The beam shaping is achieved by using an annular binary Diffractive Optical Element (DOE) whose geometry is in connection with the location of the Laguerre polynomial zeros. The DOE imposes positions of p zeros of intensity distributions on the Gaussian beam, resulting to a generation of TEMp0 beams where there are minimum losses. The LGBs are well-known family of exact orthogonal solutions of free-space paraxial wave equation in cylindrical coordinates. Theoretical and experimental results will be demonstration for higher order TEMp0 modes of LGBs.

Poster1 / 311

Intervalley and Intravalley Scattering in Diamond Structure, Si and Ge

Authors: Dr. MACHATINE, Augusto [1]; Mr. NIYONGABO, Prime [1]

Co-Authors: Mr. MAPINGIRE, Hezekia [1]; Prof. KUNERT, Herbert [1]

[1] *University of Pretoria*

Corresponding Author: augusto.machatine@up.ac.za

Optical selection rules for the intervalley scattering for direct and indirect transitions are investigated. The non-zero matrix elements of the scattering tensors are derived by the method of vector coupling coefficients. These coefficients are needed for the understanding of Gunn effect.

Theoretical / 312

Structure of Few-Nucleon Systems Studied with the Extended Antisymmetrized Molecular Dynamics

Author: Mr. RAMPHO, Gaotsiwe Joel [1]

Co-Author: Prof. SOFIANOS, Sofianos A. [1]

[1] *University of South Africa*

Corresponding Author: rampho@science.unisa.ac.za

Ground-state properties of three-nucleon and four-nucleon systems are studied with the angular-momentum-projected and parity-projected antisymmetrized molecular dynamics. The Hamiltonian of the systems is constructed with semi-realistic nucleon-nucleon interactions. The results obtained for the ground-state energies, root-mean-square radii and magnetic dipole moments are compared with the findings of other theoretical methods.

Theoretical / 313

Electromagnetic Form Factors of Three-Nucleon Systems

Author: Mr. RAMPHO, Gaotsiwe Joel [1]

Co-Authors: SOFIANOS, Sofianos A. [1]; ORYU, Shinshu [2]; WATANABE, Tagashi [2]

[1] *University of South Africa*

[2] *Tokyo University of Science*

Corresponding Author: rampho@science.unisa.ac.za

The angular-momentum-projected and parity-projected antisymmetrized molecular dynamics is used to analyse the charge and magnetic form factors of the three-nucleon systems. Non-relativistic nuclear charge and current operators with relativistic corrections are employed. The Hamiltonian of the nuclear systems is described with a semi-realistic nucleon-nucleon potential. The results obtained are compared with results obtained using other theoretical methods as well as some experimental data.

Poster2 / 314

Search for the Standard Model Higgs boson to WW with a hadronic tau channel

Author: Mrs. LEE, Claire [1]

Co-Authors: Prof. CONNELL, Simon [1]; Dr. ASSAMAGAN, Ketevi [2]; Dr. AUROUSSEAU, Mathieu [1]

[1] *University of Johannesburg*

[2] *Brookhaven National Laboratory*

Corresponding Author: claire.lee@cern.ch

In the large mass region, the dominant decay mode of the Higgs boson is to two W bosons, where the Higgs can be produced via either gluon fusion or vector boson fusion. Of the possible W decay modes, the current analyses focus on the W(->l nu)W(->l nu) decay channels where the lepton is either an electron or muon. At a center of mass energy of 7 TeV, the results from the ATLAS detector are combined for each of the three modes ee, e mu, or mu mu, in order to maximise the signal sensitivity. We investigate the possible sensitivity gained in including a single hadronic tau channel (W->tau nu->(tau_had nu) nu) in this analysis, and discuss the method in comparison to the standard H->WW->l nu l nu search. Our work currently focuses on the hadronic tau identification and understanding the jet -> tau fake rate.

Theoretical / 315

Structure of Few-Hyperon Systems Studied with the Integro-Differential Equations Approach

Author: Mr. RAMPHO, Gaotsiwe Joel [1]

Co-Author: NKUNA, John S. [1]

[1] *University of South Africa*

Corresponding Author: rampho@science.unisa.ac.za

Ground-state properties of three-nucleon systems consisting of one and two hyperons are studied with the integro-differential equations approach. The Hamiltonian of the systems is constructed with semi-realistic nucleon-nucleon interactions and phenomenological nucleon-hyperon interactions. The results obtained for the ground-state energies and root-mean-square radii are compared with the findings of other theoretical methods.

Theoretical / 316

Black-Hole Decay and Detection at LHC

Mr. CARLSON, Warren [1]

[1] *University of the Witwatersrand*

Corresponding Author: warren.carlson@students.wits.ac.za

Models with extra spacial dimensions offer a new way to address outstanding problems in and beyond the standard model. In such models the Planck scale in the bulk can be of the order of the electro-weak symmetry breaking scale. This allows the coupling strength of gravity to increase to a size similar to the other interactions, opening the way to the unification of gravity and the gauge interactions. The increased strength of gravity in the bulk space-time means quantum gravity effects would be observable in the TeV energy range - an energy range now attainable in modern particle colliders. If the Planck scale is low enough, black-holes could form during collisions at particle colliders. These black-holes will emit radiation, losing mass, energy, momentum, etc. This radiation should be detectable making it, possible to "see" black-holes in particle colliders.

Poster2 / 318

Space Weather Prediction and Forecast in South Africa

Author: Ms. TSHISAPHUNGO, Mpho [1]

Co-Author: Mr. OLCKERS, Kobus [1]

[1] *SANSA Space Science*

Corresponding Author: mtshisaphungo@hmo.ac.za, tshisaphungo2005@yahoo.com

Space weather describes the conditions in space that affect both Earth- and Space bound technological and biological systems. It is a consequence of the behavior of the Sun, the nature of the Earth's magnetic field and atmosphere, and our location in the solar system. Space weather is one of the principal threats to modern technology. With the increase in technological systems the need for accurate space weather predictions and forecasts has increased. The paper presents the space weather predictions and forecasts done by African Space Weather Centre at the Hermanus Magnetic Observatory (HMO). The African Space Weather Centre has been appointed by ISES (International Space Environment Service) as the Regional Warning Center (RWC) for Africa.

Poster1 / 319

The reduction of melting temperature with size in Gold

Author: Mr. MAHLADISA, Mokete [1]

Co-Authors: Prof. NGOEPE, Phuti [2]; Dr. ACKERMANN, Lutz [2]

[1] *University of Limpopo (Turfloop campus)*

[2] *University of Limpopo (Turfloop Campus)*

Corresponding Author: ma.mohladisa@ul.ac.za

The importance of gold for scientific use is of fundamental importance to research and technology developments. The bulk gold shows reluctance to participate in chemical reactions, the effect which has been corrected by the change in the size towards nanoclusters and, this makes the study of temperature effects on gold very important. We have performed molecular dynamics simulations on bulk and nanomaterials of gold at various temperatures to study the effect of size on the melting temperature. Melting temperature of bulk gold was determined to be 1320 K and this in good agreement with the experimental value of 1337 K. Different gold nanoclusters and nanotubes melt at temperatures lower than 1200 K which is a significant decrease in the melting temperature from the bulk. The face centered cubic (fcc) bulk gold structure remains intact at high temperatures while spherical nanoclusters and cylindrical nanotubes respectively transform into tetragonal structures and patches of spherical clusters.

APSS / 320

Searching for signatures of nearby sources of cosmic rays in their local chemical composition

Author: Mr. BISSCHOFF, Driaan [1]

Co-Authors: Dr. BÜCHING, Ingo [2]; Prof. POTGIETER, Marius [1]

[1] *North-West University*

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

Corresponding Author: 20056950@nwu.ac.za

The direct evidence for the acceleration of hadronic cosmic rays at supernova remnants underlined the need for a 3D time dependent treatment of the propagation of Galactic Cosmic Rays (CRs). Full 3D time dependent calculations of the propagation of CRs have shown that if CRs indeed originate from supernova remnants, transient point-like sources, the flux of the CR primary component measured at Earth depends strongly on the local source history, whereas the secondary component shows only little or no variations due to nearby sources. The most widely used steady state, rotational symmetric models (2D) of CR propagation cannot take into account the local source history, but rather mimic source histories that result in the same local CR flux as the smeared-out sources assumed in 2D models and do not necessarily coincide with the real local source history. Using a steady state, rotational symmetric model for a parameter study, one may expect different best fit values looking at the primary and secondary CR components separately, as it is unlikely that the source history mimicked by the 2D models coincide with the real local source history. We adapted the 2D version of the GALPROP code to a cluster environment and perform parameter studies comparing CR spectra with mainly primary and secondary CR data separately. First results of these studies will be presented and recommendations for further such studies will be given.

NPRP / 321

Search for Tetrahedral symmetries in 156Dy

Author: Mr. MAJOLA, Siyabonga [1]

Co-Authors: Prof. SHARPEY-SCHAFER, JOHN [2]; Dr. BARK, ROBERT [3]; Ms. BVUMBI, SUZAN [4]; Mr. DINOKO, TSEPO [5]; Mrs. LAWRIE, ELENA [3]; Mr. SHIRINDA, OBED [5]; Dr. MULLINS, SIMON [3]; Dr. PAPKA, PAUL [6]; Mr. NTSHANGASE, SIFISO [7]; Mr. MASITENG, LUKISI [8]; Mr. HUSSAM, MOHAMED [9]; Mr. STANKIEWICZ, MACIEK [9]; Dr. WIEDEKING, MATHIS [3]; Prof. RIEDINGER, LEE [10]; Dr. ORCE, NICO [5]; Mr. MAQABUKA, BONGANI [8]

[1] *UCT/ iThemba Labs*

[2] *UWC/ITHEMBA LABS*

[3] *ITHEMBA LABS*

[4] *UNIVERSITY OF JOHANNESBURG*

[5] *UWC*

[6] *STELLENBOSCH*

[7] *UCT/ITHEMBA LABS*

[8] *UJ*

[9] *UCT*

[10] *UNIVERSITY OF TENNESSEE*

Corresponding Author: majola@tlabs.ac.za

Negative-parity side bands in nuclei localized in the vicinity of N = 90 are known to have strong electric dipole transitions from each level to the ground-state band, with weak or unseen E2 transitions (E2s) in the medium (~15h) to low-spin region. These structures have always been regarded as octupole vibrational bands. On the other hand, Dudek et al. recently proposed that these structures might be associated with tetrahedral symmetries, as they have very weak inband E2s. In this study, data from the 148Nd (12C, 4n) 156Dy reaction, taken with GAMMASPHERE is analysed. Out of 23 rotational bands that have been observed in this present study for 156Dy, there are eleven new bands and more than 266 new transitions. We also report an observation of a band with characteristics of that discussed on the paragraph above i.e. a negative parity band with missing (or weak) inband transitions at low spin. Furthermore, the crossing between this band (tetrahedral candidate) and band 6 around spin 13h has allowed the band mixing calculation to be carried out, so that relative quadrupole moments could be deduced for these bands. However, a non-zero quadrupole moment has been deduced for our tetrahedral candidate, and this is incompatible with the tetrahedral shape. We therefore seek for an alternative description of this band.

LOS / 322

Pulse Repetition Frequency locking by pump modulation in numerical simulations of a diode end pumped passively Q-switched Nd:YAG laser with a Cr4+:YAG saturable absorber

Author: Mr. COLLETT, oliver [1]

Co-Authors: Dr. ESSER, Daniel [1]; Dr. BOLLIG, Christoph [1]

[1] *National Laser Center*

Corresponding Author: ocollett@csir.co.za

Passively Q-switched Nd:YAG lasers with Cr4+:YAG as a saturable absorber that can operate with pulse repetition frequencies(PRF) in the hundreds of kilohertz typically have problems with pulse to pulse fluctuations of pulse energy and width and the associated timing jitter as well as drift in PRF. One technique for stabilizing the PRF and reducing fluctuations is modulation of pump power. This technique has been simulated using a plane wave rate equation model with square wave pump modulation at frequency of 100 kHz. Locking of the pulse repetition rate is achieved at the modulation frequency over a range of pump powers. This locking range is dependent on the modulation function, a square wave with a 50% duty cycle and a modulation depth of 0.5 produced a 13% locking range. Additionally smaller regions of stability also occur at higher pulse repetition frequencies at higher pump powers. The effect on the stability of pulse energy and width, and the timing rate jitter of this technique have been investigated.

APSS / 323

Pulsating B stars in the LMC

Author: Dr. ENGELBRECHT, Christian [1]

Co-Author: Dr. FRESCURA, Fabio [2]

[1] *University of Johannesburg*

[2] *University of the Witwatersrand*

Corresponding Author: chrise@uj.ac.za

Pigulski and Kolaczkowski (2002, A&A; 388, 88) announced the first discovery of Beta Cephei (BCep) pulsators in the LMC. This was a remarkable discovery, since theoretical analyses of pulsational stability had previously predicted that early B main-sequence stars with metallicities lower than Z = 0.01 should not pulsate at all (e.g. Pamyatnykh 1999, Acta Astron 49, 199). Following this announcement, and announcements of 92 BCep candidates in the LMC by Kolaczkowski and Pigulski (2006, MemSAIt. 77, 336), more detailed studies adopting a variety of opacity calculations and metal mixtures indicated that BCep pulsations could be explained in low-metallicity environments after all (Miglio et al. 2007, MNRAS 375, L21; Miglio et al. 2007, Com.Ast. 151, 48; Zdravkov and Pamyatnykh 2008, J.Phys.Conf.Ser. 118, 012079). In order to ascertain the nature of these pulsations, multi-colour photometry of sufficient precision is required. We have obtained 4 weeks of UBVI photometry on two fields in the LMC that surround stars which have been identified as strong Beta Cephei candidates from OGLE data. We report on the results of this photometric campaign.

Poster2 / 324

A Magnetic Field Study Using Polarized Dust Emission of Nearby Starburst Galaxies

Author: Dr. LEEUW, Lerothodi [1]

Co-Author: THE SHARP TEAM [2]

[1] *University of Johannesburg*

[2] *Northwestern University and others*

Corresponding Author: lerothodi@alum.mit.edu

We will present submillimeter (submm) polarized imaging of the nearby star-forming galaxies M82 and NGC253. The data, obtained with the Caltech Submillimeter Observatory in Hawaii, probe the emission from dust grains aligned by magnetic fields in these galaxies, and thus fields in relatively dense regions of the galaxies.

NPRP / 325

The IThemba LABS Radioactive Beam Project

Dr. BARK, Robert [1]

[1] *iThemba LABS*

Corresponding Author: bark@tlabs.ac.za

A feasibility to develop a radioactive beam facility at iThemba LABS has commenced. The proposal envisages the addition of a new cyclotron, a k70 negative-ion accelerator. Such an accelerator can supply two beams simultaneously, one to be used for isotope production and neutron therapy, the other to create radioactive ions. These can be post accelerated by the existing SSC accelerator to energies of 5~7 MeV/A. It is envisaged that the beamtime available for nuclear physics, presently restricted to weekends only, will more than double. The feasibility study aims to minimize costs and maximize performance. However, many technical challenges remain in producing radioactive beams so the study also aims at minimizing risks.

NPRP / 326

Recent results from gamma ray studies of rare earth nuclei

Mr. STANKIEWICZ, Maciej [1]

[1] *University of Cape Town*

Corresponding Author: mstankiewicz@gmail.com

Recent theoretical work has suggested that some nuclei in the rare earth region might exhibit tetrahderal deformations. Several nuclei have been studied at iThemba LABS, resulting in evidence against the possibility of low-lying tetrahedrally deformed bands. In a continued study of the region, further gamma-ray spectroscopy experiments have been performed at iThemba LABS, populating low lying states of nuclei in the (Z,N)=(70,90) region. We present some of the results obtained for ^{156}Er, ^{160}Er and ^{158}Dy, particularly referencing the negative parity bands, and their relative structure in relation to the other nuclei in the region. Calculations of the theoretically predicted observables, such as the quadrupole deformation and the in-band transition rates and branching ratios will be discussed.

Applied / 327

Characterization of the Phase Transition of h-BN - c-BN Nanoparticles by Ion Implantation

Author: Ms. ARADI, Emily [1]

Co-Authors: Mr. ERASMUS, Rudolph [1]; Prof. DERRY, Trevor [1]; Mr. NAIDOO, S. R [1]

[1] *University of the Witwatersrand*

Corresponding Author: emilyaradi@yahoo.com

The synthesis of the c-BN (cubic boron nitride) has developed great interest due to its excellent physico-electrochemical properties. These include; high hardness values (73 GPa) second after diamond, wide band gap (6.4 eV), optical transparency in a wide region of the electromagnetic spectrum, high temperature stability (1200 oC) and chemical inertness. These properties enable c-BN to be very useful for various industrial and electrical applications such as in cutting and grinding, fabrication of high temperature high frequency devices among many others. In this work, ion irradiation effect of the soft graphitic boron nitride (h-BN) is investigated from characterization with Raman Spectroscopy before and after implantation. This was to investigate a possible phase transformation of h-BN to c-BN. Boron, lithium and helium ions were implanted into the hot pressed h-BN samples at 150keV, and with fluences ranging from 1x1014 ions/cm2 to 1x1016 ions/cm2. Raman Spectroscopy showed that implantation of all the three ions led to an h-BN to a possible c-BN phase transition, evident from the longitudinal optical (LO) Raman phonon features occurring at 1303cm-1 in the implanted samples' spectra. The nature of the phonon peaks and their downshifting is explained using the spatial phonon correlation model. The extent of these peaks was found to depend on the mass of the incident ion and the fluence, where high ion mass required low fluence compared with the low ion masses.

Poster2 / 328

Spectral response as a diagnostic tool for PV and PC solar cells

Mr. MALAPE, Maibi [1]

[1] *Fort Hare Institute of Technology*

Corresponding Author: mmalape@ufh.ac.za

The spectral response measurement system is an important tool for optimization of solar cells. Its measurement permit an examination of how photons of different wavelength contribute to the cell generated current at zero bias voltage. In this study photovoltaic (PV) and photochemical (PC) solar cells were used and their spectral responses were measured. The aim is to use the spectral response data in order to investigate the effect of shading on PV and PC solar cells. Preliminary results showed that the shading of cells degrade cells responsivity.

CMPMS2 / 330

Thermoluminescent properties of BaAl2O4:Eu2+,Gd3+phosphors prepared by combustion method at different initiating temperatures.

Author: Dr. MOTHUDI, Bakang Moses [1]

Co-Authors: Dr. LEPHOTO, Mantwa [2]; Mr. MALWELA, Thomas [3]; Ms. MHLONGO, Gugu H [3]; Prof. NTWAEABOWRA, Martin [2]; Prof. SWART, Hendrik [2]

[1] *University of South Africa*

[2] *University of the Free State*

[3] *CSIR*

Corresponding Author: mothubm@unisa.ac.za

Europium (Eu2+) and gadolinium (Gd3+) doped BaAl2O4 powder phosphors were prepared by combustion method at different initiating temperatures (400-1000 oC), using urea as a comburent. The powders were annealed at different temperatures in the range of 400-1000 oC for 3 hours. X-ray diffraction data show that the crystallinity of the BaAl2O4 structure greatly improved as the annealing temperature increased. The FT-IR absorption bands observed at 533, 629 and 798 cm-1 for the samples annealed at higher temperatures (1100-1200 oC) are consistent with the stretching mode frequencies of BaAl2O4. Blue-green photoluminescence, with persistent / long afterglow, was observed at 503 nm.This emission was attributed to the 4f65d1- 4f7 transitions of the Eu2+ ions. The phosphorescence decay curves were obtained by irradiating the samples with a monochromatized xenon lamp at an excitation wavelength of 393 nm.The glow curves and the decay curves of the samples irradiated by UV source (360 nm) were investigated using investigated using the Thermoluminescence Reader (Integral-Pc Based) Nucleonix TL 1009I.

NPRP / 331

Search for Low Spin Collective Structures in 158Er and 159Er

Author: Mr. DINOKO, Tshepo [1]

Co-Authors: Prof. SHARPEY-SCHAFER, John [2]; Dr. NEWMAN, Richard [2]; Mr. NTSHANGASE, Sifiso [3]; Prof. SIMPSON, John [4]; Dr. WIEDEKING, Mathis [2]; Dr. ORCE, Nico [1]; Dr. BARK, Rob [2]; Dr. LAWRIE, Elena [2]; Dr. LAWRIE, Kobus [2]; Mr. MAJOLA, Siyabonga [3]; Ms. BVUMBI, Suzan [5]; Mr. MASITENG, Lusiki [6]

[1] *University of the Western Cape*

[2] *iThemba LABS*

[3] *University of Cape Town*

[4] *STFC Daresbury Laboratory*

[5] *University of Johanesburg*

[6] *University of Johannesburg*

Corresponding Author: tdinoko@tlabs.ac.za

The nuclei 158,15968Er are classic examples of many phenomena in the study of nuclei at high spin. However, although the multi-quasi particle structures of 158,15968Er are well established, there is not much spectroscopic information on the vibrational structures in 158Er or how these couple to the odd neutron in 159Er. Additionally, there are several bands where the spins and/or parities are not firmly assigned. The relative lack of information at low spins is probably due to a combination of the low spins of the ground states of the nuclei 158,15969Tm that β+/ec decay to 158,15968Er, 2- and 5/2+ respectively. Two experiments were performed in the AFRODITE spectrometer to populate 158Er and 159Er using 1mg/cm2 150Sm(12C,4n) and 150Sm(13C,4n) reactions respectively at 65MeV, The intention is to study their yrare states below spin 20ħ. Preliminary results will be presented. A Coulomb excitation of 155Gd with 86Kr ions experiment is scheduled for early May at iThemba LABS. The Physics interest is in looking for collective core excitations of 154Gd that are coupled to the ground state neutron in 155Gd. The outcome of this experiment will be presented as well.

Theoretical / 332

A Quantum Hall Effect without Landau Levels in a Carbon Nanotube.

Author: Ms. BRAND, Nanette [1]

Co-Author: Dr. SNYMAN, Izak [2]

[1] *Stellenbosch University*

[2] *National Institute of Theoretical Physics*

Corresponding Author: jdbrand@sun.ac.za

The spectrum of a carbon nanotube in a strong enough magnetic field (>50T for a 3nm nanotube) revealed an almost dispersionless band at the Fermi energy. The formation of Landau levels has been theoretically and experimentally investigated. In experimental studies the existence of Landau levels is indirectly derived from longitudinal conductance measurements. We will show that a more direct indication of Landau Levels in the system exists, namely a quantized Hall effect. We present numerical results that show the application of an electric field along the length of the tube lead to a current circulating the circumference and, furthermore, that the conductance is exactly e2/h. This is interesting because the magnetic flux averages to zero around the tube's circumference. This phenomenon could be explained in terms of the two-dimensional topological theory for the quantum Hall effect even though this system is quasi-one dimensional.

Poster1 / 333

The soilid-state interaction of palladium on 6H-SiC

Ms. KABINI, Jeaneth Thokozile [1]

[1] *Univerity of Pretoria*

Corresponding Author: jthokozile@gmail.com

The interaction of Pd and SiC samples during thermal annealing were investigated using x-ray diffraction (XRD), Rutherford backscattering spectrometry (RBS) as well as Scanning Electron Microscopy (SEM). Two sample configuration were used (1) the palladium (50nm) was deposited onto a degreased 6H-SiC substrate and (2) palladium ions were implanted into the 6H-SiC substrate at room temperature and at 200°C with a fluency of 1 x $10^{15}cm^{-2}$. Both sets of the samples were annealed between temperatures of 200°C-800°C for a period of 60 min. The study showed that the thermally annealed Pd on SiC showed no detectable reaction after annealing at 200°C-400°C. At 500°C the RBS spectra shows that the Pd had reacted with SiC. Using XRD it was observed that metal rich silicides Pd3Si tend to form first after annealing at 500°C followed by the formation of Pd2Si after annealing at 600°C, 700°C and 800°C. No Carbon compounds were detected by XRD in these annealing temperature ranges. The implanted samples showed no detectable phase formation after annealing at temperature ranges of 200°C-800°C for a period of 60 min and at 1000°C for 10 hours. The RBS / Channeling results for the implanted samples are also shown.

CMPMS1 / 335

Energetic stability and charge states of 3d transition metals in diamond: Towards a diamond based diluted magnetic semiconductor

Author: Mr. BENECHA, Evans [1]

Co-Author: Prof. LOMBARDI, Enrico [1]

[1] *University of South Africa (UNISA)*

Corresponding Author: ebenecha@gmail.com

Energetic stability of magnetically ordering dopants in diamond holds the prospect of achieving a diamond based diluted magnetic semiconductor which, in addition to diamond's extreme properties may successfully be considered for spintronic device applications. However, one of the problems to be addressed is that of predicting the most energetically stable lattice configurations or charge states in which such dopants can remain electrically or optically active, and at the same time induce magnetic moments when incorporated into diamond. We report ab initio DFT calculations on the formation energies of isolated 3d transition metal impurities at various lattice sites and charge states in diamond, and show that these impurities introduce deep donor and acceptor levels in the band gap of diamond. We further show that the formation energies as well as the magnetic ordering properties are critically dependent on the position of the Fermi level in the diamond band gap, with formation energies across the 3d series being lower in n-type or p-type diamond compared to intrinsic diamond, suggesting that co-doping with impurities such as boron, nitrogen or phosphorus will considerably enhance their stability in diamond. The majority of the 3d transition metals are found to be energetically most stable at a divacancy site in any charge state, with the formation energy of transition metals in the middle of the 3d series (Cr, Mn, Fe, Ni, Co) being lowest at any lattice site.

Applied / 336

Indoor temperature predictions in an energy efficient solar house

Author: Mr. ZIUKU, Sosten [1]

Co-Author: Prof. MEYER, Edison L. [1]

[1] *Fort Hare Institute of Technology*

Corresponding Author: sziuku@ufh.ac.za

This paper presents results of long term temperature monitoring in an energy efficient solar house at the University of Fort Hare, South Africa. Measured data was stored by a datalogger every 10 minutes. Formulas for predicting the daily indoor maximum, average and minimum temperatures were developed on the basis of outdoor climatic parameters. Passive solar housing aims to raise and lower indoor temperatures in winter and summer respectively. As a result, analysis of the data and development of predictive formulas of indoor temperature were done separately on part of the winter and summer seasons. The models were then validated against measurements taken in different time periods. Results indicated that indoor maximum, average and minimum temperatures can be predicted on the basis of outdoor temperature. Prediction of maximum indoor temperature was improved by incorporating daily solar irradiance in the formula. It was also revealed that indoor temperatures are affected by outdoor temperatures of the previous two days. The different ways at which the house is cooling and heating were also investigated.

LOS / 337

Stable interferometer for orbital angular momentum sorting

Author: Mrs. DUDLEY, Angela [1]

Co-Authors: Mr. LAVERY, Martin [2]; Prof. FORBES, Andrew [1]; Prof. PADGETT, Miles [2]

[1] *CSIR National Laser Centre*

[2] *Department of Physics and Astronomy, University of Glasgow, Glasgow, UK*

Corresponding Author: angelajvr@gmail.com

Our interferometer is based on a previously reported orbital angular momentum (OAM) sorting device. By introducing a specially designed phase- and intensity-inverting prism into each arm of the interferometer, decoupling the vertical and horizontal alignment in each arm, we are able to reduce the degrees of freedom within the interferometer from initially being associated with very optical component to a mere one degree of freedom; the optical path length. The interferometer induces a phase shift, which is proportional to both the OAM of the incoming beam and the relative angle, θ, between the two phase- and intensity-inverting prisms. When the angle between the two phase- and intensity-inverting prisms is 90 degrees, and the path length is appropriately selected, constructive interference will occur in one of the two output ports for even l-valued states and in the opposite port for odd l-valued states. Apart from adjusting the path length of the interferometer, two external degrees of freedom, two mirrors, are used to align the incoming beam into the interferometer.
To test the effectiveness of the interferometer in separating odd and even l-states, the intensity of the interference pattern in one of the output ports was monitored, while the path length of one of the arms of the interferometer oscillated back and forth between constructive and destructive interference. The Michelson contrast was calculated for various incoming l-states. We obtain a maximum Michelson contrast measurement of 92% at an OAM value of l=0 and 85.3% at l=±10.

NPRP / 338

A comparison of analysis methods of gamma-ray spectra obtained with a LaBr3 scintillation detector

Author: Mr. VAN ROOY, M.W [1]

Co-Authors: Prof. DE MEIJER, R.J [2]; Dr. SMIT, F.D [3]

[1] *Stellenbosch University; iThemba LABS*

[2] *Stichting EARTH; University of the Western Cape*

[3] *iThemba LABS*

Corresponding Author: milton@sun.ac.za

The goal of any measurement and data-analysis technique should always be to minimize uncertainties, whether it is statistical or systematic. Although uncertainties are unavoidable, one can find ways to reduce them depending on the circumstances. High-precision measurements play a crucial role in constraining various quantities. Recently a new inorganic scintillation detector has become available in large cylindrical sizes (e.g. 7.6 cm in diameter and with length over 15 cm). It consists of LaBr3 and has an energy resolution which is not as good as HPGe, but superior to the energy resolution of NaI and CsI, and does not need to be cooled to LN2 temperatures. Since La has a naturally radioactive isotope, 138La, which emits γ-rays, the detector has an internal calibration source for energy and dead-time corrections. Moreover it produces pulses with fast rise time, which allows setting up the electronics such that measurements can be made with a high count rate and a low dead time. Gamma-ray spectra were collected with a 3"×3" LaBr3 detector for LaBr3 intrinsic background, 22Na and 137Cs which exhibit some gain drifts. A set of off-line analysis methods of these spectra is presented to select the procedure that yields the optimal precision and accuracy.

Theoretical / 339

Adding Flavour to Nonplanar Integrability

Ms. SMITH, Stephanie [1]; Prof. DE MELLO KOCH, Robert [2]; Mr. MOHAMMED, Badr Awad Elseid [1]

[1] *University of the Witwatersrand*

[2] *NITHEP; STIAS*

Corresponding Author: stephiiyy@gmail.com

N=4 SYM theory has been extensively studied in the planar limit. A very significant result of this study is a map from the planar dilatation operator to the Hamiltonian of an integrable spin chain. In this talk we consider a large N (but not planar) limit of the theory. This is a considerably more complicated problem since non-planar corrections need to be summed. This summation is accomplished by employing the restricted Schur polynomials. We give an analytic formula for the action of the dilatation operator on the resticted Schur polynomials and then proceed to calculate the one loop anomalous dimensions. Our result shows that the dilatation operator reduces to a set of decoupled harmonic oscillators, generalizing results known from the sector of theory constructed using two complex Higgs fields (two flavors) to the sector with three complex Higgs fields (three flavors).

CMPMS2 / 340

Ab-initio study of the energy of formation and diffusion paths of self-interstitials in silicon

Mr. PIENAAR, Jacques [1]

[1] *University of Pretoria*

Corresponding Author: jac_pienaar@hotmail.com

The formation energy of self-interstitial defects in silicon was studied. The ⟨110⟩split site was found to be the lowest energy position for the silicon self-interstitial at neutral charge state, as well as singly and doubly negative charged state. The tetrahedral site is found to be the lowest energy site for the singly and doubly charged positive states. The energy barriers for diffusion from the ⟨110⟩split site to the hexagonal and tetrahedral sites were found to be 0.370 and 0.361 eV respectively. Diffusion between the tetrahedral and hexagonal sites has an energy barrier of 0.074 eV. These energy barriers are found to be too great to account for athermal diffusion of the silicon self-interstitial, and diffusion paths involving cyclic changes in charge state are most likely to be responsible for the athermal diffusion observed at low temperature.

Theoretical / 341

The Mechanical and Structural Properties of the Pt-Ti and Ir-Ti Alloy Systems

Mr. CAVERO, Miguel [1]

[1] *University of KwaZulu-Natal*

Corresponding Author: mig.cavero@gmail.com

Ab initio density functional calculations within the generalised gradient approximation (GGA) have been carried out on a wide range of phases and stoichiometries for the platinum-titanium (Pt-Ti) and iridium-titanium (Ir-Ti) alloy systems, using the Vienna Ab Initio Simulation Package (VASP). The elastic constants and elastic moduli are calculated and the electronic structure and density of states (DOS) are considered to understand the hardness and stability properties of the alloys.

Poster1 / 342

Cathodoluminescence and energy transfer between Er3+, Tm3+and Ho3+ rare earth ions in SiO2 nanoparticles

Author: Dr. DHLAMINI, Simon [1]

Co-Authors: Ms. MHLONGO, Gugu [2]; Prof. SWART, Hendrick [1]; Prof. HILLIE, Thembela [3]

[1] *University of South Africa*

[2] *Council for Scientific and Industrial Research*

[3] *Council for Scientific and Industrial Resaech*

Corresponding Author: dhlamms@unisa.ac.za

Preparation of Er3+, Ho3+ and Tm3+ ions co-doped SiO2 nanoparticle phosphor powders by sol gel method is reported. The morphology and the particle size of the SiO2 host matrix were confirmed by field emission scanning electron microscopy (FESEM). Ultraviolet, visible (UV/VIS) and cathodoluminescence measurements were carried out in order to investigate the optical properties of our powder phosphors. Green emissions at 520 nm from Er3+ and 544 nm from Ho3+, and red emissions at 665 nm from both Er3+ and Ho3+ ions are reported. Another emission peak in the near infra-red (NIR) region at 875 nm from Er3+ was also measured. Blue emission at 460 nm, red at 705 nm and a NIR peak in the region of 865 nm from Tm3+ were observed. Red, green and blue (RGB) colours were measured from both SiO2:Er3+,Tm3+ and SiO2:Ho3+,Tm3+ systems. The change in the intensities of the emission peaks in both the SiO2:Ho3+,Tm3+ and SiO2:Er3+,Tm3+ systems with the change in accelerating beam voltage is shown. Energy transfer from Tm3+ ions to Er3+ and Ho3+ ions was observed. A mechanism explaining the increase and decrease behaviour of the emission with accelerating beam voltage from both systems is reported.

Poster1 / 343

Ab initio thermodynamic and elastic properties of Pt-Cr binary alloys

Author: Mrs. TIBANE, Malebo [1]

Co-Author: Prof. NGOEPE, Phuti [2]

[1] *University of South Africa*

[2] *University of Limpopo*

Corresponding Author: tibanmm@unisa.ac.za

Planewave pseudopotential calculations were conducted to predict the phase stability of Pt-Cr binary alloys. The heats of formation are determined for five different phases, L12, A15, DOC, DO'C and tP16 of Pt3Cr and PtCr3. We observed that the cubic L12 Pt3Cr is the most stable structure in agreement with the experiments. The results for PtCr3 indicate the negative heat of formation for the A15 phase whereas all the remaining studied phases have positive heats of formation. In addition the phase stability study was performed on two phases, B2 and L10 of the PtCr alloy. L10 phase was found to be more stable compared with the PtCr B2 phase. Elastic constants and moduli were investigated to determine the strength of the Pt-Cr systems. The strength of PtCr L10 is greater than that of B2 phase. The ratio of shear to bulk modulus (G/B) has been used to predict the ductility or the brittleness of the material.

Poster1 / 344

Computational modelling study of $PtAs_2$ and PtAsS structures

Authors: Ms. MAKGAI, Dinah [1]; Dr. NTOAHAE, Peter [2]

Co-Author: Prof. NGOEPE, Phuti [2]

[1] *university of limpopo*

[2] *Materials modeling centre*

Corresponding Author: dinah880608.makgai@webmail.co.za

We have investigated the electronic, structural and optical properties of the PtAs< sub >< /sub>2 and PtAsS structures using the density functional theory in the framework of Vienna Ab initio Simulation Package (VASP) code within the generalized gradient approximations of Perdew, Burke and Erzenhof (GGA-PBE) . The total energy calculation of PtAs < sub >< /sub>2 and PtAsS have been computed and predict equilibrium lattice parameters that are in good agreement with the experiment. Elastic constants of these structures compare well with experimental measurements, both PtAs< sub >< /sub>2 and PtAsS gave positive independent elastic moduli, condition of mechanical stability. We found good correlation between heats of formation, elastic constants and phonon dispersion curves, all satisfying stability conditions. In particular the phonon dispersion display real frequencies along high symmetry direction of the Brillion zone.

CMPMS2 / 345

Magnetic vector charges in the mystery of a circular current's pair of distinct Cartesian elemental magnetic dipoles

Dr. CHIRWA, Max [1]

[1] *Walter Sisulu University*

Corresponding Author: mmchirwa@wsu.ac.za

A circular electric current, perpendicularly bisected by a field plane, was modelled as a continuum of pairs of distinct Cartesian component elemental magnetic vector charges normal and parallel to the field plane. The Cartesian elemental magnetic vector charges normal to the field plane pair up into Cartesian elemental magnetic dipoles with intra-dipolar displacements parallel to the plane. These dipoles generate the overall magnetic vector potential at the field point. The Cartesian elemental magnetic vector charge components parallel to the field plane form Cartesian elemental magnetic dipoles (with intra-dipolar displacements perpendicular to the field plane) which individually and collectively contribute nothing to the overall magnetic vector potential. Each continuum of these two sets of Cartesian elemental magnetic dipoles independently yields the traditionally renowned "magnetic dipolar moment of a circular current". However, together their two distinct magnetic fields, as well as their two distinct magnetic torques, constitute the circular current's overall magnetic field and the total magnetic torque respectively. These results reconcile only if the magnetic dipolar moments of both sets are endorsed, that is a circular current of any spatial size is a continuum of pairs of distinct Cartesian elemental magnetic dipoles and that consequently its overall magnetic dipolar moment is numerically twice the traditional value. In addition the customary ad hoc definition of the magnetic dipole moment of a current loop is deceptively erroneous, thus prompting a review of many relations involving it. These include the magnetic torque and magnetic field generated by it, and the classical magneto-mechanical ratio.

Poster2 / 346

Elemental magnetic vector charges linked to zero outward magnetic flux from any surface enclosing non-dipolar magnetic sources

Dr. CHIRWA, Max [1]

[1] *Walter Sisulu University*

Corresponding Author: mmchirwa@wsu.ac.za

A harmonious formulation of the inverse−square laws for fields shows that elemental sources are rightfully represented as scalars for both gravitational and electric fields, but as vectors for magnetic fields. This permits an effective simple illustration that, unlike the gravitational or electric flux, the magnetic flux out of any closed surface is zero irrespective of whether the enclosed magnetic source is dipolar or non-dipolar. Then Gauss' laws for gravitational, electric and magnetic fields can be re-stated as: Out of any enclosing surface, if the source is a scalar quantity then the net flux is equal to the source itself; whereas if the enclosed source is any vector quantity, the net flux is the scalar zero.

Poster2 / 347

Ultrafast Transient Absorption measurements on Indoline D149 Dye

Mr. ROHWER, Egmont [1]

[1] *Stellenbosch University*

Corresponding Author: erohwer@sun.ac.za

D149 Dye has proven to be an effective photo-absorber for use in dye sensitized solar cells. Pump-probe measurements were conducted on D149 dye as well as D149 adsorbed to Zinc Oxide semi-conducting particles. Ultrafast dynamics on a sub-ps time scale, easily resolved by the current experimental setup at the LRI, were observed in both samples. Significant quenching of the excited state dynamics of the D149 molecule was seen in samples adsorbed to Zinc oxide, indicating the occurence of intermolecular charge transfer of photo-excited electrons from the singlet excited state of the D149 molecule and subsequent injection into the conduction band of the Zinc Oxide particles.

Poster2 / 348

The pair-model of monopolar and dipolar moments of elemental electric scalar and magnetic vector charges

Dr. CHIRWA, Max [1]

[1] *Walter Sisulu University*

Corresponding Author: mmchirwa@wsu.ac.za

A sequel to representing elemental sources of magnetic fields as elemental magnetic vector charges is realizing that electric and magnetic dipole moments are different classes of moments. The distinction between monopolar and dipolar moments becomes clearer when any distribution of electric scalar charge or magnetic vector charge is depicted as one or more pairs of charges with equal magnitudes. It is shown here that separation of the charges (electric scalar or magnetic vector) is essential for the very existence and other attributes of a dipole, but not for a monopole. These representations are markedly different from the traditional analogous representations and notions of electric and magnetic dipole moments as sources of corresponding fields or potentials. It also emphasizes that fields and potentials are generated by the sources and not by their moments; hence the difference between these two entities.

Poster1 / 349

Critical behaviour near magnetic phase transition in CeCuGe

Author: Ms. SONDEZI-MHLUNGU, Buyi [1]

Co-Author: Prof. STRYDOM, Andre [1]

[1] *University of Johannesburg*

Corresponding Author: bmhlungu@uj.ac.za

CeCuGe is one of the few compounds to order ferromagnetically at low temperatures. The compound has been observed to exhibit paramagnetic-ferromagnetic (PM-FM) magnetic transition, TC = 10 K This magnetic ordering has been observed from specific heat (Cp), magnetization, (M(T,B)) and resistivity data. Isothermal magnetization of a hexagonal, highly ordered CeCuGe were measured in order to study the critical scaling behavior in the vicinity of magnetic ordering in this polycrystalline compound. From the analyses of the magnetization data, TC was confirmed using modified Arrott plot technique. It was also observed from the critical exponents, beta, gamma and sigma corresponding to the spontaneous magnetization, initial susceptibility and isothermal magnetization were obtained, respectively. The resulting critical exponents obtained reveals that the system falls within Heisenberg and 3-D Ising model.

Poster1 / 350

Depth-resolved studies of plasma sprayed hydroxyapatite coatings by means of diffraction techniques

Author: Mr. NTSOANE, Tshepo [1]

Co-Author: Dr. TOPIC, Mira [2]

[1] *Necsa*

[2] *iThemba LABS*

Corresponding Author: tshepo.ntsoane@necsa.co.za

Hydroxyapatite coating (HAp, Ca10(PO4)6OH2), produced by air plasma spraying, was investigated for depth profiling behavior of phase composition, crystallinity and residual stress using diffractometry techniques. Probing was carried out using conventional 8 keV laboratory X-rays, 11 keV and 100 keV radiations from 2nd and 3rd synchrotron facilities, respectively. The latter employed measurements in transmission geometry. Results showed HAp together with its thermal products tetracalcium phosphate (TTCP), tricalcium phosphate (TCP) and calcium oxide to be present throughout the coating thickness. Quantitative refinement results employing Rietveld refinement showed HAp and TTCP to be the two main phases, with the former decreasing with depth whilst the latter increases. The largest changes occurred in the former showed a significant decrease in the first 45 m. Crystallinity investigation indicated the coating to be more crystalline at the near-surface region decreasing with depth below the surface. Both the normal stresses 11 and 33 show a change in stress state i.e. from compressive in first 135m to tensile towards the coating-substrate interface.

Applied / 352

Industrial application for Global Quantum Communication

Author: Mr. MIRZA, Abdul [1]

Co-Author: Prof. PETRUCCIONE, Francesco [1]

[1] *UKZN*

Corresponding Author: mirzaa@ukzn.ac.za

In the last decade the quantum communication community has witnessed great advances in photonic quantum cryptography technology with the research, development and commercialization of automated Quantum Key Distribution (QKD) devices. These first generation devices are however bottle necked by the achievable spacial coverage. This is due to the intrinsic absorption of the quantum particle into the communication line. As QKD is of paramount importance in the future ICT landscape, various innovative solutions have been developed and tested to expand the spatial coverage of these networks [R. Alleaume, 2007, C. Elliott, 2004, F. Xu, 2009] as in the QuantumCity initiative. One such technique that is being considered for the creation of a global QKD network is to couple quantum-secured Metropolitan Area Networks(MANs) with secured ground-to-satellite links as access points to the global network. This technique, however, is susceptible to atmospheric parameters and provides very limited contact times for the quantum key exchange. As parallel step to the development of satellite-based QKD networks, we intend to investigating the use of commercial aircrafts as secure transport mechanisms for a global QKD network. Commercial airliners create an ideal alternate global network for key distribution in terms of coverage, reliability and frequency. Further the airports at each connected city have the appropriate supporting infrastructure to serve as an access point to the global network. The quantum-secured global network will provide the infrastructure to create, distribute and manage encryption keys for use in secure global communication. The objective of this initial concept to create a proof of concept test network to investigate the aforementioned global QKD Network with the use of commercial airliners. The initial systems that are to be used will require the aircraft to be a trusted zone although certified tamper-proofing techniques will be used. The longterm objective is to upgrade the systems to contain quantum security through the use of quantum-powered memory solutions. A secure key management network layer will also be developed and implemented to control the flow and usage of keys within the global network. The secure key management network layer will further control the distribution of keys and encryption within the MAN.

LOS / 354

2 μm pumped HBr Oscillator-amplifier

Author: Dr. ESSER, M J Daniel [1]

Co-Authors: Mr. KOEN, Wayne [1]; Dr. STRAUSS, Hencharl [1]; Mr. JACOBS, Cobus [1]; Dr. BOTHA, Lourens [1]; Dr. BOLLIG, Christoph [1]; Mr. BURD, Shaun [1]

[1] *CSIR National Laser Centre*

Corresponding Author: desser@csir.co.za

Optically pumped molecular lasers are attractive alternatives to generate high energy pulses in the mid-infrared wavelength range, compared to non-linear conversion that can suffer from optical damage. One such laser is based on HBr, for which it has been experimentally demonstrated to emit laser light in the 4 μm wavelength range when pumped at 1.3 μm or at 2 μm. Prior to the work presented here the highest reported output energy from an optically pumped HBr oscillator was 2.5 mJ in a 132 ns pulse at 50 Hz repetition rate when pumped at 2.064 μm. To scale the output energy of this technology we have designed and implemented an HBr master oscillator power amplifier (MOPA) system which was pumped by a Ho:YLF slab amplifier (pumped by a Tm:YLF slab laser) which amplified the 70 mJ output of our single longitudinal mode 2.064 μm Ho:YLF oscillator (pumped by a Tm:fibre laser) to 330 mJ per pulse at 50 Hz pulse repetition rate. Initially all the available pump energy from the Ho:YLF amplifier was coupled into the HBr oscillator which produced up to 5.5 mJ per pulse for 200 mJ incident energy, at which point optical damage of the HBr oscillator cell window was observed due to the high intensity of the pump light in the double-pass configuration. The oscillator was subsequently operated at a reduced input energy of 50 – 60 mJ at the point where the HBr laser was most efficient with respect to incident energy. The HBr MOPA system produced 9 mJ per pulse when seeded with 2.3 mJ from the HBr oscillator and pumped with 200 mJ incident energy, of which approximately 75% was absorbed when the HBr amplifier cell pressure was 60 mBar. The measured output wavelengths of the HBr MOPA were 4.20 μm and 4.34 μm.

NPRP / 355

Quasi-elastic binary breakup in the interaction of ^{12}C with ^{12}C, ^{93}Nb and ^{197}Au at 400 MeV incident energy

Author: Mr. MIRA, Joele [1]

Co-Authors: Dr. FORTSCH, S. V [2]; Dr. STEYN, G. F [2]; Dr. PAPKA, P [3]; Dr. BUTHELEZI, Z. B [2]; Prof. CONNELL, S. H [4]; Prof. COWLEY, A. A [3]; Dr. MABIALA, J [3]; Dr. NEVELING, R [2]; Dr. SMIT, F. D [2]; Dr. USMAN, I. T [2]

[1] *University of Stellenbosch/iThemba LABS*

[2] *Department of Nuclear Physics, iThemba Labs, Old Faure Road, Faure 7130*

[3] *Department of Physics, University of Stellenbosch, Stellenbosch South Africa*

[4] *Department of Physics, University of Johannesburg.*

Corresponding Author: joele.paulus.mira@gmail.com

In heavy ion reactions the emission of Intermediate Mass Fragments (IMFs) at forward angles is dominated by the direct break-up process. To improve our understanding of this process in the reaction mechanisms involving the interaction of light projectiles with light to heavy target nuclei, a coincidence measurement was performed at iThemba LABS. Standard ΔE-E detector telescopes were used to identify and measure the energies of the of the correlated ^{8}Be and alpha particles produced in the binary break-up of ^{12}C projectiles at an incident energy of 400 MeV. While the ^{8}Be fragments were detected in their ground state at a fixed angle of 9°, the correlated alpha particles were measured on the opposite side of the beam, covering an angular range from 16° to 26°. Two dimensional energy spectra were generated for each alpha-particle angle in order to distinguish quasi-elastic events from inelastic break-up events. These spectra also allowed to identify events originating from the interaction of the ^{12}C beam with an H contaminant on the target foils and to subsequently correct for these events in the extraction of angular distributions for alpha particles in coincidence with quasi-elastic ^{8}Be particles. The angular distributions obtained from the interaction of ^{12}C with ^{93}Nb and ^{197}Au show a smooth decreasing trend with respect to the alpha-particle angle, which suggests that the binary break-up of ^{12}C seems to be independent of the target nucleus. A deviation from this trend is however observed for the ^{12}C target. As a first attempt to interpret these results a comparison between the measured angular distributions and GEANT4 simulations will be presented.

Applied / 356

The effective ionization region and its variation with geometrical and electrical properties of the HVDC transmission system

Author: Mr. KASEKE, Richmore [1]

Co-Author: Prof. MEYER, Edson [1]

[1] *Fort Hare Institute of Technology*

Corresponding Author: rkaseke@ufh.ac.za

High Voltage Direct Current (HVDC) overhead power transmission trends are currently advancing toward high system voltages over very long distances in a bid to viably tap from remotely located renewable energy sources. Corona effect plays a very crucial role in the design of overhead power transmission systems. Through corona, part of the energy carried on the transmission line is expended through ionization and movement of charges in the air dielectric. Corona limitations influence selection of key line parameters such as diameter of phase conductors, the number of conductors per phase and conductor clearances to the ground. Since overhead transmission lines are installed in open air, the generated electric fields are non-uniform. As a result, the accompanying ionization in the surrounding air is non-uniform and does not occur throughout the inter-electrode gap. Instead, the ionization is confined to a very small region around the high voltage fitting referred to as the Effective Ionization Region (EIR). As such, corona power loss is proportional to the size of the EIR. This paper discusses the concept of effective ionization region from a theoretical perspective. Computer modeling was used to investigate the effect of geometrical as well as electrical line parameters on the size of the EIR. A comparison is made between single and bundled conductor configurations. Results show that the radius of the EIR of a single conductor that is energized at 800 kVDC drops by about 45% if the conductor were a sub-conductor in a four-bundle configuration.

Education / 357

"Seeing is believing": Visual perceptions and the learning of kinematics

Dr. LEMMER, Miriam [1]

[1] *North-West University (Potchefstroom)*

Corresponding Author: miriam.lemmer@nwu.ac.za

The proverb "seeing is believing" is generally applied in science education today. Many of the contemporary teaching strategies engage the learners in activities that guide them in making their own observations. Still, problems regarding the learning of physics, especially the prevalence of alternative conceptions, remain a head-ache in physics education research. A variety of causes are ascribed to the occurrence of alternative conceptions, e.g. that textbooks contain them, teachers themselves have them or do not attend to learners' intuitive ideas or that learners focus to contextual features of an event and do not observe what we intend them to. Even with seemingly sufficient experimental proof, some alternative conceptions remain persistent. The study reported here investigated learners' visual perceptions as possible cause for the existence, persistence and transfer of the intuitive conception in kinematics that DiSessa called changes-take-time. An example of this conception is the assertion that a cannon ball keeps on accelerating after the shell has been launched. A questionnaire, group discussions and individual questioning contributed to the investigation. Grade 9 and 10 physical science learners as well as student teachers participated in the study. The results revealed that although the learners' intuitive conceptions are context-dependent, the majority of them feel confident about their responses. Limitations and inaccuracies in visual perceptions (such as differences in real and perceived velocities and changes in velocities) seem to contribute to their intuitive conceptions. A teaching sequence that attends to learners' visual perceptions is developed. The sequence further intends the conceptual refinement of learners' productive experiential knowledge in the learning of kinematics. Consistent application of physics concepts and principles in a variety of everyday and classroom experiences is emphasized for the formation of a meaningful explanatory model.

NPRP / 358

Study of fusion evaporation channels in the 18 O+ 18 O reaction at 65 MeV

Author: Ms. KHALEEL, ESRA [1]

Co-Authors: Dr. PAPKA, Paul [1]; Dr. MULLINS, Simon [2]

[1] *Stellenbosch University*

[2] *iThemba LABS*

Corresponding Author: khaleel@sun.ac.za

The fusion evaporation reaction is mainly used to populate high spin states in atomic nuclei. Using stable beams, a large number of β + unstable nuclei were studied i.e. those nuclei on the neutron deficient side of the valley of stability. A plethora of experimental data is available in a wide range of mass A ~ 20 to A ~ 250 and was used to test the statistical model codes such as PACE, CASCADE, GEMINI. With the advent of radioactive beams, a new landscape will be available to provide further tests to the models. However, a study of fusion evaporation reactions will only be possible with sufficient beam intensities. In this research β − unstable nuclei were populated with one of the few reactions where nuclei approaching the neutron rich region can be populated with stable beams. Due to the relatively low Coulomb barrier the evaporation of charged particles is a relatively strong channel. The DIAMANT light charged particle detector was set in coincidence with the AFRODITE γ-ray spectrometer to trigger between light charged particles and γ-rays. The coincident data allows the evaporation channels involving p, d, t and particles to be identified due to excellent particle identification with the CsI charged particle detectors while the A, Z of the residual nuclei are identified with the gamma transitions measured with germanium detectors. In this work, the cross sections of the residual nuclei were calculated with the statistical model code CACARIZO, a Monte Carlo version of CASCADE based on the Hauser-Feshbach formalism. Experimental and theoretical results and charged particle energy spectra are compared.

Theoretical / 359

Beyond the Planar Limit in ABJM Theory

Mr. MOHAMMED, Badr [1]

[1] *PhD student at university of the Witwatersrand*

Corresponding Author: badr.mohammed@students.wits.ac.za

ABJM theory is an N=6 Superconformal Chern-Simons theory with gauge group U(N)XU(N). This gauge theory has been extensively studied in the planar limit. Motivated by similar results for N=4 SYM, the planar dilatation operator of ABJM theory has been mapped to the Hamiltonian of an integrable system. Recently, it has been argued that there are large N (but not planar) limits of N=4 SYM theory for which the dilatation operator remains integrable. Indeed, it reduces to a set of decoupled harmonic oscillators. Motivated by this result, in this talk we study large N but non-planar limits of the ABJM theory. This is accomplished by constructing a complete set of gauge invariant operators for the theory. The free two point functions of these operators is computed and the action of the dilatation operator on these gauge invariant operators is constructed.

CMPMS1 / 360

Nanostructured WO3 thin films by Aqueous Chemical Growth: Structural, Optical and Gas sensing characteristics

Author: Mr. SONE, Bertrand [1]

Co-Authors: Mr. SITHOLE, Joseph [2]; Prof. MAAZA, Malik [2]; Prof. IWUOHA, Emmanuel [3]

[1] *Materials Research Department, iThemba LABS*

[2] *Materials Research Department, iThemba LABS*

[3] *Sensor Laboratories, Chemistry Department, University of the Western Cape*

Corresponding Author: sonebert@gmail.com

Crystalline thin solid films of WO3 have been prepared on Corning glass, FTO and Si through the low temperature, wet chemistry method of Aqueous Chemical Growth. SEM images of the thin films produced show that the surface morphology of the films is influenced by the kind of substrate used for the synthesis. While nanoplatelet-containing flower-like structures were consistently obtained on the Corning glass substrates, nanorod-containing urchin-like structures were consistently produced on the F-doped SnO2-glass substrates. A review, using SEM, is done here of the different kind of nanostructures that make up the thin films produced on these different substrates. Structural characterization of the different thin films synthesized on all three substrates was carried out using XRD, TEM, HRTEM and SAED. These showed that the films produced were made up of WO3 in the monoclinic, triclinic, cubic and hexagonal phase depending on what heat-treatment procedures the different substrates were subjected to post-synthesis. The quantum confinement effect is clearly demonstrated in the thin films as the optical band gap calculated for these films is seen to undergo a blue shift from the theoretical values of 2,7eV in the bulk to values of 3.18 eV, 3.93eV and 4.12 eV at the nano/microscale. This can be explained as being a consequence of the reduction of the grain size in these films to values in the nano-range, values as small as 9nm. By varying the time of synthesis for these films, a growth mechanism for the nanostructures produced is proposed. A comparative study of the hydrogen sensing properties of the WO3 thin films produced on all three substrates is carried out. This is compared to hydrogen sensing carried out on WO3 thin films prepared on Corning Glass, FTO and Si via the method of electrospinning. The structure-property relationship for gas sensing is thus assessed.

Theoretical / 361

Spectral method for studying nuclear four-body reactions

Author: Mr. MASITA, Dithlase [1]

Co-Author: Prof. LEKALA, Mantile [1]

[1] *UNISA*

Corresponding Author: masitdf@gmail.com

Reactions involving four particles, either in the entrance or final channel, are quite involved when computing observables in comparison to three-body reactions. Yet these reactions are of interest in studying reactions of astrophysical interest, such as hep process, which is essential for describing the quantitative solar model. At lower solar energies, it is difficult to measure the cross-section for the hep reaction. Moreover, there are discrepancies in calculations of the S-factor using different models and compared to the value predicted by the Standard Solar model. This problem in turn implies problems in estimating the correct value for the reaction cross-section which is crucial for the understanding of the Standard Solar model. In order to address this discrepancy and other observables, a reliable numerical technique is necessary. In this work we propose a new spectral method capable of calculating low-energy phase shifts for scattering of the nucleon off a light nucleus. We consider reactions of the type (3+1) --> (3+1), within the Faddeev-Yakubovsky framework. We show that these equations can be transformed into spectral-type set of equations that are numerical less expensive to solve in comparison to competing methods.

Poster2 / 362

Ultraluminous X-ray Sources in Nearby Galaxies

Mr. FOSTER, Deatrick [1]

[1] *South African Astronomical Observatory*

Corresponding Author: deatrick@saao.ac.za

For many Galactic black hole binaries, there exists kinematic data that constrain the black hole masses to be within the stellar-mass regime. However, due to their extragalactic distances, ultraluminous X-ray sources (ULXs) have no such available dynamical information. Hence, in order to constrain the system parameters, we must use indirect methods. We present an analysis of recent observations which suggest that, rather than being powered by intermediate-mass black holes, ULXs may represent an extreme form of "conventional" stellar-mass black holes.

CMPMS2 / 363

NON-SPECIALIST: Organic solar cells: An overview focusing on metal oxide buffer layer and post-fabrication annealing

Author: Prof. NTWAEABORWA, Odireleng [1]

Co-Authors: Ms. MBULE, Pontsho [1]; Prof. SWART, Hendrik [1]

[1] *University of the Free State*

Corresponding Author: ntwaeab@ufs.ac.za

Photovoltaic cell devices constructed from organic materials are becoming increasingly efficient because of the discovery of the bulk heterojunction concept. Today, organic photovoltaic cell (OPVC) devices fabricated from the blends of poly(3-hyxylthiopene) (P3HT) and [6,6] –phenyl C61-butyric acid methyl ester (PCBM) are the most widely studied bulk heterojunction systems because of their relatively good photovoltaic (PV) properties. Although the P3HT:PCBM based solar devices exhibit excellent PV properties compared to other bulk heterojunction polymer solar cells, their efficiency (☒ 8%) is still too low compared to that (☒ 20%) of conventional silicon PV cells. One way of improving the performance of these devices is by inserting a metal oxide buffer layer between the active layer and the anode. In addition, the PV properties of OPVC devices can also be improved by post-fabrication heat treatment (or annealing). This review provides an overview of OPVC devices focusing on: a brief history of the OPVC devices, device construction, and the effects of ZnO nanoparticles buffer layer and post-fabrication annealing on the general performance of P3HT:PCBM based solar devices.

Theoretical / 364

From few-body to many-body problems

Author: Prof. LEKALA, Mantile [1]

Co-Author: Mr. MUKERU, Bahati [1]

[1] *UNISA*

Corresponding Author: lekalml@unisa.ac.za

Problems involving bound states of few particles can be solved exactly since the number of degrees of freedom are small. Several methods in this direction exist. One of these is the Integro-differential equation approximation method (IDEA). These few-body methods have been succesfully applied to obtained bound and scattering states for three- and four-body problems for nuclear and molecular systems. On the other hand, calculating observables for many-body systems, such as Bose-Einstein condensates, is quite involved. Approximations at different levels, i.e. formalism and numerical, are necessary. In this work we show that the IDEA method can be extended to many-body systems via the transformation of the kernel, and this transformation accelerate convergence quite dramatically. Examples of molecular systems consisting of particles upto 1000 atoms are handled quite easily. Technical aspects of the method are discussed.

Theoretical / 365

One-way Quantum Computing with Photonic Orbital Angular Momentum

Ms. BASSA, Humairah [1]; Prof. KONRAD, Thomas [1]

[1] *UKZN*

Corresponding Author: konradt@ukzn.ac.za

One-Way Quantum computing is based on the preparation of certain entangled states of several particles, which are subsequently individually measured. The measurements serve to process information as well as to read out the final result of the computation. The implementation with OAM carrying photons is based on the usage of qubits (only two OAM values are relevant) but is a first step towards the implementation of a generalized form of One-Way Quantum computing by means of qudits (involving more then two OAM values).

Poster2 / 366

Investigating the thermal performance of a hybrid PV solar system

Dr. SIMON, Michael [1]

[1] *FHIT*

Corresponding Author: msimon@ufh.ac.za

Photovoltaic thermal heating system have gained momentum in the recent years with many investigations be been done on how to maximize the heat harnessing mechanisms. In some case copper tubes fixed on the back part of the module, are used to circulate forced water around them by external driving force e.g. pumps and, in the process extract heat from the module and provide the cooling effect as well. As more heat is extracted from the these devices, the final water temperature rises above the ordinary ambient temperature and stays hot for longer hours after the sun has gone down. This effect on the performance of the PV system due to long temperature lag and uneven heat distribution on the back of the module as a result of thermodynamics processes in the water will be presented in the final paper.

NPRP / 367

Radon escape from mine tailings dams

Author: Mr. ONGORI, Joash [1]

Co-Author: Prof. LINDSAY, Robert [1]

[1] *UWC*

Corresponding Author: rlindsay@uwc.ac.za

Gold mine tailings dams contain considerable amounts of Ra-226 and have therefore been identified as large sources of radon. In this contribution we will discuss measurements at a disused Kloof mine dump near Carletonville to investigate the radon exhalation from the dump as well as the gamma radiation from the dump. We have also taken soil samples in order to find the activity concentrations as well as to study the diffusion and emanation of radon.

LOS / 368

Digital control of a pulsed Ho:YLF ring laser

Author: Mr. JACOBS, Cobus [1]

Co-Authors: Dr. CHRISTOPH, Bollig [1]; Dr. THOMAS, Jones [2]

[1] *CSIR National Laser Centre*

[2] *Stellenbosch University*

Corresponding Author: cjacobs@csir.co.za

We have previously demonstrated a novel laser pulse energy control system based on two analog controllers to control a Q-switched Nd:YLF laser. We now present the improved technique based on a custom-designed high-speed FPGA (field programmable gate array) digital logic controller, together with experimental results from controlling a high-energy Ho:YLF ring laser. Laser pulses of constant and predictable energies are required in most applications, especially materials processing, micro-machining and medical laser surgery. Furthermore, for these applications the time between individual laser pulses may be purposely varied, which result in significant pulse-to-pulse variations in energy. These variations can cause damage and/or non-uniform processing of optics and target materials. Simultaneous electronic control of both an intra-cavity loss modulator (acousto-optic modulator) and the laser pump source (laser diode) provides the means to accurately stabilise and control the output pulse energy. This “dual loop” electronic feedback technique has been successfully demonstrated using two analog PID (proportional, integral and derivative) controllers. We have now implemented the control in a high-speed digital controller, adding several advantages in terms of computer programmability, flexibility and accuracy. The digital electronics consist of a FPGA processing unit (which can calculate programmed control algorithms at high-speed in parallel) sandwiched between high-speed analog-to-digital and digital-to-analog converters. The digital dual loop pulse control system was connected to a custom developed 2 micron single-frequency Ho:YLF ring laser. Normally, injection-seeding and resonator-length control (based on the Pound-Drever-Hall technique) are used to achieve stable single-frequency pulsed operation. The digital pulse control system provided a less expensive and more compact method for stable operation, and could selectively produce between 15 − 45mJ pulses set via a computer control interface. The control could also maintain constant pulse energies (within 4.3% of the set-point) across a range of pulse repetition rates.

CMPMS2 / 369

Structural features of the Cu-In-Ga-Se precursors for formation of Cu(In,Ga)Se2 thin films by thermal reaction of InSe/Cu/GaSe alloys to elemental Se vapour.

Prof. DEJENE, Francis [1]

[1] *University of the Free State*

Corresponding Author: dejenebf@qwa.uovs.ac.za

The quaternary compound semiconductor Cu(In,Ga)Se2 is one of the most attractive materials for high efficiency solar cells due to its tunable band gap to match well the solar spectrum. In this study, semiconducting Cu(In,Ga)Se2 thin films were prepared by a classical two-step growth process, which involves the selenization and/or sulfurization of In/Cu-Ga precursor. During the precursor formation step metallic In/Cu-Ga alloys were deposited onto the Mo coated soda lime glass substrates by DC magnetron sputter process. The respective precursors were subsequently reacted with H2Se and/or H2S gasses, at elevated temperatures. By optimizing the selenization parameters, such as the gas concentrations, reaction time, reaction temperature, and the flow of H2Se and H2S, high quality, single phase quaternary films were obtained. The gallium and sulfur diffusion behaviors were found to depend strongly on the selenization/sulfurization profile. The surface morphology, phase structure and composition of the layers were analyzed by scanning electron microscope (SEM), atomic force microscopy (AFM), X-ray diffraction (XRD), and electron diffraction spectroscopy (EDS). Photoluminescence (PL) measurements were performed to examine the optical properties of the films.

Poster1 / 370

Synthesis and photoluminescence properties of CaxSiyOz:Tb3+ nanophosphors prepared using solution-combustion method.

Author: Prof. DEJENE, Francis [1]

Co-Author: Dr. KEBED, Mesfin [2]

[1] *University of the Free State*

[2] *University of the Free Stae*

Corresponding Author: dejenebf@qwa.uovs.ac.za

Tb3+-activated calcium silicate (CaxSyyOz:Tb3+) nanophosphors have been synthesized by means of simple and low temperatures (500°C) using the solution-combustion of corresponding metal nitrate, TEOS and urea solution mixtures. The structural evolution of the phosphor was studied by X-ray powder diffraction (XRD), scanning electron microscopy (SEM), and the luminescence properties of the phosphor powders investigated as a function of terbium concentration. The XRD study indicates that new peaks appear as the terbium concentration increase results in phase changes from CaSiO3 to Ca3Si2O7. The later phase may be favored as a result of some Si sites substituted by the Tb ions as the concentration of Tb was changed from 1 to 4 mol. %. The CaxSiyOz:Tb phosphor powders show the characteristic emission of Tb3+ under UV excitation, with the emission transitions of (5D4⟶7F3,4,5,6) with excitation 257nm have been measured. Particularly, the green emission transition at 545nm has been found to be more prominent and intense which is due to an electronic transition of 5D4-7F5. The decay curves implied that these phosphors contain fast, medium and slow-decay process. The oxygen vacancies trap levels may be considered to be responsible for the long afterglow phosphorescence at room temperature. Such green strong emission displaying powder phosphor will find applications in the development of coated screens in certain electronic systems.

CMPMS2 / 371

Synthesis and Characterization of Ba1-xMgxAl2O4:Eu nanophosphors Prepared Using Solution – Combustion Method.

Author: Prof. DEJENE, Francis [1]

Co-Author: Dr. KEBEDE, Mesfin [2]

[1] *University of the Free State*

[2] *University of the Free Stae*

Corresponding Author: dejenebf@qwa.uovs.ac.za

Europium-doped barium magnesium aluminate (BaMgAlx0y:Eu) phosphors were obtained at low temperatures (500˚C) using the solution - combustion of corresponding metal nitrate–urea solution mixtures. The particle size and morphology and the structural and luminescent properties of the as-synthesized phosphors were examined by means of scanning electron microscopy (SEM), X-ray diffraction (XRD), Auger spectroscopy, transmission electron spectroscopy (TEM) and photoluminescence (PL). It was found that the Ba:Mg molar ratios showed greatly influence not only on the particle size and morphology, but also on their PL spectra and crystalline structure. The BaMgAl2O4 nanophosphors display a monoclinic structure indicating a small change in peak position at high angles due to differences in size between Ba and Mg ions. The peak of the emission band occurs at longer wavelength (around 615nm) with increase in Mg concentration but display a broad band emission at 515 nm for lower Mg concentration. The green emission is probably due to the influence of 5d electron states of Eu2+ in the crystal field because of atomic size variation causing crystal defects while the red emission is due to f-f transitions. This finding clearly demonstrate the possibility of fine tuning the color emission and solid solubility limit in Ba1-xMgxAl204:Eu phosphors through the simple and cheap process. A green phosphor with almost pure phase with significantly enhanced luminescence and longer after glow can be easily prepared by solution combustion method by doping with slight magnesium concentration (1 mole % Mg).

Poster1 / 372

Computer simulation of cobalt pentlandite

Mr. MEHLAPE, Mofuti [1]

[1] *University Of Limpopo (Turfloop Campus)*

Corresponding Author: mofuti.mehlape@ul.ac.za

Cobalt pentlandite (Co_9S_8)is the major source of cobalt. Of the several cobalt minerals, cobalt pentlandite is the most abundant and has the widest geographical distribution. This presentation looks at the computer simulation of Co_9S_8 structure using different computer simulation techniques, i.e. METADISE, VASP. These techniques have been employed to investigate the effect of molecular adsorption of water on the low-index surfaces of Co_9S_8

Theoretical / 373

The Giant Graviton Oscillator

Author: Prof. DE MELLO KOCH, Robert [1]

Co-Authors: Mr. MATHWIN, Christopher [1]; Mr. DESSEIN, Matthias [1]; Dr. GIATAGANAS, Dimitrios [1]

[1] *University of the Witwatersrand*

Corresponding Author: robert@neo.phys.wits.ac.za

N=4 SYM theory has been extensively studied in the planar limit. An important result is that the planar dilatation operator can be mapped to the Hamiltonian of an integrable system. In this talk we study certain large N (but not planar) limits of the theory. We argue that the dilatation operator remains integrable: it reduces to a set of decoupled harmonic oscillators. This challenges claims that integrability is spoiled by non-planar corrections. We argue that the decoupled oscillators that arise describe the vibration modes of a quantum membrane.

Poster2 / 374

Ionospheric response during the geomagnetic storm events on 24-27 July 2004: Long-duration positive storm effect

Author: Mr. NGWIRA, Chigomezyo [1]

Co-Authors: Dr. MCKINNELL, Lee-Anne [2]; Dr. CILLIERS, Pierre [2]

[1] *Rhodes University/SANSA Space Science*

[2] *SANSA Space Sceince*

Corresponding Author: chigongwira@yahoo.co.uk

Ionospheric storms represent large global disturbances in the ionospheric F2 region electron density in response to geomagnetic storms. The mechanisms for generation of negative storms are well understood and accepted. In contrast, positive storms show different characteristics and have not been fully understood. In this study, we investigate the ionospheric response during the geomagnetic storm events on 24-27 July 2004 using a multi-instrument approach. The period was characterised by strong geomagnetic activity that produced a positive ionospheric total electron content (TEC) effect over a four day period, but the most significant enhancements (with respect to the quiet day reference) were observed on 25 and 27 July and are presented here. It is noted that the enhancement on 25 July (40 TECU) was about twice as high as that observed on 27 July, even-though the later day was more geomagnetically disturbed. The positive storm enhancement on 25 July lasted over 9 hours and that on 27 July lasted about 7 hours, thus can both be classified as long-duration positive storm effects. Also, IMF Bz had a southward orientation for more than 15 hours on 25 July and could have been the mean by which energy was continuous fed into the magnetosphere. The DMSP F15 satellite which flew over the region of positive storm also observed the enhancement. In addition, the F-region critical frequency (foF2) values observed at two ionosonde stations showed marked positive responses and were associated with increase in ionospheric height.

Applied / 375

Construction and thermal analysis of a parabolic collector for small scale concentrating thermal system

Author: Mr. NHABETSE, Tomas [1]

Co-Authors: Prof. CUAMBA, Boaventura [2]; Prof. LOVSETH, Jorgen [3]; Mr. VERIMACH, Amos [2]; Mr. TAMELE, Basilio [2]

[1] *Eduardo Mondlane University, Maputo, Mozambique*

[2] *Eduardo Mondlane University*

[3] *The Norwegian University of Science and Technology, Trondheim (Norway)*

Corresponding Author: nhabetse@hotmail.com

Few options are apparent for achieving a benign, sustainable energy future except those relying on the utilization of solar energy in one way or another. Experience with fossil and nuclear sources has revealed an array of unsolved problems of increasing concern as more evidence and understanding emerges. Africa has the world's best solar resources. Several countries have exploited solar energy for water heating, crop drying, medical applications, and telecommunications, among other things. Solar energy can contribute to supply heat energy in households of Sub-Saharan African countries. Having this in mind a small scale dish concentrating solar energy system is being developed at the Eduardo Mondlane University in Mozambique. The system comprises of the collector, the heat storage and the oven. The main structure of the system has been constructed, consisting of the dish reflector, the sun tracker and the piping mechanism. The reflector consists of 6 petals which together resemble nearly a parabolic surface with the following parameters: Diameter................ Dp = 2400mm Focal length............ f = 915mm F/D ratio..................... n=0.135 Half opening angle..............66.50o Half complementary angle........23.49o Angle of incidence..............33.26 The process of gluing trapezoidal mirrors was done on individual petals using the laser beam radiation. Using reflection laws on planar surfaces which states that rays of light parallel to the parabola axis are reflected to a focal point, each trapezoidal mirror tile gluing was preceded by scanning its reflection close to the theoretical focal point. An individual petal was covered by 163 mirror tiles. The reflector surface is comprised by 978 mirror tiles. An infrared camera was used to scan the temperature of the concentrated heat. The maximum temperature reached so far is 350oC. The experimental focal area was found by mapping the reflections of the whole reflective surface. The shape of the receiver/absorber obtained by the scanning process is semi-spherical. The future work is the study of efficiency of the collector as a whole. This will be done by measuring the ambient air temperature, the inlet and outlet temperature of the absorber.

CMPMS1 / 376

Vibrational properties of Mass produced graphene monolayer by chemical method

Author: Mr. KHENFOUCH, MOHAMMED [1]

Co-Authors: Prof. MAAZA, MALEK [2]; Prof. BAITOUL, MIMOUNA [3]; Prof. AARABE, HASSAN [3]

[1] *PhD STUDENT*

[2] *iThemba Labs*

[3] *University Sidi Mohammed Ben Abdellah, Faculty of sciences, LPS*

Corresponding Author: khenfouch@yahoo.fr

Graphene is a two-dimensional crystal of carbon atoms arranged in a honeycomb lattice. It is a zero band gap semimetal with very unique electronic optical and mechanical properties which make it useful for many applications such as ultra-high-speed field-effect transistors, p-n junction diodes, terahertz oscillators, and low-noise electronic, NEMS and optical sensors. The high quality mass production of this nanomaterial is a big challenge, for this work we have used chemical method which helped to get this goal. Raman and FTIR vibrational spectroscopies were investigated to the examination of the production quality.

Poster2 / 377

Performance monitoring of a downdraft System Johansson Biomass Gasifier™

Author: Dr. MAMPHWELI, Sampson [1]

Co-Author: Prof. MEYER, Edson [2]

[1] *University of Fort Hare*

[2] *University of Fort Hare, Institute of Technology*

Corresponding Author: smamphweli@yahoo.com

Biomass gasification for electricity generation has attracted much attention over the past few years. This is due to the fact that biomass is a renewable resource, which is also considered to be carbon neutral. However electricity generation using biomass gasifiers can only be technically and economically achieved at small scale using downdraft gasifier systems, which produce gas that has very little quantities of tar. This paper presents the technical and operational challenges experienced in biomass gasification for electricity generation. The data was collected at the System Johansson Biomass Gasifier installed by Eskom. NDIR and Pd/Ni gas sensors were used to measure the gas profiles while type K thermocouples were used to measure the temperature in the reactor. This paper presents the performance monitoring results including the gasifier operating conditions, fuel properties, gas profiles as well as gas heating value and cold gas efficiency.

LOS / 378

CSIR-NLC mobile LIDAR for atmospheric remote sensing

Author: Prof. SIVAKUMAR, Venkataraman [1]

Co-Authors: Mr. SHARMA, Ameeth [1]; Dr. BOLIG, Christoph [1]; Dr. PRUSSLER, Dieter [1]

[1] *CSIR-National Laser Centre*

Corresponding Author: svenkataraman@csir.co.za

Light Detection and Ranging (LIDAR) studies on particulate matter (Aerosols) and pollutants; elucidate their distribution and concentration in the atmosphere. Particulate matter plays a key role in atmospheric physical and chemical processes from local to global scale. The complexity of these processes have been largely reviewed in literatures and LIDAR measurements have mostly contributed to a better understanding the role of atmosphere dynamics and particle microphysics. The atmospheric backscatter measurements of Aerosols (solid particles floating in the air and formed by combination of different pollutants), can be used to identify the stratification of pollutants and will enable the classification of the source regions, such as industrial, biological and anthropogenic sources. A mobile LIDAR system is developed at the Council for Scientific and Industrial Research (CSIR) National Laser Centre NLC), Pretoria (25° 44' S; 28° 11' E), South Africa. The system currently employed for atmospheric remote sensing including aerosols, clouds, boundary and mixed layers and other meteorological applications. The LIDAR is operated at 532 nm and 355 nm wavelength and capable of providing the backscatter information from ground to 40 km with the range resolution of 10 m (see. Fig.1). In this presentation, we shall present the results obtained from LIDAR and further ongoing research activities.

Poster1 / 379

Synthesis and Characterization of Y_2O_2S:Eu Nanophosphors Using Sol-combustion Method

Author: Mr. ALI, Ali Abdub Guyo [1]

Co-Authors: Prof. DEJENE, Francis [2]; Prof. SWART, Hendrik [3]

[1] *University of the free State, Qwaqwa campus.*

[2] *Universty of the free State*

[3] *iversity of the free State*

Corresponding Author: aliag@qwa.ufs.ac.za

Rare earth oxysulfide materials exhibit high luminescence efficiency as well as excellent chemical stability. These materials are widely used as luminescent host materials of several commercially available red emitting phosphors. However, there still remain issues affecting the operational parameters such as luminescence efficiency, stability against temperature, high color purity and long afterglow. Y_2O_2S:Eu nano powders were prepared by low-temperature synthesis method using sulfur-contained organic fuel in an ethanol-aqueous solution. The prepared nano powders were characterized by Scanning electron microscope, X-ray diffraction, photoluminescence spectra and X-ray photoelectron spectroscopy. It is shown that the assistant fuel ethanol has the effect of decreasing the water needed, simplifying the experiment procedure by dissolving rare earth nitrate and sulfur-contained organic fuel into an even solution, and prompting the formation of rare earth oxysulfide by igniting first during heating that leads to combustion decomposition reaction. Y_2O_2S:Eu nano crystallines with strong photoluminescence and X-ray luminescence are obtained using thiourea as organic fuel. Mixtures of Y_2O_3:Eu and Y_2O_2S:Eu are acquired using thiourea as fuel, and the content of Y_2O_2S:Eu increases until reaches to about half of the Y_2O_3:Eu with the increasing amount of thiourea. $Y_2O_2SO_4$:Eu emerges when S/Y=6 and increases with increasing thiourea content.

APSS / 380

An African VLBI Network of Radio Telescopes

Dr. GAYLARD, Michael [1]

[1] *HartRAO*

Corresponding Author: mike@hartrao.ac.za

The advent of international wideband communication by optical fibre has produced a revolution in communications and the use of the internet. Many African countries are now connected to undersea fibre linking them to other African countries and to other continents. Previously international communication was by microwave links through geostationary satellites. These are becoming redundant in some countries as optical fibre takes over, as this provides 1000 times the bandwidth of the satellite links. In the 1970's and 1980's some two dozen large (30m diameter class) antennas were built in various African countries to provide the satellite links. As these antennas become redundant, the possibility exists to convert them for radio astronomy at a cost of roughly one tenth that of a new antenna of similar size. HartRAO and the SA SKA Project have started exploring this possibility with some of the African countries.

Poster1 / 381

Hydrogenation of Ti6Al4V alloy

Ms. SENTSHO, Zeldah [1]

[1] *iThemba labs*

Corresponding Author: ngwanakgagane@tlabs.ac.za

Hydrogen is the lightest element and it has the highest energy content per unit of weight of any known element and thus, it can be used as a source of clean energy. Previous research studies on hydrogen storage show that storing hydrogen as a solid hydride is preferred compared to liquid and gas because of the very high pressures and low temperatures needed to maintain the system. Hydrogen storage in solid form offers the safest alternative for transportation and storage of hydrogen. Metal hydrides are known to possess high volumetric hydrogen densities (of the order of 3 to 8 wt. %) along with the ability to store hydrogen at atmospheric pressure and room temperature. Moreover, many metals and alloys are capable of reversibly absorbing large amounts of hydrogen. The unique properties of hydrogen storage alloys are used in numerous applications such as rechargeable batteries, cooling devices, hydrogen storage systems for fuel cells and in gas sensors applications. The research interest of this project is placed on Ti6Al4V alloy as promising candidate for hydrogen storage. The changes in microstructure (volume fractions of alpha- and beta-phase) will be studied as a function of hydrogen concentration and pressure. X Ray Diffraction (XRD) will be used for phase analysis, while the hydrogen content and hydrogen depth profile will be determined by Electron Recoil Detection Analysis (ERDA) and Heavy Ions (ERDA) methods.

Poster2 / 382

Radiation Shielding calculations using MCNPX transport code for cost optimization of the shielding material to be used in the new cyclotron vault at iThemba Labs

Author: Mr. NGCOBO, Zipho [1]

Co-Authors: Dr. BARK, Robert [1]; Prof. NDWANDWE, Muzi [2]

[1] *iThemba Labs*

[2] *University of Zululand*

Corresponding Author: ingquevents@gmail.com

Ion Beam Applications (IBA) commercial cyclotron (IBA Cyclone 70) with capability of accelerating protons up to 70MeV and 350μA of current is to be constructed at iThemba Labs to increase the capacity of the current facility. The two opposite simultaneous extraction of beams using the Carbon foil stripper, enable for the concurrent production of radioactive ion beam (RIB) for nuclear research and isotope production. This high energy beam is expected to have losses of about 10% in total meaning 70μA of the total beam will interact with surrounding materials during acceleration. Thus this proton beam is a possible radiation source, presenting a threat of ionising radiation. The cyclotron is mainly made of magnetic steel which is rather stable provinding local shielding inside the vault. There are not many significant openings for the radiation to rather escape in the less dense media to the surrounding other than in the extraction sides. Between the two poles of the cyclotron, the strip made of steel, which seals the two poles, is thick enough to shield radiation. Considering efficiencies at the extraction side of the cyclotron, it is expected that radiation contamination will accumulate and be transported to the vault and surroundings during cyclotron operations. Particles of concern are neutrons and photons formed during proton beam interaction. Bremstrahlung x-rays (photons) could be from proton acceleration and neutrons could be produced by (p, n) reactions. Photons and neutrons are not easy to shield. There is a need to simulate the radiation transport using MCNPX transport code so that the levels of doses can be investigated to provide extra safety cautions and adequate selection of materials and correct dimensions for shielding walls to keep the dose rates at acceptable levels. Additionally, water in the cooling system as it consists of Hydrogen isotopes that can react with protons to produce neutrons will also be investigated as it will increase the neutron flux into the vault.

LOS / 383

Dielectric barrier discharge CO2 TEA laser operated at frequencies up to 400 Hz

Author: Mr. BARICHOLO, Peter [1]

Co-Authors: Mr. STEHMANN, Timo [2]; Dr. HLATYWAYO, Dumisani John [3]; Prof. ROHWER, Erich [4]; Prof. COLLIER, Mike [5]; Prof. BERGMANN, Hubertus M. [4]

[1] *National University of Science and Technology, Stellenbosch University*

[2] *University of Stellenbosch*

[3] *National University of Science and Technology, Bulawayo, Zimbabwe*

[4] *Laser Research institute, University of Stellenbosch*

[5] *National University of Science and Technology*

Corresponding Author: pbaricholo@yahoo.com

A dielectric barrier discharge CO2 TEA laser excited by a thyratron driven power supply has been developed and characterized. Laser output was observed at frequencies up to 25 Hz for an electrode separation of 10 mm with 1.8 mm Suprasil glass covering the electrodes. At this gap separation, pulsed power output of about 9 W was detected for gas pressures between 100 and 400 mbar. Changing the electrode gap separation to 5 mm and using 1.4 mm Suprasil glass dielectric increased the output power to 23 W and enabled laser output to be observed at gas pressures up to 700 mbar and maximum pulse excitation frequencies of up to 400 Hz. The developed laser does not require water cooling since the system operates in burst pulse mode.

LOS / 384

Implementation of intra–cavity beam shaping technique to enhance pump efficiency

Dr. LITVIN, Igor [1]

[1] *CSIR NLC*

Corresponding Author: ilitvin@csir.co.za

In this work we propose an implementation of a new intra–cavity beam shaping technique to vary the intensity distribution of the fundamental mode in a resonator cavity while maintaining a constant intensity distribution at the output. This method can be useful for fitting a transversal intensity profile of the required mode with a pump beam profile in the region of the active medium to increase mode discrimination.

LOS / 385

The behavior of an instantaneous Poynting vector in the laser beams

Dr. LITVIN, Igor [1]

[1] *CSIR NLC*

Corresponding Author: ilitvin@csir.co.za

In this work we investigate the behavior of an instantaneous Poynting vector for different types of cylindrical symmetric beams such Gaussian beams, Bessel beams and so on. In most investigations for energy flow in real laser beams, the oscillation component of the Poynting vector is not considered. However this component of the Poynting vector carries useful information regarding beam behavior such as beam divergence, self reconstruction and diffraction effects, which are difficult or nearly impossible to extract from the field of the beam or the time averaged component of the pointing vector. The behavior of the Poynting vector is different in the near and far fields and understanding such differences leads to useful interpretation of the different beam behavior in these regions which is also part of what is investigated in this study.

Poster1 / 386

Behaviour of iodine implanted in HOPG after heat treatment

Author: Mr. MUKHAWANA, Mxolisi [1]

Co-Authors: Prof. THERON, Chris [1]; Prof. MALHERBE, Johan [1]

[1] *University of Pretoria*

Corresponding Author: mxolisistar@gmail.com

The behaviour of iodine implanted in highly oriented pyrolytic graphite (HOPG) has been investigated using Rutherford backscattering spectrometry (RBS), scanning electron microscopy (SEM) and x-ray diffraction (XRD). Iodine ions were implanted into HOPG using an energy of 360 keV and a dose of 1×1015 atoms cm-2 at room temperature. The implanted samples were annealed in vacuum at 900 0C, 1000 0C, 1100 0C and 1200 0C, all for 9 hours. The results revealed that iodine was released from the HOPG at the above annealing temperatures. RBS evaluation of the full width at half maximum (FWHM) and the number of iodine atoms before and after annealing did not reveal Fickian diffusion as the mechanism by which the iodine atoms were released from the HOPG. Evaluation of (002) peak intensities using XRD revealed an increase in preferred orientation of the graphitic layers after heat treatment of 1200 0C. The high resolution SEM micrographs of the HOPG samples before and after heat treatment showed no evidence of alterations on the polished surface.

LOS / 387

Quantum cryptography for satellite communication

Author: Mr. MARIOLA, Marco [1]

Co-Authors: Mr. MIRZA, Abdul [1]; Prof. PETRUCCIONE, Francesco [1]

[1] *University of Kwazulu-Natal*

Corresponding Author: mmspazio@libero.it

Quantum key distribution (QKD) is a secure method of transferring encryption keys between two distant parties. It provides a physical layer of security rather than a mathematical algorithm used in conventional encryption systems. As QKD is of paramount importance in the future ICT landscape, various innovative solutions have been developed and tested to expand the spatial coverage of these networks [R. Alleaume, 2007, C. Elliott, 2004, F. Xu,2009]. One such technique to create a global QKD network is to couple quantum-secured MANs with secured ground-to-satellite links. We present our recent work in ground-to-balloon QKD systems as an intermediary to the satellite QKD. We have considered a number of parameters in developing our solution. Firstly, the link with the earth station should be guaranteed and robust. Other parameters that we have taken into account include the design of the payload, tracking systems, synchronization balloon/satellite and ground station and choice of the public channel. The balloon or satellite will send the QKD signal to the ground station. We use the radio modulation PSK for the transmission of data and synchronize the laser signal for QKD. In this way the distance and velocity relative between earth and satellite (or Balloon) is not a constraint. The public channel will be used to send a string of bits (from satellite to earth) that indicates the data start and from that moment, for every bit of the clock, the satellite sends the quantum bit. Radio communication will be used also for the public communication during the QKD transmission. Data for correction for the tracking laser will be controlled by a feedback loop on the ground station, however, the tracking system of the Balloon or satellite must work separated from the ACS.

CMPMS1 / 388

Effects of ZnO and Ce3+ incorporation on the photoluminescence and cathodoluminescence intensity of Pr3+ doped SiO2.

Authors: Ms. MHLONGO, Gugu [1]; Prof. SWART, Hendrik [2]; Dr. DHLAMINI, Mokhotjwa [3]; Dr. SOLARZ, Piotr [4]

Co-Authors: Prof. HILLIE, Thembela [5]; Prof. NTWAEABORWA, Martin [2]

[1] *CSIR/UFS*

[2] *UFS*

[3] *UNISA*

[4] *Polish Academy of Sciences*

[5] *CSIR*

Corresponding Author: gmhlongo@csir.co.za

The successful incorporation of ZnO nanoparticles and Ce3+ ions in Pr3+ doped SiO2 using a sol-gel process is reported. SiO2:Pr3+ gels, with or without ZnO and Ce3+, were dried at room temperature and annealed at 600 oC. The Field Emission Scanning Electron Microscopy (FESEM) indicated clustered SiO2 nanoparticles with with particle size diameter ranging between 20 to 120 nm while the high resolution transmission electron microscopy (HRTEM) revealed and energy dispersive x-ray spectroscopy (EDS) the presence of Zn, Ce, and Pr nanoclustures enveloped in SiO2 matrix.. The emission intensity from SiO2:Pr3+-Ce3+ was slightly enhanced compared to single doped SiO2:Ce3+. For ZnO.SiO2:Pr3+, the ZnO green emission was suppressed and enhanced emission from Pr3+ was observed. Energy transfer mechanism between Pr3+and Ce3+ as well as between ZnO and Pr3+ ¬ is discussed in detail.

Poster1 / 389

The influence of Pr3+ co-doping on the photoluminescence and cathodoluminescence properties of SiO2:Eu3+ /Tb3+.

Authors: Ms. MHLONGO, Gugu [1]; Prof. SWART, Hendrik [2]; Dr. SOLARZ, Piotr [3]

Co-Authors: Prof. NTWAEABORWA, Martin [2]; Prof. HILLIE, Thembela [4]

[1] *CSIR/UFS*

[2] *UFS*

[3] *Polish Academy of Sciences*

[4] *CSIR*

Corresponding Author: gmhlongo@csir.co.za

Pr3+-Tb3+, and Pr3+-Eu3+ ion pairs co-doped in SiO2 matrix were prepared by a sol-gel method. The photoluminescence (PL) measurements revealed the red and green emissions centred at 614 nm (5D0-7F2) and 541 nm (5D4⟶7F5) for single doped Eu3+ and Tb3+ ions in SiO2, respectively. Co-doping of Eu3+ and Tb3+ ions with Pr3+ in SiO2 showed that the energy transfer between Pr3+ and nearest Eu3+ and Tb3+ ions takes place. At the same time, however, there was evidence of luminescence quenching of Eu3+ and Tb3+ emissions at certain concentrations of Pr3+. The quenching was also confirmed by cathodoluminescence (CL) measurements recorded from the same powders. . Possible mechanism of energy transfer from Pr3+ to Eu3+ and Tb3+ and its quenching effects are discussed.

CMPMS2 / 390

Tailoring of Mechanical, thermal and electrical properties of polymers composite: A micro fuel cell perspective

Author: Mr. CHEN, Hao [1]

Co-Authors: Dr. BOTEF, Ionel [2]; Mr. LAND, Kevin [1]; Prof. SRINIVASU, Vallabhapurapu [3]

[1] *CSIR*

[2] *Wits*

[3] *Unisa*

Corresponding Author: jerrychenhao@gmail.com

Fuel cells have been intensively researched for the past few decades for macro applications. However, micro fuel cells have not received so much attention. A micro fuel cell delivers power in the mW-W range, and would be suitable for mobile purposes, e.g. as a charger for cell-phone or other small devices. We consider polymers such as polydimethylsiloxane (PDMS) as a prospective structural material candidate for a Micro Fuel Cell. The introduction of such a polymer as structural material will reduce the mass and the size of the micro fuel cell and therefore optimize the current micro fuel cell models. In this perspective, our work focuses on the tailorability and optimization of thermal, mechanical, and electrical properties of PDMS with different micro/nano fillers such as silver particles, carbon black,. The mechanical property is characterized by Dynamic Mechanical Analysis(DMA). The thermal properties are measured using Thermal Gravimetric Analysis (TGA) and Cut-Bar thermal conductivity measurement. Four point probe was used for electrical conductivity measurement. Scanning Electron Microscopy (SEM) was used for surface morphology characterization.

Applied / 391

Nuclear and related analytical techniques for biotechnology

Dr. FRONTASYEVA, Marina [1]

[1] *Joint Institute for Nuclear Research*

Corresponding Author: mfrontasyeva@yahoo.com

Some results from applying nuclear and related analytical techniques in medical, environmental and industrial biotechnologies are presented. In the biomedical experiments biomass from the blue-green alga Spirulina platensis has been used as a matrix for the development of pharmaceutical substances containing such essential trace elements as selenium, chromium and iodine. The feasibility of target-oriented introduction of these elements into Spirulina platensis biocomplexes retaining its protein composition and natural beneficial properties was shown. The negative influence of mercury on growth dynamics of Spirulina platensis was observed. Detoxification of Cr and Hg by Arthrobacter globiformis 151B was demonstrated. Microbial synthesis of technologically important silver nanoparticles by the novel actinomycete strain Streptomyces glaucus 71 MD was characterized by a combined use of Transmission Electron Microscopy (TEM) and ENAA. It was established that the tested actinomycete Streptomyces glaucus 71 MD produces silver nanoparticles extracellularly when acted upon by the silver nitrate solution, which offers a great advantage over an intracellular process of synthesis from the point of view of applications. The synthesis of silver nanoparticles by Spirulina platensis proceeded differently under the short-term and long-term silver action. Our studies will help to develop a rational microbial nanoparticle synthesis procedure.

Poster2 / 393

An investigation of high velocity flows in HF radar data during northward interplanetary magnetic field, non-substorm intervals

Author: Mr. MTUMELA, Zolile [1]

Co-Author: Prof. RASH, J.P.S. [1]

[1] *University of KwaZulu-Natal*

Corresponding Author: 208516464@ukzn.ac.za

Several previous studies, including one using early Sanae radar data, have found examples of high speed ionospheric plasma flows on the nightside, mapping to the magnetospheric tail, during periods which were magnetically quiet. These high speed flows were interpreted to be associated with the release of energy from a rapid reconfiguration of tail magnetic field lines due to reconnection. Such events are now known as 'TRINNIs' or 'tail reconnection during IMF northward, non-substorm intervals'. The purpose of this study was to identify further TRINNI events, using SuperDARN data from both hemispheres. In situations where the y-component of the Interplanetary Magnetic Field dominates over the z-component, the directions of both the high speed flows and the underlying convection pattern depend on the direction of the y-component. Some examples of likely TRINNI events for cases where the y-component was positive and negative are presented and discussed. The assumption of a non-substorm interval is justified by magnetometer and GOES satellite data, and the observations are discussed in relation to magnetic reconnection in the magnetotail.

LOS / 395

Spectroscopy with a mode-locked Femtosecond Laser Frequency Comb

Author: Mr. MBELE, Vela Lincoln [1]

Co-Author: Prof. SIDERAS-HADDAD, Elias [2]

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

[2] *School of Physics*

Corresponding Author: m_l_vela@yahoo.com

The Nobel prize winning technology involving a mode-locked femtosecond laser frequency comb (FLFC) has been at the epi-centre of a scientific revolution over the last two or so decades. Even though originally designed to count cycles in optical clocks, it has had a profound impact on other research areas, with a range of applications including spectroscopy, trace gas detection, signal processing, astrophysics and many others. In the near future most of these applications may be taken over by the compact monolithic micro-resonator generated frequency combs, there is, however, no doubt that mode-locked FLFC will continue growing their range of applicability over the next few decades. We present a brief overview of two simple high-resolution high-precision spectroscopy experiments. One experiment is of caesium-133 atoms contained in a vapour cell, and the other molecular spectroscopy where multi-channels are simultaneously detected by a charge coupled device (CCD) camera with a specimen imprinting its unique fingerprint. In both experiments excitation is through radiation from a mode-locked FLFC. In the caesium experiment the laser beam is set counter-propagating after the beamsplitting cube, focussed to a reasonable waist in the interaction region in the vapour cell, thereby exciting a multitude of low lying magnetic dipole and electric quadrupole transitions allowing the measurement of transition energies and hyperfine coupling coefficients for the 8S, 9S and $7D_{3/2,5/2}$ states. In the second experiment the comb is filtered by a Fabry-Perot cavity changing the repetition rate of the laser from 1 GHz to repetition rates in the range 3 - 15 GHz to match the resolution of the spectrometre. The spectrometre comprises of the Virtually Image Phased Array, the 2400 lines/mm reflection grating and the CCD camera. We discuss, the spectrometre, the results of both experiments, and briefly some other possible applications of laser comb.

Poster2 / 396

Simulation of a pencil proton beam in a water phantom using various monte carlo codes.

Ms. JACOBS, Carmen [1]

[1] *University of the Western Cape*

Corresponding Author: 2765727@uwc.ac.za

This study investigates the Pencil Proton Beam scanning technique to determine the dosage obtained during clinical treatments due to secondary radiation. Simulations in MCNPX and GEANT4/GATE are of particular interest in this study. The study is based on a variation of the traditional Hogstrom Pencil beam model for electron beams to provide a description of clinical proton beams. This new Hogstrom model is based on the Fermi-Eyges theory of particle transport. The method used in this investigation is to simulate a proton pencil beam entering a water phantom at various discrete energies and determining the secondary particles distributed throughout the water phantom by studying both Coulombic and Nuclear interactions of the incident proton in water. This allows one to determine how much of the total dosage obtained by the patient is from the primary particle and what part of the dosage is due to the secondary particles. In order to accurately compare the Monte Carlo codes, a further study was done to understand the underlying physics principles used by MCNPX and GEANT4. The development of an analytical model for primary proton beams which included depth distribution, propagations of protons in matter, and scattering theory was also investigated. Besides comparing Monte Carlo codes this study also has real life implications. Pencil beam scanning leads to improving and advancing treatment planning.

Poster2 / 397

Investigating the effect of atmospheric dymanics on HF propagation

Author: Ms. ATHIENO, Racheal [1]

Co-Author: Dr. MCKINNELL, Lee-Anne [1]

[1] *South African National Space Agency (SANSA) Space Science*

Corresponding Author: rathieno@hmo.ac.za

HF propagation involves transmission and reception of radio signals within a frequency range of 3 – 30 MHz. It finds applications in a number of communication fields such as international short wave broadcasting, mobile telephone systems, radio navigation and operation of radar systems. However, it depends on the ionosphere which is constantly varying mainly due changes in the neutral atmosphere which are a consequence of atmospheric dynamics. In this paper, we investigate the effect of atmospheric dynamics on High Frequency (HF) propagation using the co-located radars at SANSA Space Science (19.2o E, 34.4o S), Hermanus, South Africa. These radars include the HF Doppler radar, Ionosonde, Global Positioning System (GPS) receiver and GPS Ionospheric Scintillation Total Electron Content (TEC) Monitor (GISTM). HF propagation results from the HF Doppler radar are presented. The comparison of results of the HF Doppler radar with other radars is also included. Results show that radio communication is affected by atmospheric dynamics which results into signal fading or at worst signal loss.

Theoretical / 398

Towards the unconditional security proof for the Coherent-One-Way (COW) protocol

Author: Mr. MAFU, Mhlambululi [1]

Co-Authors: Ms. MARAIS, Adriana [2]; Prof. PETRUCCIONE, Francesco [3]

[1] *Centre for Quantum Technology*

[2] *center for Quantum Technology*

[3] *Center for Quantum Technology*

Corresponding Author: mafizix@yahoo.co.uk

Quantum Cryptography, one aspect of which is Quantum Key Distri- bution (QKD), provides the only physically secure and proven method for the transmission of a secret key between two distant parties, Alice and Bob. The goal of QKD is to guarantee that a possible eavesdropper (Eve), with access to the communication channel is unable to obtain useful information about the message. The Coherent-One-Way (COW) protocol is one of the most recent practical QKD protocols. However, its security proof still remains unrealized. We therefore present a necessary condition for the security of the COW protocol. In the proof, we describe bob's measurements by non-commuting POVM elements which satisfies this proof.

Poster2 / 399

Radon from building materials

Ms. THELEDI, RABECCA RAMOKONE [1]

[1] *UWC*

Corresponding Author: 3071882@uwc.ac.za

Radon is a naturally occurring radioactive inert gas in the decay chain of uranium-238. High radon levels in houses have been linked to the occurrence of lung cancer via the deposition of radon progeny in the lungs. The radon activity in houses depends on the concentration of radium in the soil below the house and the diffusion of radon into the house. Another pathway is the concentration of radium in building materials. There has been concerns that indoor radon from granite countertops and zircon tiles might contribute significantly to the radon concentration in a house. The aim of this work is to look at how much radon is coming out of some South African tiles and granite used in houses, as well as other building materials. Radium content has been measured using a NaI detector and radon with the use of a RAD7 continuous radon monitor as well as electrets ion chambers. Preliminary measurements will be presented on material that has been used in construction in South Africa.

CMPMS2 / 400

Electrical characterization of two metastable defects introduced in GaN by Eu-ion implantation

Author: Dr. MEYER, Walter [1]

Co-Authors: Prof. AURET, F Danie [1]; Dr. DIALE, Mmantsae [1]; Mr. JANSE VAN RENSBURG, P Johan [1]; Dr. SONG, Shufang [2]; Dr. TEMST, Kristiaan [2]; Prof. VANTOMME, Andre [2]

[1] *University of Pretoria*

[2] *KU Leuven*

Corresponding Author: wmeyer@up.ac.za

Defects introduced by 300 keV Eu ions in HVPE grown Si-doped GaN were investigated by means of deep level transient spectroscopy (DLTS). After implantation, the samples were annealed at 1000 °C and Ti/Al/Ni/Au ohmic and Ni/Au Schottky contacts were deposited. The Schottky contacts were found to be of high quality, with leakage current at 1 V reverse bias of below 10 8 A. Two peaks in the DLTS spectrum showed metastable behaviour. They were labelled E1 and E2 and had activation enthalpies of 0.20 eV and 0.28 eV respectively. Laplace analysis showed that the E1 was a due to a single exponential decay, while the E2 consisted of the sum of three exponential decays. We found that the E1 and E2 defects are metastable, and that the E2 defect may be reversibly transformed to the E1 defect by a zero bias. We found that the transition between these defects is not described well by a single exponential decay, but rather by the integral over a range of exponential decays.

CMPMS2 / 401

Equivalent parameters for empirical pseudopotential and k•p models

Author: Mr. MPSHE, Kagiso [1]

Co-Authors: Prof. BOTHA, Andre [1]; Prof. LOMBARDI, Enrico [1]

[1] *Unisa*

Corresponding Author: 44455585@mylife.unisa.ac.za

After thirty-five years the empirical pseudopotential electronic band structures that were fitted by James R. Chelikowsky and Marvin L. Cohen (Phys. Rev. B 14, 556, 1976) are still used widely and are regarded by some workers as being among the best. Although the original paper by Chelikowsky and Cohen has received more than 600 citations, not all subsequent workers have been able to reproduce the band structures accurately. In a few of the citing papers, significant errors were introduced by, for example, incorrectly adding the effects of non-locality in the core potentials and spin-orbit coupling. In the original work both of these effects were added as perturbations. In the present work it is shown that the original calculations of Chelikowsky and Cohen can be reproduced accurately, even without the use of perturbation theory. This reproduction allows the original band structures to be used with great ease. As an example, the original band structures are used as input to an optimization calculation which produces equivalent fourteen-band and thirty-band (full-zone) k•p parameters for the original eleven diamond and zinc-blende semiconductors. The original band structures are also compared to those obtained through state-of-the-art ab-initio density functional calculations.

LOS / 402

The optical syringe for selective differentiation of pluripotent stem cells

Dr. MTHUNZI, Patience [1]

[1] *CSIR - NLC*

Corresponding Author: pmthunzi@csir.co.za

Due to their self-renewal and pluripotency characteristics, stem cells possess the potential to dramatically advance current therapies in tissue regeneration and engineering. Nonetheless, there still remains a pressing necessity to answer the biological questions concerning how stem cell renewal and differentiation programs are operated and regulated at the genetic level. Genetic manipulation such as delivery of exogenous gene expression or knockout with small interfering RNA (siRNA) is relatively rare in mouse embryonic stem (ES) cells. However, genetic species can be selectively introduced and subsequently expressed in live mammalian cells via optical systems, a technique normally referred to as photo-transfection. During photo-transfection, localized application of femtosecond (fs) laser pulses onto the cell plasma membrane induces transient submicrometer holes, thereby facilitating cytosolic uptake of extracellular exogenous materials. This novel optical cell transfection technique allows targeted treatment of cells promoting limited use of reagents or chemicals that can cause spontaneous differentiation and also interfere with the physiological properties of ES cells. In this work, we report for the first time that fs laser pulses can be utilized as an optical syringe for successful transient photo-transfection and induced differentiation of mouse ES cell colonies. This was achieved by using a tightly focused titanium sapphire laser beam spot (~1.1 μm diameter spot size, 790nm, 80MHz, 200fs and 50 mW average power output), where E14g2a cells were differentiated into the extraembryonic endoderm via photo-transfection with the Gata-6 transcription factor.

Poster2 / 403

Schottky contact on GaN

Dr. DIALE, Mmantsae [1]

[1] *University of Pretoria*

Corresponding Author: mmantsae.diale@up.ac.za

Metal Au, Ni and Ni/Au contacts on n-GaN were studied for metal contacts for the fabrication of Shottky barrier ultraviolet photodetectors. AES, RBS and current-voltage measurements were used to study the samples. Figure 2 shows the current voltage mechanism of Au, Ni and Ni/Au transparent contacts onto GaN. The Schottky barrier heights of Au contacts were averaged at 0.84 ± 0.02 eV and the ideality factors of 1.7 ± 0.3. Series resistance for these contacts was about 481 ± 4 Ω. Ni contacts onto GaN are dominated by tunneling currents and the leakage current is higher than that of Au. The Schottky barrier heights of Ni contacts were averaged at 0.82 ± 0.04 eV and the ideality factors of 1.9 ± 0.2. Series resistance for these contacts was about 38 ± 1 Ω, far less than that of Au contacts. Ni/Au contacts are annealed at 500 °C for transparency. The leakage current of Ni/Au is two orders of magnitude lower than that of Ni and Au, and the Schottky barrier height was averaged at 2.04 ± 0.01 eV for ideality factors of about 1.6 ± 0.4.

Poster1 / 404

Deposition and structural properties of Silicon Carbide thin films for solar cells applications

Author: Mr. KHOELE, Joshua [1]

Co-Authors: Prof. VANFLEET, Richard [2]; Dr. HALINDINTWALI, Sylvain [1]; Prof. JULIES, Basil [1]

[1] *University of the Western Cape*

[2] *Department of Physics and Astronomy, Brigham Young University*

Corresponding Author: 3075072@uwc.ac.za

Amorphous and nanocrystalline silicon carbide thin films were deposited on corning glass 7059 and c-Si (100) substrates using the Hot Wire Chemical Vapor Deposition (HWCVD) and Magnetron Sputtering (MS) techniques. Samples were prepared at low substrate temperatures below 300 degrees celsius and a gas mixture of SiH4/CH4/H2 was used in case of HWCVD. For MS, the temperature of the substrate was varied between 300-600 degrees celsius and Ar plasma was used to sputter a SiC target in a H2 plume environment. X-ray diffraction (XRD) and transmission electron microscopy (TEM) were used to investigate the phase changes and crystallinity in the films. Plan view and cross section specimen were prepared by the TRIPOD polishing technique for the TEM structural investigation. Fourier Transform Infrared Spectroscopy (FTIR) was used to investigate the hydrogen content and the SiC vibrational bonds in the samples.

CMPMS1 / 405

ZnO Nanorods/Nanoplates for Gratzel-Type Dye Solar Cells Applications: Growth Mechanism

Mr. SITHOLE, Joseph [1]

[1] *NRF iThemba Labs*

Corresponding Author: sithomj@tlabs.ac.za

Zinc oxide is a direct, wide bandgap semiconductor material with many promising properties for blue/UV optoelectronics, transparent electronics, spintronic devices and sensor applications. ZnO has been commonly used in its polycrystalline form in a wide range of applications such as sunscreens, catalysts, piezoelectric transducers, varistors, and as transparent conducting electrodes. ZnO has numerous attractive characteristics for electronics and optoelectronics devices especially in solar cells. It has direct bandgap energy of 3.37 eV, comparable to of TiO_2 which makes it transparent in visible light. The exciton binding energy is about 60 meV for ZnO. The room temperature electron Hall mobility in single crystal ZnO is of the order of 200 $cm^2 V^{-1}$. Unlike TiO_2, ZnO can be grown easily in anisotropic shape, specifically in form of nanorods or nanotubes. This central geometry of nano-scaled ZnO, in addition to the high surface/volume ratio for the adsorption of light-harvesting molecules, would offer a larger free mean path for electronic charge transfer and minimizes the e-hole recombination in a ZnO nanorods/nanotubes based excitonic Gratzel dye solar photocells. Indeed, this tubular ZnO geometry would enhance the device efficiency through the direct electrical pathways provided by the nanorods/nanotubes, ensures the rapid collection of carriers generated throughout the device, in addition to an effective light trapping. This contribution reports the growth mechanism of the ZnO nanorods by the so called Vayssieres hydrothermal method. It is demonstrated for the first time that in a large pH range within the hydrothermal process, the growth mode of the ZnO nanorods is a pure Frank-van der Merwe driven process. More precisely, nano-platellets of ZnO are formed at the early growth stage growing towards nano-rods. From crystallographic view point, both the ZnO nano-plattelets and nanorods exhibit the standard hexagonal wurtzite crystal structure, with (002) main orientation and lattice parameters a=~3.25 Å and c=~5.12 Å. The room temperature luminescence and Raman investigations indicates that the defects are mainly O deficiency driven.

NPRP / 406

Low level counting using a NaI(Tl) detector

Author: Mr. NONCOLELA, Sive [1]

Co-Author: Prof. LINDSAY, Robert [1]

[1] *UWC*

Corresponding Author: prosive@yahoo.com

In this work a 7.5 cm x 7.5 cm NaI (Tl) detector was used to study activity concentrations of primordial radionuclides in soil and sand samples. The detector and the sample were placed inside a lead castle to reduce background measurements from the surroundings such as the wall and the floor. The samples were placed inside a 1L Marinelli beaker which surrounds the detector for better relative. Additional lead bricks were placed below the detector to further reduce the background by 10%. A Full Spectrum Analysis (FSA) method was used to extract the activity concentrations of 238U, 232Th and 40K from the measured data. The FSA method uses standard spectra corresponding to the radionuclides being investigated, which are multiplied by the activity concentrations and then added to fit the measured spectrum. Accurate concentrations are then extracted using a chi-squared (χ2) minimization procedure. Eight samples were measured using the NaI detector and analyzed using the FSA method. The samples were measured for about 24 hours for good statistics. The 238U activity concentration values varied from 10 ± 2 Bq/kg (iThemba soil, HS6) to 256 ± 10 Bq/kg (Kloof sample). The 232Th activity concentration values varied from 7 ± 1 Bq/kg (Anstip beach sand) to 45 ± 5 Bq/kg (Rawsonille soil #B31). The 40K activity concentration values varied from 45 ± 27 Bq/kg (iThemba soil, HS6) to 120 ± 9 Bq/kg (Rawsonille soil, #B28). The χ2 values also varied from sample to sample with the lowest being 0.13 (Anstip beach sand) and the highest being 6820 (iThemba soil, HS1). A high χ2 value usually represents incomplete gain drift corrections, improper set of fitting functions, proper inclusion of coincidence summing or the presence of anthropogenic radionuclei.

Poster1 / 407

Deposition,Optical and Electrical Characterization of Silicon Carbide Thin Films for Solar Cell Applications

Author: Mr. MKHWANAZI, Sihle [1]

Co-Authors: Dr. HALINDINTWALI, Sylvain [1]; Dr. NAZEEM, J [1]; Prof. NEMROAUI, O [2]; Dr. MULLER, T [1]

[1] *University of the Western Cape*

[2] *University of the Zululand*

Corresponding Author: 3011982@uwc.ac.za

Silicon carbide (SiC) materials have attracted a lot of attention because of their good optical and electrical properties. In recent years there has been an intense focus in research on controlling the optical and electrical properties of amorphous SiC thin films deposited at low temperature of the substrate. SiC has a wide bandgap which can be tuned by varying the carbon content in the thin film. The SiC thin films also have a high electron mobility, high electron saturation velocity, optical transparency which make them candidates for use as window layer in solar cells. The low deposition rate issue in SiC thin films processing has not yet been resolved. This contribution will focus on optimizing the deposition rate by studying the influence of the deposition parameters on the deposition rate. The thin films ranging from amorphous to microcrystalline SiC has been deposited by magnetron sputtering and hot wire chemical vapour deposition at low substrate temperature of the substrate below 300 oC. The optical properties of the films have been investigated transmission/reflectance spectrum using the OJL model in SCOUT and by computation using the iterative method of Swanepoel. The electrical properties such as conductivity, bulk concentration and mobility will be investigated by Hall Effect measurements.

NPRP / 408

Coulomb excitation of light nuclei.

Dr. ORCE, Nico [1]

[1] *University of the Western Cape*

Corresponding Author: rlindsay@uwc.ac.za

The Coulomb excitation of light nuclei can provide unique information on the matrix elements for excited states. This contribution will discuss experiments to measure such excitation as well as ab initio large shell model calculations calculations that can be tested by these measurements.

Poster1 / 409

Electrical characterization of irradiated n-GaN

Author: Mr. MORONGWA, Maisela [1]

Co-Author: Dr. MMANTSAE, Diale [1]

[1] *University of Pretoria*

Corresponding Author: maiselamm@yahoo.com

We investigate the electrical parameters of n- GaN irradiated at room temperature with 5.4 MeV alpha-particles from an americium-241 (Am-241) radio-nuclide source under dark conditions. The radiation damage was studied using current–voltage (I–V) and capacitance –voltage (C–V) characteristics for a total irradiation time of 14 hours at a dose rate of and the corresponding dose range of . Diode parameters such as the Schottky barrier height, ideality factor, saturation current, free carrier concentration and reverse leakage current were monitored from the I–V and C–V measurements that were recorded by a computer programme developed using National Instrument's LabView software. The irradiation results reveal an increase in the ideality factor, series resistance, saturation current and reverse leakage current over the dose range investigated. The free carrier density and the Schottky barrier height were found to decrease with increasing dose. Our results suggest that the observed effects are as a result of the radiation damage to our sample.

Poster2 / 410

Direct water cooling effect on a photovoltaic module

Author: Mr. MTUNZI, Busiso [1]

Co-Author: Prof. MEYER, Edson [2]

[1] *Fort Hare Institute of Technology, University of Fort Hare, Physics Department*

[2] *Fort Hare Institute of Technology,Physics Department,University of Fort Hare*

Corresponding Author: bmtunzi@ufh.ac.za

This paper gives the details of a photovoltaic water heating system and the effects of direct water cooling on the performance of a photovoltaic module. The SW 80 polcrystalline modules were used in the investigation. They wehre both fixed next toe ach other on a north facing rack located on roof top. One of the modules had a batch water cooling container and the other module had no cooling system attached to it. The water cooled module wer noted to operate at an average temperature of 43°C on a sunny cloudless day, while the uncooled module's temperature rose to about 70°C impacting negatively on electricity production.Photovoltaic water heating system may improve life span of the module and at the same time alleviate the burden of conventional energy consumption in South Africa for heating and lighting purposes.

NPRP / 411

Synthesis and Labelling of DISIDA (N-2,6-diisopropyl-phenylcarbamoylmethyliminodicetic) acid

Author: Mr. MUSA LONWABO, KWETANA [1]

Co-Author: Dr. OTTO, Knoesen [2]

[1] *UNIVERSITY OF PRETORIA*

[2] *NECSA(NTP)*

Corresponding Author: musakwetana@yahoo.com

Radiopharmaceuticals is compounds labelled with a radioactive isotope that are used for studying different organs in the human body. Technetium-99m (99mTc) labelled iminodiacetic acid (IDA) derivatives are commonly used as hepatobiliary imaging agents. Radiopharmaceuticals used for hepatobiliary imaging are divided into two groups based on the physiologic function of the liver they are designed to evaluate.The IDA agent of choice for NTP is DISIDA (N-2,6-diisopropyl-phenylcarbamoylmethyliminodicetic acid).A cold kit is a pre prepared vial consisting of the compound to be labelled with the radioactive isotope and a suitable reducing agent. The radioactive isotope of choice for IDA labelling is 99mTc. Kits for DISIDA is commercially available and usually contain the IDA derivative and stannous chloride dihydrate as the reducing agent. Twenty gram DISIDA is needed for each production batch of DISIDA kits Labelling is accomplished by adding 99mTcO4- to the kit and mixing well. Approximately 3 to 5 mCi (111-185 MBq) 99mTc-IDA derivative is injected intravenously into patients who have fasted for 4 to 6 hours prior to administration. The biodistribution DISIDA was confirmed by performing a biodistribution study on a Chacma baboon.The yield of the DISIDA synthesis was improved from 26 - 34 g to 76 g (53%).The labelling with technetium give > 95% radiochemical purity.The improved synthesis resulted in increased cost effectiveness of the commercial DISIDA kits.

Poster2 / 412

Variability of methanol maser in the massive star formation regions

Mr. MASWANGANYE, jabulani Paul [1]

[1] *Wits University/HartRAO*

Corresponding Author: pop7paul@gmail.com

Star formation constitutes one of the basic problems of astrophysics due to the fact that stars are fundamental objects of astronomy. Shu et al. (1987) reviews the theory of low mass star formation from the molecular cloud via accretion disk-outflow. The formation of high mass stars is still not well understood. They may also be formed through accretion disk plus outflow (Shu et al. 1987) or by collision-coalescence which was proposed by Wolfire \& Cassinelli (1987) and Bonnell et al. (1998), but most observations support the accretion disk-outflow model. The brightest methanol masers occur at 6668 MHz and 12178 MHz and are found in the star forming regions containing very young massive protostars even before the formation of an ultracompact HII region (Longmore et al. 2007). These masers serve as useful tools to study these regions. The poster will be on the analysis of the time series of 6668 MHz and 12178 MHz methanol maser emission lines in some of the sources which were showing periodic variations in monitoring before the 26 meter Hartebeesthoek Radio Astronomy Observatory (HartRAO) Telescope bearing failure in 2008. After the telescope was repaired in 2010, the programme to monitor these sources was restarted. These two methanol emission lines are radiatively pumped which implies that their variability could be due to the decrease or increase in the seed photons at the radio frequency, or the infrared radiation field that pumps the masers. Since there has been a two year gap in the monitoring program of these sources, we want to establish whether the periodic variations continue. Such periodic behaviour has not been seen in other maser species in star forming regions, so it can provide new insights into what is happening in these regions.

Poster2 / 413

Observations of the 22GHz Water maser in the source Orion KL

Ms. OTTO, Sunelle [1]

[1] *HartRAO*

Corresponding Author: sunelle@hartrao.ac.za

Stars are believed to be formed from massive stable gas clouds, which under enough perturbation will collapse to form a protostar. The protostar evolves to form a star by accreting matter until the fusion is initiated in the dense core. Surrounding these protostars are ionized hydrogen (HII) regions and molecule species where masing occurs. MASER is an acronym for Microwave Amplification by Stimulated Emission of Radiation. It is here that Water masers are also found. Amongst the sources of water masers, is the Orion KL source region. Flares in this region from the 1.35cm water maser emission line occurred in 1984, with the second flare in 1998 and again this year (2011) there have been reports of the flare. The flare is very intense, increasing its flux density from around hundreds to millions of janskies. This poster will show the summary of observations made by the Hartebeesthoek Radio Astronomy Observatory (HartRAO) telescope for the water maser in the Orion KL source region as well as the calibration method. Jupiter is used as the calibrator source, while the absorption by atmospheric water vapour must also be allowed for. This uses estimates based on atmospheric temperature and humdity or can also be based on the time delay of GPS signals, corrected for barometric pressure.

CMPMS2 / 415

Parametric Resonance Features in the Coupled Josephson Junctions

Dr. SHUKRINOV, Yury [1]

[1] *BLTP, JINR, Dubna*

Corresponding Author: shukrinv@theor.jinr.ru

A review of our last results on the phase dynamics of a stack of coupled Josephson junctions in layered superconductors is presented. The current voltage characteristics (CVC) of intrinsic Josephson junctions (IJJ) are numerically calculated in capacitively coupled Josephson junction model (CCJJ model) and CCJJ model with diffusion current (CCJJ+DC model). We discuss the features of the parametric resonance and its manifestation in the breakpoint region of CVC. We demonstrate the fine structure in CVC and investigate it by charge-charge and current-current correlation functions. The ideas concerning the experimental observation of the breakpoint features are considered. Charge creation in superconducting layers and nucleation of longitudinal plasma wave (LPW) for stacks with different number of junctions are predicted. Time dependence of the charge oscillations in the superconducting layers is analyzed at different values of bias current. We demonstrate the different time stages in the development of the LPW and present the results of FFT analysis at different values of bias current. The effects of noise in the bias current and the external microwave radiation on the charge dynamics of the coupled Josephson junctions are found. These effects introduce a way to regulate the process of LPW nucleation in the stack of IJJ. A role of diffusion current in the hysteretic behavior of coupled Josephson junctions is discussed. The superconducting, quasiparticle, diffusion, and displacement currents have been calculated as functions of the total current through the system. The role of the diffusion current in the formation of the CVC curves has been studied and its influence on the CVC curve branching and the magnitude of the return current has been revealed. The calculation results agree qualitatively with the experimental data.

Education / 416

International Astronomical Union Global Office of Astronomy for Development

Mr. GOVENDER, Kevindran [1]

[1] *IAU Office of Astronomy for Development*

Corresponding Author: kg@saao.ac.za

The International Astronomical Union (IAU), in recognition of the immense use of astronomy to stimulate development, has developed a decadal strategic plan entitled "Astronomy for the Developing World". At the heart of the implementation of this plan is the Global Office of Astronomy for Development. South Africa bid in 2010 to host this office and was selected as the host country, with the South African Astronomical Observatory, a facility of the National Research Foundation, being selected as the host organisation. With stong support from the Department of Science and Technology and the IAU, the Office began its work on 1st March 2011. The history and implications of this Office will be discussed, as well as its implementation plan moving into the future.

LOS / 417

Structured Light

Prof. FORBES, Andrew [1]

[1] *CSIR*

Corresponding Author: aforbes1@csir.co.za

With modern liquid crystal devices it is possible to implement digital holograms for the modulation in amplitude and phase of light: so called 'structured light'. In this non-specialist talk, we will introduce the concept of complex amplitude modulation, and show how light can be tailored to have interesting properties: defying diffraction, twisted like a spring in intensity and phase, and made to bend around corners! The ability to create arbitrarily complex fields opens up a plethora of applications, from controlling the micro-world through optical traps, to probing the quantum world with twisted light.

Applied / 418

X-ray crystallographic studies and quantum mechanical modeling of the amidase reaction mechanism

Author: Prof. SEWELL, Bryan Trevor [1]

Co-Author: Ms. KIMANI, Serah [1]

[1] *University of Cape Town*

Corresponding Author: trevor.sewell@uct.ac.za

The amidases catalyse the conversion of amides to the corresponding carboxylic acid and ammonia. We have visualized the structure of the amidase (MW= 30 kDa) from a bacterium, Nesterenkonia sp. at atomic resolution by X-ray crystallography. The primary components of the active site are two negatively charged carboxylates (E1 and E2) arising from two conserved glutamate side chains, a positively charged amino group (K) arising from a conserved lysine, a sulphydryl arising from a conserved cysteine and a water molecule. Mutation of the active site residues has enabled us to visualize the unreacted substrate and a number of artificial intermediate states which have led to our insights. We propose a reaction mechanism which passes through a thioester adduct to the cysteine. Although this in itself is not controversial, our studies demonstrate for the first time how exquisitely accurate geometrical placement of the various groups leads to accurate stereoelectronic alignment which allows the transition states to form. The configuration of E1, E2 and K ensures that K remains positively charged throughout the reaction thus enabling it to act as an acid catalyst and provide an oxyanion hole to stabilize the tetrahedral transition states. The configuration also accurately positions the substrate for nucleophilic attack by the sulphydryl by hydrogen bonding to the amide, positions E1 as a base catalyst and positions the water with the correct stereoelectronic alignment for a nucleophilic attack on the thioester. The transition state energies, electron densities and hydrogen placements calculated using Gaussian09 demonstrate the plausibility of our proposal.

Applied / 419

Three-dimensional electron microscopy and molecular modelling studies of a spiral-forming biocatalyst

Author: Dr. WATERMEYER, Jean [1]

Co-Authors: Dr. GUMBART, JC [2]; Mr. CHAIN, Kwok-Yan [2]; Prof. SCHULTEN, Klaus [2]; Prof. SEWELL, Trevor [1]

[1] *University of Cape Town*

[2] *University of Illinois at Urbana-Champaign*

Corresponding Author: jeanwatermeyer@gmail.com

Nitrilase and amidase enzymes catalyse the conversion of nitriles and amides to their corresponding acid and ammonia - chemistry which is useful in synthesis of drug compounds and fine chemicals. The conversion of cyanide, a nitrile, to ammonia and formic acid is useful in detoxification of contaminated wastewater. The cyanide dihydratase from Bacillus pumilus (CynDpum) catalyses this reaction and is thus a potentially useful biocatalyst. CynDpum and related nitrilase enzymes become activated by formation of spiral-shaped multimers. Evidence suggests that multimer formation regulates activity, by mechanisms which are still not clear. We have used a combination of transmission electron microscopy (EM) with 3-D image reconstruction, molecular modelling, and mutagenesis to investigate the mechanism of helix formation in CynDpum. We have implemented a new routine in the molecular dynamics package, NAMD, that allows helical symmetry to be used as a constraint, together with the EM volume. This method improves on asymmetrical modelling procedures and has aided in our atomic-level interpretation of low-resolution 3-D maps from negative-stain EM. This in turn has allowed us to make testable predictions about the importance of specific amino acids for the mechanical stability of the spirals. We show that salt bridges in one interface are not required for complex formation, but that mutations in this area can enhance the mechanical stability of the enzyme.

Theoretical / 420

Einstein - Eddington generalized gravity

Author: Dr. DAVYDOV, Evgeny [1]

Co-Author: Prof. FILIPPOV, Alexander [1]

[1] *Joint Insitute for Nuclear Research*

Corresponding Author: davydov@theor.jinr.ru

The present observational data strongly suggest that Einstein's gravity must be modified, one of the popular modifications being provided by superstring ideas. In view of the mathematical problems of the string theory, other, much simpler, modifications of gravity that affect only the gravitational sector (not touching other interactions) are also popular. One of them is based on Einstein's idea to formulate the gravity theory in a non-Riemannian space with a symmetric connection by use of a special variational principle that allows one to determine the connection from a "geometric" Lagrangian. This Lagrangian is assumed to depend on the generalized Ricci curvature tensor and on other fundamental tensors and is varied in the connection coefficients. We discuss new models of this "affine" theory of gravity in multidimensional space-times with symmetric connections. We use and generalize Einstein's proposal to specify the space-time geometry by use of the Hamilton principle to determine the connection coefficients from a geometric Lagrangian that is an arbitrary function of the generalized Ricci curvature tensor and of other fundamental tensors. Such a theory supplements the standard Einstein gravity with dark energy (the cosmological constant, in the first approximation), a neutral massive (or tachyonic) vector field (vecton), and massive (or tachyonic) scalar fields. These fields couple only to gravity and can generate dark matter and/or inflation. The concrete choice of the geometric Lagrangian determines further details of the theory. The most natural geometric models look similar to recently proposed brane models of cosmology usually derived from string theory.

Poster1 / 421

Electrical characterisation of the interface in a Au \ Ni \ n -Al0.18Ga0.82N Scottky contact system

Author: Mr. LEGODI, Matshisa [1]

Co-Authors: Dr. MEYER, W. E. [1]; Prof. AURET, F. D. [1]

[1] *University of Pretoria*

Corresponding Author: matshisa.legodi@up.ac.za

The AlxGa1-xN materials system is important for realising tuneable LED and laser sources and short wavelength photodetectors. While AlxGa1-xN (x = 0) is fairly known, there is interest in studying the effects of an increasing Al fraction on properties of devices. In particular, on the properties of a bi-metal Ni\ Au Schottky contact. We utilise Current-Voltage (I-V) and the forward Capacitance-Voltage (C-V) characteristics; and, Admittance (Capacitance-Frequency (C-f) and Conductance-Frequency (G-f) techniques to study the Ni\ Au Schottky barrier contact by monitoring the diode ideality (n), the Schottky barrier height and the density of interface states (Dit). The as deposited Ni\ Au Schottky contact is non- ideal with an ideality factor, n = 1.6 eV. We also observe for low forward voltages, a Recombination-Generation (R-G) component to current conduction. The forward C-V measurements reveal an anomalous peak at 0.45 V confirming the observed non-ideality. The as deposited Dit increases exponentially to about 4.5 x 1011 eV-1 cm-2 towards the mid band gap. G-f measurements reveal a broad peak around 300 kHz at room temperature, which below 240 K evolves into two peaks centred around 40 kHz and 1 MHz. Preliminary isochronal annealing in Oxygen between room temperature and 623 K indicate that the I-V characteristics improve with idealities around 1 eV and the Dit is reduced from 4.5 x 1011 eV-1 cm-2 to about 3.5 x 1010 eV-1 cm-2 in the annealed samples. Our results are consistent with a metal-oxide-semiconductor model for the annealed Ni\ Au Scottky contact.

Poster2 / 422

Intra-cavity beam control: a comparison of spatial light modulators and adaptive mirrors

Author: Mrs. BURGER, Liesl [1]

Co-Authors: Dr. LITVIN, Igor [2]; Prof. FORBES, Andrew [2]

[1] *National Laser Centre*

[2] *CSIR National Laser Centre*

Corresponding Author: lburger1@csir.co.za

It is well understood that the fundamental mode of a cavity may be selected by suitable choice of intra-cavity amplitude or phase elements. If one wishes to dynamically control the mode, for example, to manage thermal aberrations, then intra-cavity elements that are controllable are required. Two such elements are adaptive mirrors and spatial light modulators (SLMs). In this poster we present early results on the intra-cavity use of SLMs, and highlight some expected and unexpected problems. We then compare our results to our first attempts at the use of an intra-cavity adaptive mirror.

APSS / 432

Astrophysics Poster Blitz

APSS / 433

Space Physics Poster Blitz

Plenary / 435

Soft Matter Properties: What can we learn from computer simulations?

Dr. MUKHERJI, Debashish [1]

[1] *Max-Planck Institute for Polymer Research*

Corresponding Author: mukherji@mpip-mainz.mpg.de

I will present three unrelated examples in which efficient computer simulations have been employed to address soft matter properties. The first example will deal with the dynamics of polymers near surfaces. Despite the significant progress within the last decade, in particular on the structure and thermodynamic properties in confinement, their dynamics remained an active field of research. Unlike some of the prior studies, we introduced atomic scale roughness of the confining surface(s) while abstaining from introducing any artificially-imposed divergent obstacles. Because of this type of modeling, we could reproduce the scaling of the single polymer dynamics near attractive surface and relate the dynamics of adsorbed polymer films with the degree with which they interlock with the surface. The second example will explore the mechanical behavior of highly cross-linked polymer (HCP) glasses; such as epoxy and vinyl-ester thermosets, which are used as both high-strength adhesives and as composite matrices. One particular property of HCPs which limits their usefulness is their lack of toughness. Fully cured epoxies, for example, can have about 2 GPa of tensile strength but are brittle, failing at about 1% strain. Using computer simulations, we were able to devise ways of toughening the HCP networks by introducing engineered micro-voids. We have also performed experiments on amine cured epoxy networks by introducing voids using reactive encapsulation of nonreactive solvent tetrahydrofuran. The experiments were consistent with our prediction. Lastly, as the third example, I will briefly mention our recent work on the solvation properties of liquid mixtures using an Adaptive Resolution Molecular Dynamics Scheme in which particles can change their resolution (atomic or coarse-grained) on the fly.

LOS / 436

NON-SPECIALIST: Spectroscopy in Chemistry

Dr. LITWINSKI, Christian [1]

[1] *Rhodes University*

Corresponding Author: c.litwinski@ru.ac.za

Since the 1960's, in many fields of Chemistry, spectroscopy is an important diagnostic tool. The key to the widespread use of spectroscopy in chemistry is that it permits one to probe the microscopic structure of molecules; the ultimate building blocks of the chemical sciences. Spectroscopy is used for a wide variety of procedures in chemistry.
This talk will present an overview of the spectroscopic methods used in the Chemistry Department and the DST/Mintek Nanotechnology Innovation Centre (NIC) at Rhodes University. Examples of simple steady state absorption measurements to check the purity of synthesized phthalocyanine molecules over time resolved fluorescence spectroscopy to investigate energy transfer between phthalocyanines and nanoparticles to surface analysis with x-ray photoelectron spectroscopy will be presented. The applications of phthalocyanines range from sensors for pesticides to drugs for photodynamic therapy of cancer.

LOS / 437

Quantum Physics with Trapped Ions

Dr. UYS, Hermann [1]

[1] *National Laser Centre, CSIR*

Corresponding Author: huys@csir.co.za

In this non-specialist lecture I will provide an overview of the field of ion trapping. Ion traps are used world wide to push the limits of quantum technologies. They are a lead contender for building quantum computers, they are capable of measuring tiny forces at the level of yocto (10^{-24}) Newton and to date they hold the record for the most accurate atomic clock (that clock would neither gain nor lose a second in about 4 billion years!). Moreover, the technological capability of trapping single ions make these traps ideal for studying quantum optical phenomena.

Plenary / 438

A Century of Nuclear Theory: a greatly condensed treatment

Prof. AMOS, Ken [1]

[1] *School of Physics, University of Melbourne*

Corresponding Author: amos@unimelb.edu.au

Over centuries, defining the underlying structure of matter has been a holy grail for scientists and the public alike. The discovery of the 'ultimate' nature of matter has often been seen as offering the ability to explain almost everything else in the universe, from life to the cosmos. During the twentieth century, nuclear physics became a science which promised to reveal many of these secrets. Through theory and experiment, nuclear scientists charted the underlying structure of matter and gave new insights into the
fundamental nature of things. Over the last century, progress in nuclear physics has relied on a symbiotic relationship between theory and experiment. I will begin this talk with some (highly condensed) history of the first half century of developments in nuclear theory. I will then discuss the original shell model and the three stage view which Weisskopf proposed for nuclear reactions, as both are watersheds of the 50's. The period between the 1950's and 1990's was one of incredible developments in nuclear physics. There were many practitioners, the computer revolution made possible more and more complex evaluations, the numbers of models for structure and reactions became legion. Thus I will give only abridged catalogues of structure models and reaction types before a specific note on Butler's identification of direct reaction theory of deuteron stripping; a major process in defining spin-parities of nuclear states. Next, as it is one of the central aspects of scattering theories, I consider the optical model for nucleons, just what it should be, and its use in direct reaction theory of inelastic scattering. I restrict consideration to just two methods, the MCAS and the g-folding methods, with which I am most familiar. They were used to obtain results involving the scattering radio-active ions, that appear subsequently. Finally I look at the nuclear landscape as it is today, with the exotic nuclear systems, some of which are termed Borromean. I show how some are needed in the CNO stellar burning cycle and then give examples of spectra evaluation and scattering analyses made using the specific two methods considered.

Plenary / 439

Mass Distribution in Galaxies using Multi-Wavelength 3D Spectroscopy

Spiral and dwarf galaxies are known to present an important mass discrepancy between their dynamical and visible masses. The commonly accepted hypothesis is to assume a more or less spherical halo of unseen matter in addition to the stars and gas. To study properly this mass discrepancy, different observational techniques at different wavelengths need to be combined in order to probe as best as possible the gravitational potential at all radii and different theoretical tools are necessary to sort out which distribution law represents best the dark matter component.
This Multi-wavelength approach will be illustrated by discussing the radio HI aperture synthesis observations of our Local Group neighbours, M31 (Andromeda) and M33 and the optical Ha Fabry-Perot interferometric observations of the SINGS sample of galaxies. As an example, it will be showed how important it is to model properly velocity perturbations, such as those produced by bars, before using the kinematics to derive the gravitational potential as a tracer of both the luminous and the dark matter components.

Plenary / 440

The Photochemistry and Photophysics of DNA

Prof. PARKER, Anthony [1]

[1] *Central Laser Facility,*

Corresponding Author: a.w.parker@stfc.ac.uk

Our DNA is constantly being subjected to chemical and physical changes. Understanding the molecular dynamics of this biological stress and how it leads to mutation and the onset of cancer represents a key scientific challenge. During evolution cells have evolved an enormous array of weaponry to minimise the risks of mutation, however, under certain conditions things can go badly wrong. A primary example is the over exposure of sunlight to skin. The initial photophysical processes that take place following from the initial absorption of a photon to chemical reaction occur in the ultrafast (femtoseconds to picoseconds) time domain. As such studying these reactions falls into the world of ultrafast laser spectroscopy and both linear (pump and probe) and non-linear (2D-IR, stimulated fluorescence) methods are utilised. The major factor of the components that make up DNA, the four nucleic acid bases, that gives them exceptional photo-stability is the fact that they posses exceptional short lifetimes (ps). The presentation will introduce DNA photochemistry and photophysics, the technology used to investigate them and emphasise how time-resolved infrared spectroscopy can be applied to gain insights into structural changes occurring in the ultrafast molecular time frame.

Plenary / 441

Building a National Digital Library for Computational Physics Education at All Levels

Dr. CHRISTIAN, Wolfgang [1]

[1] *Davidson College*

Corresponding Author: wochristian@davidson.edu

Over the past dozen years we have produced some of the most widely used interactive computer-based curricular materials for the teaching of introductory and advanced physics courses. These materials are now hosted on and distributed from the Open Source Physics (OSP) Collection of the ComPADRE National Science Digital Library. This talk outlines the tripartite integration of ComPADRE with the Easy Java Simulations modeling and authoring tool and the OSP code library. The pedagogical and technical features of this learning platform and our current efforts to align this material with United States national and state standards for science teaching are described. The Open Source Physics Collection is available on the: http://www.compadre.org/osp/ Partial funding for this work was obtained through NSF grants DUE-0442581 and DUE-0937731.

Plenary / 442

Top Down Causation and the Emergence of Complexity

Prof. ELLIS, George [1]

[1] *UCT*

Corresponding Author: george.ellis@uct.ac.za

The emergence of true complexity (such as life and the human brain) on the basis of the underlying physics is enabled by top-down processes in the hierarchy of complexity. This talk will propose that there are five different types of top down causation that can all be shown by many examples to exist and be causally effective in the real world. There is room for them at the bottom both because of statistical and quantum randomness at lower levels, and because the nature of lower level elements is altered by top down effects. While the evidence for top-down effects is very strong in the life sciences, computers, and engineering systems, there may also be cases in physics where their influence is significant; examples are the arrow of time, the origin of inertia, and both state preparation and decoherence in quantum theory.

Applied / 443

The structure and flexibility of the photosynthetic machinery in plants and algal cells

Prof. GARAB, Gyözö [1]

[1] *Biological Research Center, Hung. Acad. Sci.*

Corresponding Author: gyozo@brc.hu

In order to increase the efficiency of light capturing, all photosynthetic organisms capable of oxygen evolution have evolved multilamellar membrane systems of the thylakoid membranes, flat closed bilayer lipid vesicles, which accommodate the densely packed protein complexes in ordered, often semi-crystalline arrays. This highly organized system with substantial stability exhibit remarkable structural and functional flexibility at different levels of complexity, which enables these organisms to carry out rapid adaptations in response to changes in the environmental conditions. In this talk, my attention will be focused on the macro-organization of the protein complexes - and their role in determining the multilamellar membrane ultrastructure, and will show mechanisms that allow well identifiable reversible reorganizations in the internal order of the complexes and in the membrane system.
We have shown that the main chlorophyll a/b light harvesting complexes of photosystem II (LHCII) form chirally organized macrodomains both in vivo and in vitro. These macrodomains, together with stacking, play important roles in the lateral segregation (sorting) of the two photosystems between the granum and stroma membranes, and thus in the assembly and stabilization of the membrane ultrastructure [Mustárdy and Garab, 2003, TIPS 8: 117], which has been determined by electron tomography [Mustárdy et al., 2008, Plant Cell 20: 2552]. The macrodomains also possess a remarkable structural flexibility, being capable of undergoing light-induced reversible reorganizations, that are largely independent of the photochemical activity of thylakoids, and are approximately linearly proportional to the light intensity above the saturation of photosynthesis – an important, unique feature with respect to protection of plants against excess excitation [Barzda et al., 1996, Biochemistry 35: 8981]. This type of reorganizations include (i) unstacking of membranes, (ii) a lateral desorganization of the macrodomains, and (iii) monomerization of the LHCII trimers [Dobrikova et al., 2003, Biochemistry 42: 112726]. Isolated, lipid-enriched, loosely stacked lamellar aggregates of LHCII also possess the ability to undergo similar reorganizations, accompanied by fluorescence quenching transients. These structural transitions are accounted for by a biological thermo-optic mechanism: fast thermal transients, arising from dissipated excitation energy, which can lead to elementary structural transitions in the close vicinity of the site of dissipation due to the presence of 'built-in' thermal structure-instabilities [Cseh et al., 2005, Photosynth Res 86: 263]. They lend local structural flexibility to molecular (macro)assemblies of high stability, and appear to be involved in important enzymatic reactions, as revealed in other laboratories [Zer et al., 1999, PNAS 96: 8277, Yang et al., 2000, FEBS Lett 466: 385]. The lipid content of the membranes is self regulated by non-bilayer lipids, via their segregation capability. By this means they safe-guard the high protein content of the thylakoid membranes and, at the same time, they contribute to the structural flexibility of the membrane system [Garab et al., 2000 Trends Plant Sci. 5:489; Krumova et al., 2008, Biochim. Biophys. Acta, Biomembranes 1778: 997].
In order to characterize the multilamellar membrane system, we determined characteristic repeat distances of the photosynthetic membranes in living cyanobacterial and eukaryotic algal cells and in intact thylakoid membranes isolated from higher plants with time-resolved small-angle neutron scattering (SANS). It has been shown how the different organization of multilamellar membrane system can be correlated with different compositions and protein macro-organizations in different organisms. SANS also revealed small (~10 Å) but well identifiable light-induced reversible changes in these organisms, observed for the first time in living cyanobacteria and diatom cells. These reorganizations, which could be recorded with time resolutions of several seconds and minutes, appear to be associated with functional changes in vivo [Nagy et al., 2011, Biochem J. 436: 225].

Poster2 / 444

Ion irradiation effects on the formation of metal nanoparticles in crystals

Author: KOZAKIEWICZ, Anna [1]

Co-Authors: Prof. DERRY, Trevor [2]; Dr. NAIDOO, S.R. [2]; Prof. THERON, Chris [3]; Mr. FRANKLYN, Paul [2]

[1] *Wits*

[2] *University of the Witwatersrand*

[3] *University of Pretoria*

Corresponding Author: anna.kozakiewicz.9@gmail.com

Metal nanoparticles (MNP) were synthesized by room temperature ion implantation of high fluences (from $6x10^{16}$ to $5x10^{17}$ cm^{-2}) of 150 keV Ag and 15 -22 MeV Au ions into Al_2O_3 and MgO single crystals. Optical absorption (OA) spectra show surface plasmon resonance (SPR) bands characteristic of the implanted metal ions. Upon annealing (300°-1200°C) the optical response of the metal nanostructures changes, related directly to their morphology, shape and size. High resolution transmission electron micrographs indicate that the particles are often crystalline. The implanted ions profiles were obtained from 1.6 MeV He^+ Rutherford Backscattering (RBS) for the silver implanted substrates and High Resolution Transmission Electron Microscopy (HRTEM), revealed buried layers of implanted ions.

Winter School / 445

Computational Physics And The Physics Curriculum

Dr. CHRISTIAN, Wolfgang [1]

[1] *Davidson College*

Corresponding Author: wochristian@davidson.edu

Winter School / 446

Easy Java Simulations: A Computational Tool For Science Education and Research

Prof. ESQUEMBRE, FRANCISCO [1]

[1] *Universidad de Murcia*

Corresponding Author: fem@um.es

Winter School / 447

Molecular Dynamics Simulations : An experimental laboratory for a computational physicist.

Dr. MUKHERJI, Debashish [1]

[1] *Max-Planck Institute for Polymer Research*

Corresponding Author: mukherji@mpip-mainz.mpg.de

Winter School / 448

Using Python in Computational Physics

Prof. BRAUN, Moritz [1]

[1] *University of South Africa*

Corresponding Author: moritz.braun@gmail.com

Winter School / 449

High Performance Computing in Solid State Physics

Prof. LOMBARDI, Enrico [1]

[1] *UNISA*

Corresponding Author: lombaeb@unisa.ac.za

Winter School / 450

Overview of the Center for High Performance Computing

Dr. MOEKETSI, Daniel Mojalefa [1]

[1] *CSIR Meraka Institute (CHPC)*

Corresponding Author: dmoeketsi@csir.co.za

Winter School / 451

Practical demonstrations on the use of the CHPC Cluster.

Dr. MOEKETSI, Daniel Mojalefa [1]

[1] *CSIR Meraka Institute (CHPC)*

Corresponding Author: dmoeketsi@csir.co.za