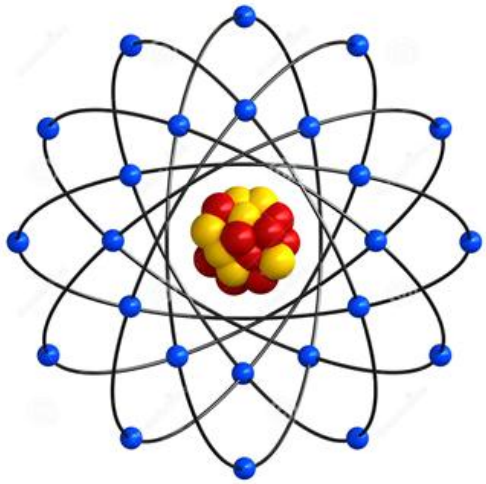
POSTGRADUATE IN PHYSICS AT PIETERMARITZBURG



2016

PHYSICS HONOURS PROGRAM

The Physics Honours program is a one year long training which culminates with degree of Honours in Physics after successful completion of the course works and honours project thesis. The project thesis starts at the beginning of the year and conducted in consultation with project supervisor until the conclusion of the thesis. In this program, you will be able learn advanced physics concepts through well-organized modules accompanied by tutorials and assignments. The current courses for the program are given in the following table.

Course code	**Course Name**	**Credit Hours**
PHYS721	Special Topic in Physics I	16
PHYS735	Physics Project	32
PHYS741	Statistical Physics	16
PHYS752	Special Topic in Physics II	32
PHYS791	Quantum Mechanics	16
PHYS792	Electrodynamics	16
		Total 128

Honours Project: Students are expected to choose a project title from the available research fields in the department. Then, the candidate discusses the project title with his/her potential supervisor for the details of the research topic. Once the project title and a possible supervisor are determined, student are expected to start working on the project from the first day of the program. Before the completion of the project work, students are expected to make at least two presentations.

First Presentation: Progress about the project work. Date : 05 August 2016
Second Presentation: Completed project work. Date : 21 October 2016

Please note that student cannot graduate without a successful completion of the honours project. The passing mark for honours courses is 50%. By the end of a semester if a student scores above 40% of the total then he/she will be allowed to seat for supplementary examination.

Current course contents:

PHYS721 : Special Topic in Physics I
Special Relativity and Electromagnetism (Relativity principle, invariant intervals, Lorentz transformation of kinematic and dynamic quantities, relativistic Doppler effect, 4-vectors, covariance of Maxwell’s equations). **Biomedical Optics** (light-matter interactions, light-tissue interactions, biophysical optical treatment).

PHYS735: Physics Project
Specialized area of physics which students are interested to pursue research and postgraduate study. There are wide range of areas in the physics program which students can choose from in the field of experimental, theoretical, Computational or Educational physics.

PHYS741: Statistical Physics
Microcanonical, canonical, and grand canonical ensembles. Thermodynamic fluctuations and the thermodynamic limit. Quantum statistics. The ideal fermion and boson gases. The photon gas.

PHYS752: Special Topic in Physics I
Semiconductors and device Physics, Advanced Mathematical Methods, Theoretical Mechanics

PHYS791: Quantum Mechanics
Abstract vectors, Quantum operators, position and momentum operators, coordinate representation, time evolution, Hellman-Feynman, Varial and hypervirial theorems, Shift operators, Quantum Oscillators, Angular momentum, Hydrogen atom, degeneracy of states, time-dependent perturbation theory.

PHYS792 Electrodynamics
Electrostatics & magnetostatics, Maxwell’s equations, Electromagnetic potentials & gauge, Waves in: vacuum, lih media, plasmas, waveguides, Electromagnetic radiation, Electrodynamics and the Lorentz transformation

Available Research Topics in Physics

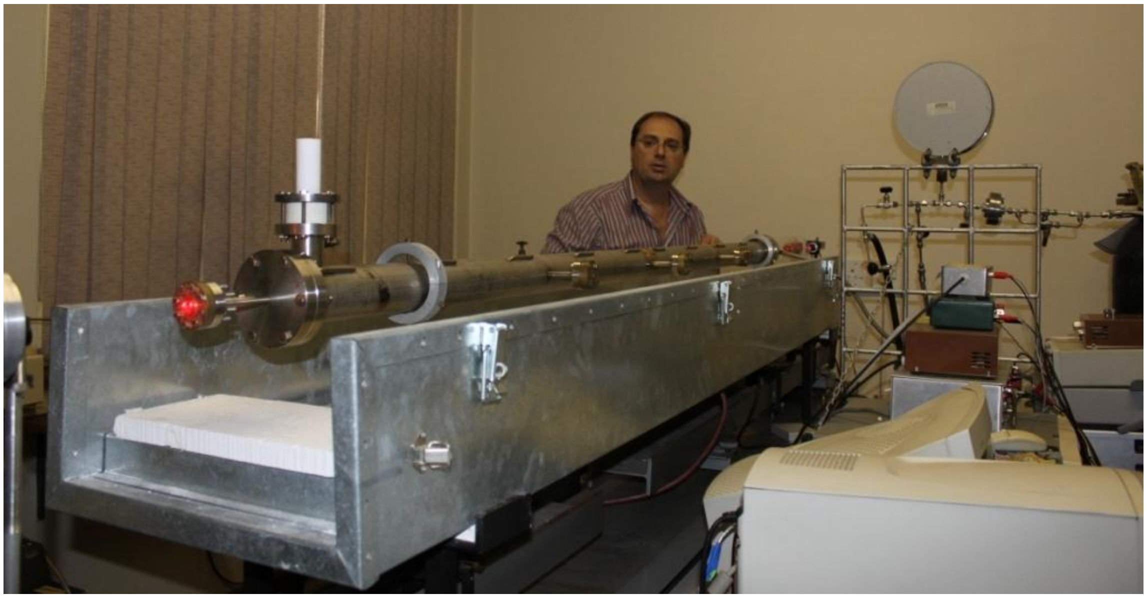
Measurement of Optical, Electric and Magnetic Properties of Molecules

Group Leader: Dr Vincent Couling
(couling@ukzn.ac.za; tel 033 260 5237)

Our research group is concerned with the precise and accurate experimental measurement of the fundamental optical, electric and magnetic properties of molecules.

Experimental work being undertaken on electro- and magneto-optical phenomena include the measurement of depolarized Rayleigh light-scattering, and the Kerr, Cotton-Mouton and Buckingham effects (where polarized laser light passes through a medium in the presence of a strong electric or magnetic field, or electric field gradient respectively, thereby inducing a measurable birefringence). This allows for the determination of fundamental electric and magnetic molecular properties, including the (hyper)polarizabilities, (hyper)magnetizabilities and electric quadrupole moments.

The polarizability is crucial in describing the interaction of atoms and molecules with electric fields while the hyperpolarizabilities describe the nonlinear optical response of a molecule to applied electric fields, knowledge of this nonlinear response being essential to the development of practical devices for optical harmonic generation and signal processing. In an analogous way, the magnetizability and hypermagnetizabilities of a molecule describe the interaction of the molecule with magnetic fields. The quadrupole moment is a fundamental molecular property which, like the dipole moment, contributes to the description of the charge distribution of a molecule as well as its interaction with external electric fields.



Picture Caption: The Buckingham-effect experiment, used to measure molecular electric quadrupole moments

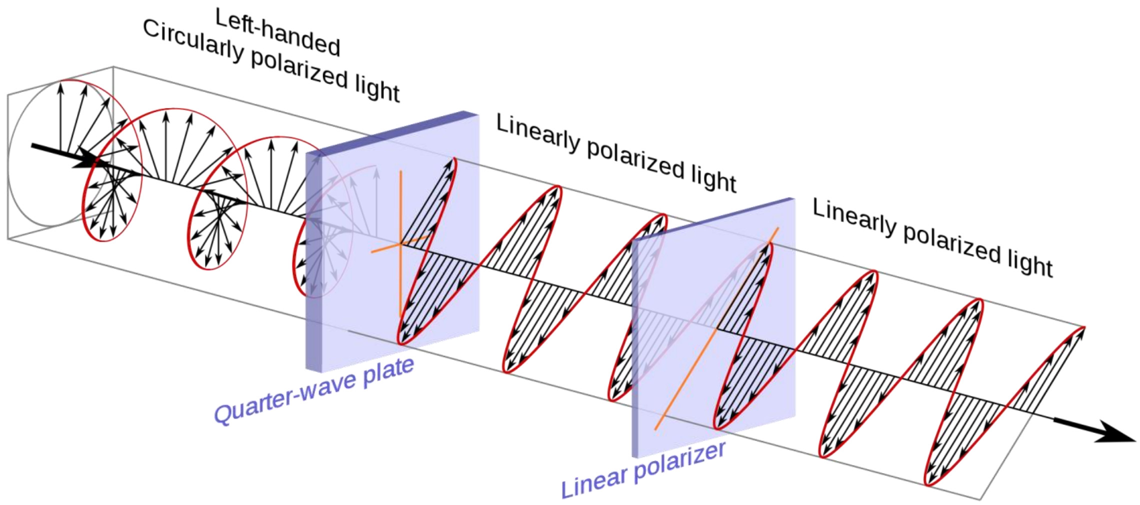
These molecular properties are crucially important in the fields of physics, chemistry, engineering and biology, since they are used in describing the structural, thermodynamic and spectral properties of molecules. They are also essential in the computational modelling of a wide range of phenomena, be it the molecular-dynamics simulation of biological phenomenon (e.g. carbon monoxide migration in myoglobin), or the prediction of thermodynamic reaction data, or the design of non-linear optical devices.

Research equipment includes argon-ion and helium-neon lasers, custom-built high-pressure gas cells with electrode arrays, state-of-the-art lock-in amplifiers and IEEE data-acquisition units and precision high-voltage controllers.

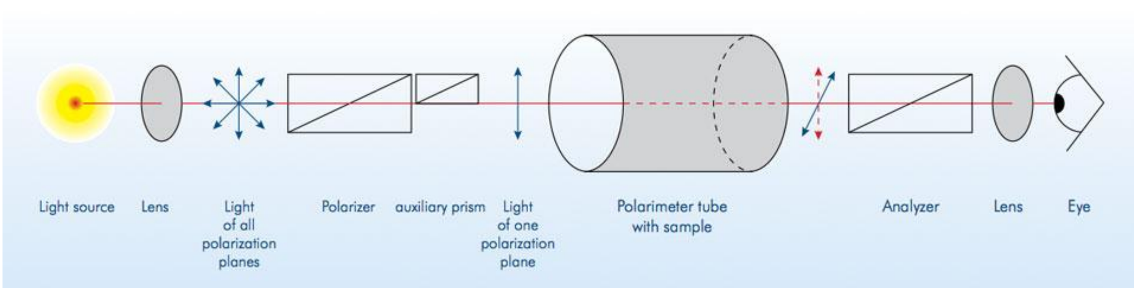
Current research students: 3 x PhD students, 2 x MSc students

Project Title: "Polarization of Light"

Supervisor: Dr V W Couling



The goal of this project is to introduce the student to the theory of polarization of light, and to foster an understanding of the optical elements used to manipulate the polarization states of light. The matrix representation of polarization will be explored via the Jones calculus, so that the effects of optical elements in an optical cascade on the polarization states of a light beam can be analyzed. The theory will be applied to the experimental measurement of the Faraday effect in liquids and solids, which will require knowledge of phase-sensitive detection techniques and IEEE automation of optical experiments.



Atmospheric Physics

Project Leader: Dr. Sibusiso H. Mthembu

Space Physics is the branch in Physics that involves the study of the processes and dynamics that occur in the space between the sun and the earth (see left side of Figure 1). Most of these processes are driven by activities emanating from the sun. Atmospheric Physics, on the other hand, is the branch that falls under Space Physics. Atmospheric Physics deals with the application of physics laws and principles to study the earth's atmosphere. The neutral atmosphere is separated into layer such as troposphere, stratosphere and mesosphere as shown on the right side of Figure 1. Its main endeavour is to model the earth's atmosphere using **fluid flow equations**, radiation budget and **energy transfer processes**. There are numerous mechanisms used to model the atmosphere which includes **wave propagation model**, scattering theory, cloud physics, statistical physics, etc. Atmospheric Physics is closely related to meteorology and climatology. These two branches concentrate on the study of weather patterns and their effects on humans and the environment. Meteorology focuses more on short-term weather conditions while climatologists are more interested in long-term climate conditions. Atmospheric Physics, in addition, concentrate on the design and construction of measuring instrument used to monitor the atmosphere.

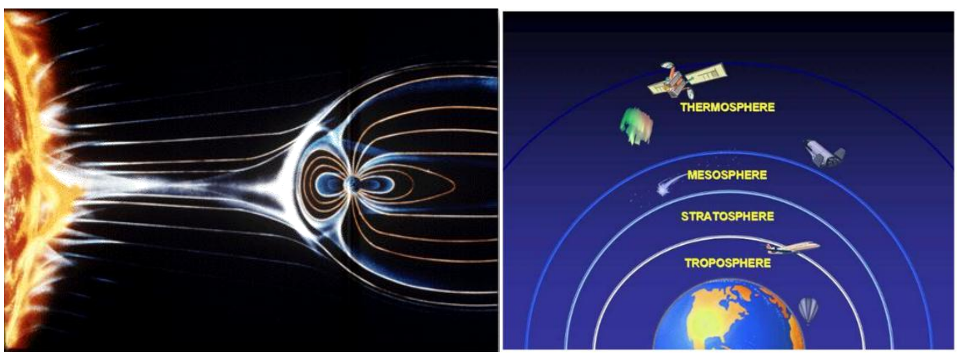


Figure 1: Interaction between the sun and the earth. The space between is the laboratory for Space Physics (Left). Layer of the neutral atmospheric.

Instrumentation

It is practically impossible to deploy measuring instrument in the atmosphere on a permanent basis. Thus, remote sensing is the technique used to probe and monitor the earth's atmosphere. This technique uses instruments which are ground-based and those on-board satellites, aircrafts, hot-air balloons to measure atmospheric parameters. Example of remote sensing instruments includes Lidar, Radar, SODAR. Figure 2 shows the hot air-balloon which will propagates upward and the high frequency HF radar.

Figure 2: Hot air-balloon launched to measure atmospheric temperature (Left). A new design of the SuperDARN HF radar at SANAE erected in 2009. (Right).

Education

A person who is interested in Atmospheric Physics should have a background in Physics and Math, however relevant background information can be picked up along the way. It is highly recommended to pursuing a PhD in Physics. This is due to the fact that a doctoral degree is required for most of the senior-level research positions.

Application and Job opportunities

In South Africa, Atmospheric Physicist is employed in the institutions like University, South African Space Agency (SANSA), South African Weather Services (SAWS), etc. In the university Atmospheric Physics works as a Lecturer or a researcher. The duties are to train and mentor young generation of atmospheric Physicist and to conduct research. SANSA is the research institution based in Cape Town that conducts research in Space Physics, of which Atmospheric Physics is part of it. Atmospheric Physicist in this institution studies the long term variation of atmospheric dynamics. SAWS employs meteorologist to conduct research on the short term variation in the atmosphere and its dynamics. Furthermore, meteorologist focus on weather forecasting.

My research area

My research focuses on (1) the atmospheric dynamics in the mesosphere-lower thermosphere (MLT) region (80-110 km) caused by upward propagating atmospheric waves like tides, planetary waves and their interactions. I also research on the coupling effect between the MLT region and the Ionosphere through upward propagating planetary wave type oscillations (PWTO). Also of interest is the study on the mesospheric temperature inversion. A project relevant to an honours level is outlined on the next page.

TTTLE: A study of vertical propagation characteristics of tidal wave studied using mesospheric wind velocity data from Rothera MF radar (Antarctica).
LEVEL: Honors

BACKGROUNG

The earth and the living organisms on it are protected by the earth's atmosphere from, among other thing, harmful radiations from the sun and external bodies emanating from outer space. Furthermore, the atmosphere makes climate possible and provide oxygen and water to sustain the living organisms on earth. The neutral atmosphere is separated into layers which are troposphere, stratosphere and mesosphere. The whole atmosphere is a coupled system such that its behaviour is influenced by numerous processes emanating from above and below. Examples of processes emanating from above includes solar radiations and meteors while those coming from below include atmospheric waves like gravity waves, atmospheric tides and planetary waves. An understanding of these processes is of great importance when it comes to weather predictions, early warning about catastrophic events, understanding of the behaviour of the atmosphere, etc. This project concentrates on the processes that are coming from below i.e. atmospheric tides.

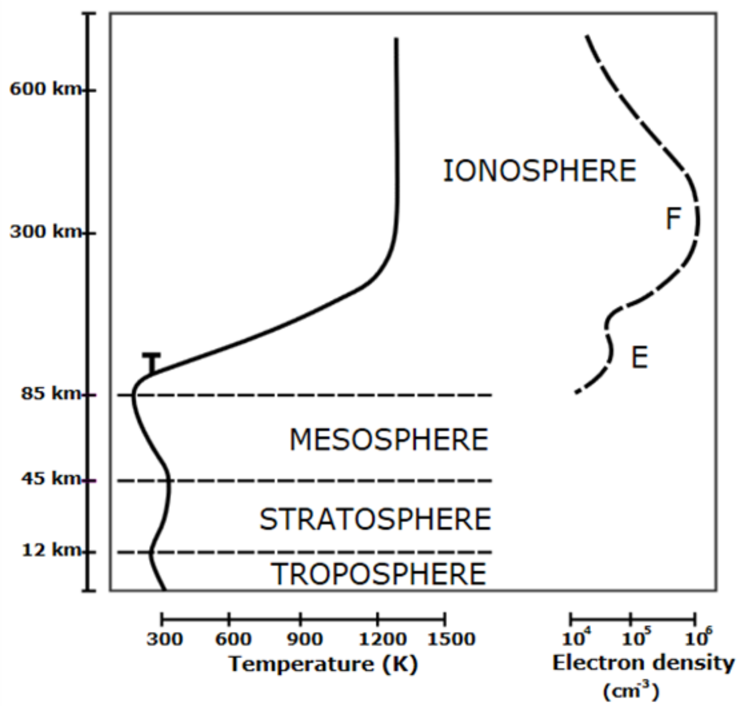


Figure 3: Vertical profile of the atmosphere. Modified version from http://en.wikipedia.org/wiki/Ionosphere.

PROJECT

Atmospheric tides are global-scale oscillations which are excited by, among other things, variation in heating due to absorption of solar radiation by atmospheric water vapor (in the troposphere) and ozone (in the stratosphere and mesosphere). These waves are measured as fluctuations in atmospheric wind, density, temperature and pressure. Atmospheric tides are classified according their periods, i.e. those with periods of 24 h, 12 h, 8 h and 6 h are called diurnal, semidiurnal quad diurnal and terduirnal tides, respectively. Upon excitation, these waves propagate upward and their amplitude increase with altitude due to a decrease in atmospheric density. In the mesospheric region, the amplitudes of the atmospheric tides are large enough to drive other atmospheric processes/dynamics which includes tide-planetary wave interaction, interaction between tide and mean wind circulation etc. Vertical propagation of tides can also act as a coupling effect between the neutral atmosphere and the ionosphere (see Figure 3).

In this project, mesospheric wind velocity is used as a tracer of atmospheric waves to investigate the vertical propagation characteristics of atmospheric tides in an 80-97 km altitude range. The wind velocity data were collected using the medium frequency (MF) radar located at Rothera in Antarctica. In particular, the objective of this project is to

1. Investigate vertical propagation characteristics of tides, i.e. their amplitude, phase, wavelength and wavenumber.
2. Investigate possible interaction between tides and mean wind.

LEARNING OUTCOMES

1. Learn the introduction to atmospheric wave dynamics
2. Learn about MF radar.
3. Learn and apply various signal processing techniques (Fourier spectra)
4. Learn computer programming in IDL.

REFERENCES

Mthembu, S.H ,Studies on atmospheric tides and planetary waves in the mesosphere-lower thermosphere (MLT) region using SuperDARN HF radars and meteor radar, PhD thesis, University of KwaZulu-natal, 2014.

Mthembu, S.H, Sivakumar, V., Mitchell, N. J., and Malinga, S.B., Studies on planetary waves and tide interaction in the mesosphere/lower thermosphere region using meteor RADAR data from Rothera (68°S, 68°W), Antarctica, J. Atmos. Solar and Terres. Phys., 102, 59-73, 2013.

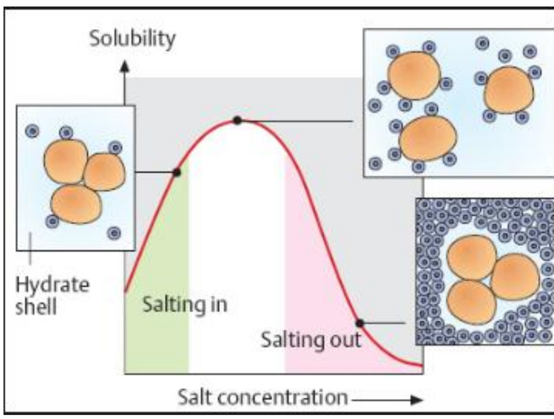
Deepa, V., G. Ramkumar, M. Antonita, K. K. Kumar, and M. N. Sasi Vertical propagation characteristics and seasonal variability of tidal wind oscillations in the MLT region over Trivandrum (8.5 N, 77 E): first results from SKiYMET Meteor Radar, Ann. Geophys., 24, 2877–2889, 2006.

N. J. Mitchell, D. Pancheva, and H. R. Middleton, Mean winds and tides in the Arctic mesosphere and lower thermosphere, J. Geophys Res., vol. 107, no. a1, 1004, 10.1029/2001ja900127, 2002.

Computational Condensed Matter Physics

Group Leader : Dr. Giuseppe Pellicane

The research focus of Dr Pellicane's group is on structural and thermodynamic properties of simple/complex fluids, including globular proteins solutions, thin polymer films, and colloidal systems.In general, the interaction properties of molecules consisting of a huge number of atoms dissolved in a solvent can be tuned by changing the composition and chemical properties of the solution. For example, protein interactions in a water solution can be modified by increasing the concentration of an added electrolyte (salt), so to increase the protein solubility (see Figure 1).



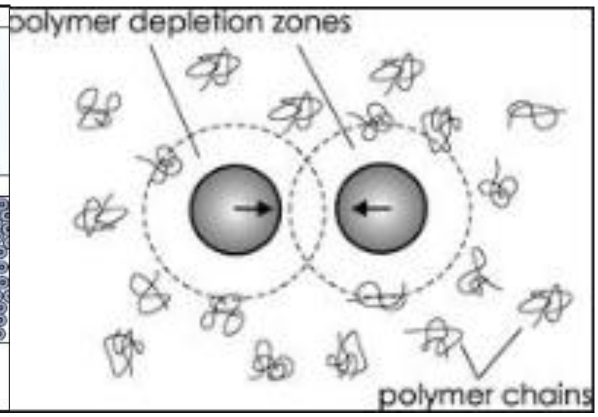
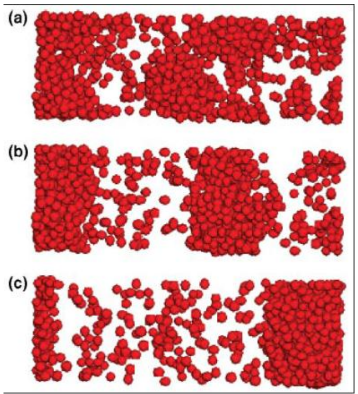


Figure 1 **Figure 2**

This phenomenon can be explained in terms of the change screening of the protein surface operated by salt counterions, which decrease the electrostatic free energy of the protein (salting-in). However, when the salt concentration becomes too high, the solubility decreases and proteins tend to precipitate (salting-out). Similarly, the interactions between colloidal particles can be made short-range attractive by varying the concentration of a non-adsorbing polymer to the solution (see Figure 2). This mechanism is based on the depletion force generated by the unbalanced polymers' pressure on the outer surface of colloidal particles, when their distance becomes comparable with the radius of gyration of polymers.

We use both theory and computer simulation in order to provide a basic understanding of how microscopic interactions influence the macroscopic properties of a wide class of (fluid) materials.

For instance, protein interactions can be characterized starting from their atomic structure in computer simulations where the presence of salt and water is explicitly taken into account. The knowledge of these interactions can then be exploited in additional computer simulations spanning more extensive time and length scales, or in theoretical methods based on statistical mechanics, in order to predict phase separation into two protein-rich and protein-poor phases (see Figure 3). This phenomenon is at the origin of the undesired protein aggregation found in some human diseases, such as cataract and cell anaemia.



Our research activity is mainly supported by the National Research Foundation (NRF) and by the National Institute for Theoretical Physics (NITheP). Different aspects of our research activity are performed in collaboration with researchers of local and international institutions, including for instance the University of Akron (USA), the University of Edinburgh (UK), the California State University (USA), the University of Messina (Italy).

Figure 3

Abstracts and Titles of previous Honours Projects completed by students:

Gibbs Ensemble Monte Carlo Applied to a symmetric Binary Hard-Disk Mixture

The main goal of this research project was to study liquid-liquid phase coexistence in systems of nonadditive hard disk mixtures (NAHDMs). Many techniques for studying phase separation exist, however the Gibbs Ensemble Monte Carlo (GEMC) method is a versatile and useful approach to study phase separation without the bias deriving from the presence of an interface between the two coexisting phases. The results obtained through GEMC simulation are compared with results published in literature by Fiumara and coworkers.

Gibbs Ensemble Monte Carlo Applied to Square Well Fluids
This report will focus on the liquid-liquid phase transitions of Phase equilibria and critical behaviour of square-well fluids of variable width, as investigated by means of Gibbs ensemble Monte Carlo simulation. The Gibbs ensemble Monte Carlo simulation allows us to study a two-phase system without the presence of interface at the constant value of temperature, pressure and chemical potential. The calculation of the phase diagram of a model fluid is a computationally expensive task. The Gibbs ensemble Monte Carlo is an efficient Monte Carlo method which is used to identity first-order phase transitions. We will discuss a standard classification of phase transitions, and the Monte Carlo computer simulation in general. Then we will introduce the statistical mechanical model that we investigated, namely the Square-Well Fluid.

Computer simulation of a colloidal model of lysozyme solutions
The Derjaguin-Landau-Lishiftz-Overbek (DLVO) model is adapted to a globular protein solution consisting of lysozyme, water, and 10% (by weight) D2O citrate-phosphate buffer. We study this system at different pHs in order to predict the structural behaviour. The Hamaker constant of the DLVO model is fit so to reproduce the second virial coefficient at the critical temperature of the experimental protein rich-protein poor phase separation region. The effective charge, the ionic strength, and the Stern layer are inferred by the relevant solution conditions. We use Monte Carlo computer simulations in the NVT ensemble in order to evaluate the radial distribution function and the structure factor for the different ionic strength/pH regimes, at the intermediate protein concentration ρ = 100g/l. The theoretical estimate of the scattered intensity is compared

with its experimental counterpart reported in the literature, as measured by means of small angle neutron scattering (SANS).

Titles of Honours Project(s) offered this year:

- Gibbs Ensemble Monte Carlo of asymmetric Binary Hard-Disk Mixtures.
- Computer simulation of a colloidal model of globular protein solutions.

Atmospheric, Biomedical and Educational Physics

Group Leader: Dr N Chetty

This research group has vast interests in the applied Physics domain with a sub-focus area in educational Physics. There are currently 4 Masters and 3 PhD students in the group. We collaborate with the Defense, Peace, Safety and Security division of the CSIR (DPSS), the National Laser Centre (NLC) and Armscor. Many of the current research projects are funded by these organisations and these collaborations allow students in the group access to state of the art facilities, scholarships, internships and ultimately employment opportunities within the research and development sector. The defense sector in South Africa is in great need of graduates and as such this research group focusses on defense related application and as such we tend to attract lucrative funding opportunities.

ATMOSPHERIC PHYSICS

Project 1: In this work, we classify the thermal effects on a laser beam propagating in air. The experimental setup is robust but inexpensive and easy to assemble with high accuracy which includes a HeNe laser and a precision-designed turbulence delivery system and imbedded pressure sensor and a platform for height adjustability between laser beam and the turbulence model. From this setup we can determine the turbulence strength C2n, the Rytov variance (scintillation) and the coherence diameter (Fried's parameter). Analysis of the produced interferograms and the effect of thermal turbulence on the laser beam have been discussed using Fast Fourier Transforms. This project provides a student with both experimental and computational knowledge. An inexpensive and reliable technique of producing interferograms using a point diffraction interferometer (PDI) to study the turbulence effects on a laser beam propagating through air is proposed. A PDI is used to detect, quantify and localize thermal turbulence effects on a laser beam propagating through air in a laboratory. Interferograms were formed from a propagating beam passing through the PDI pinhole. The interferograms were observed and digitally processed to study the wavefront behavior as a result of this thermal turbulence. This technique was sensitive enough to detect minor thermal fluctuations attributed to body heat radiating from a hand. The study of the behaviour of a laser beam propagating in the atmosphere plays a crucial role in defence laser weapons.

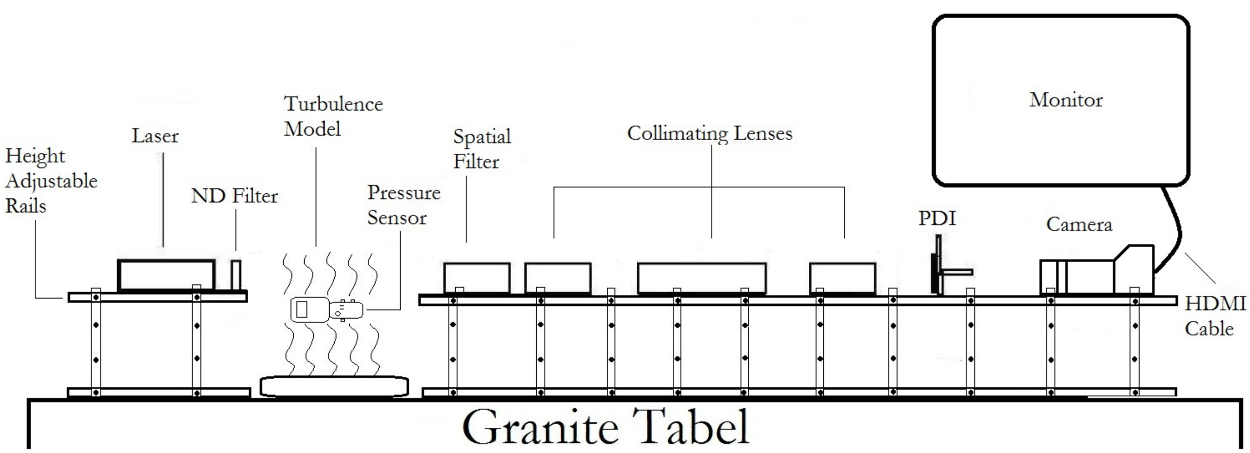


Fig. 1 Experimental setup

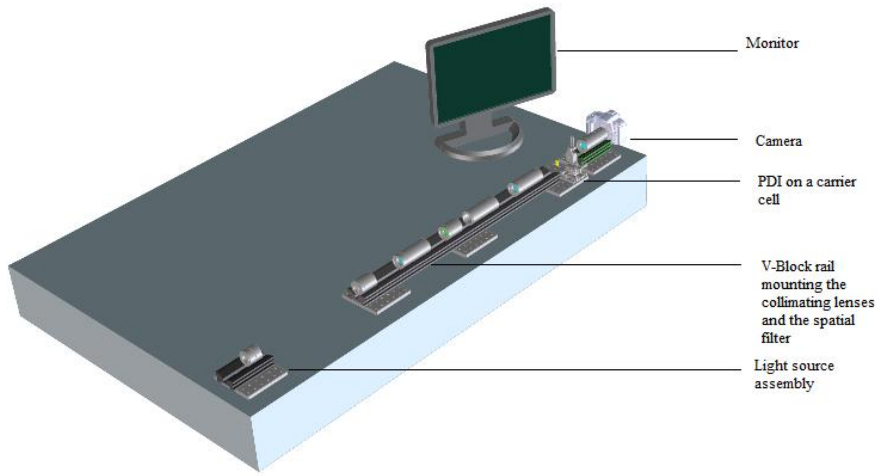


Fig.. 2. Schematic of the complete optical train on the granite table in the laboratory

BIOMEDICAL PHYSICS

Project 1: As polarized light propagates through light-scattering media such as biological tissues, microsphere solutions, or an atmosphere with particulates, the polarization status of the light changes. Hence, a medium can be characterized by the degree to which polarized light is altered during propagation. The propagation of polarized light through a biological tissue causes the polarization status of photons to change due to tissue birefringence and tissue scattering. In this project we attempt to study the effect of pseudo-tissues on light propagating through it.

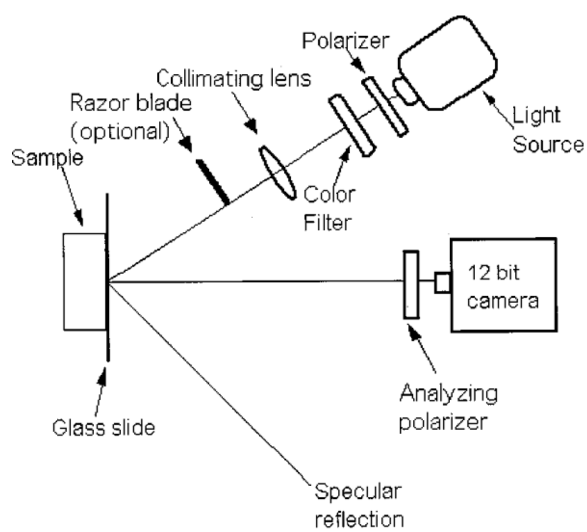


Fig. 3 Schematic of camera system. used bt Jacques et al. (Journal of Biomedical Optics 7(3),

329–340 (July 2002))

Project 2: In this research, particular requirements for the safety of surgical luminaires and luminaries for diagnosis are investigated. Most countries have fixed standards for the building of operation rooms/theatres with respect to illumination by surgical luminaries. South Africa is one of the countries which does not have any fixed standards in place and most South African hospitals, both private and public, operate with different surgical luminaires and theatre lighting. This project aims to investigate, with the use of a digital camera to measure illuminance, if standards such as the BS60601:2000 from UK needs to be implemented in South Africa for a uniformity in critical applications. A digital camera was used to measure the illuminance provided by surgical luminaires in state and private hospitals in the Pietermaritzburg. The aim of this work has been to highlight the need for the introduction of standards for illumination in critical applications.

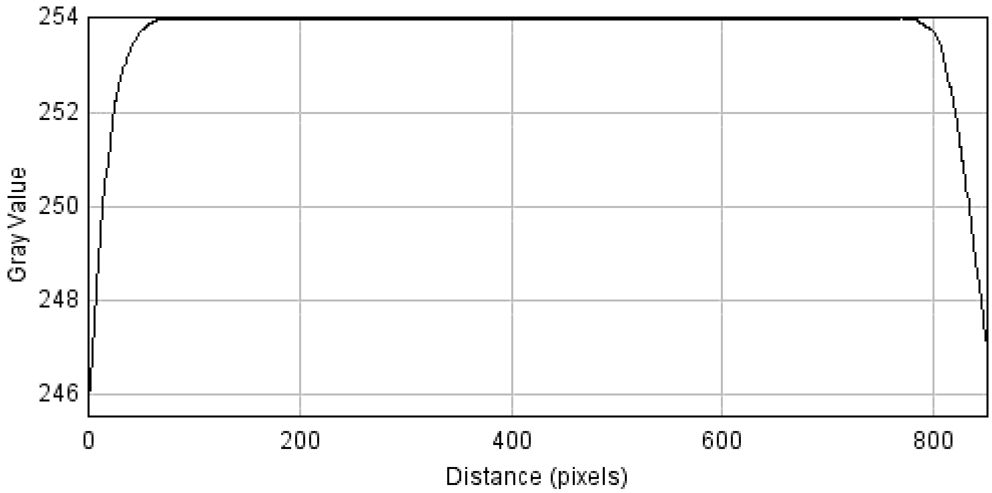


Fig. 5: Shows the plot profile for the uniformity of illuminance for the surgical luminaire used in a hospital. From the plot it is seen that the illuminance is uniform around the center of the beam.

Project 3: Optical tweezing involves the controlled manipulation of microscopic particles by the use of laser light. Since its inception in 1970 by Arthur Ashin, who demonstrated that particles suspended in laser light experience an accelerating force due to radiation pressure, this field has rapidly developed, providing a tool for the micrometer and nanometer 'worlds'. The implementation of different beams in optical tweezing setups has offered additional manipulation methods. For example, beams with helical wavefronts which consequently carry orbital angular momentum (OAM) transfer their OAM to trapped particles, resulting in the rotation of microscopic particles for the realization of photon-driven micro-gears. This study will focus on the experimental construction of a holographic optical tweezer, which implements a spatial light modulator for the creation of arbitrary beams shapes (such as those which carry OAM). A theoretical description of the interaction of light with matter will be considered. Each of the OAM-carrying beams will be generated and their properties investigated prior to inclusion in the optical tweezer. Of particular interest will be the generation and investigation of superpositions of non-canonical Bessel beams which are carriers of OAM. By controlling a single morphology parameter the rate of rotational acceleration provided by these beams can be controlled.

EDUCATIONAL PHYSICS

Project 1: The University of KwaZulu-Natal (UKZN) is in the process of formulating a language policy that to introduces teaching and learning in isiZulu as well as in English to improve throughput and increase the number of graduates. The purpose of this research is to conduct a feasibility study of teaching Physics in isiZulu at the University of KwaZulu-Natal. It also aims to critically engage with students and the literature to determine the potential gains and pitfalls for such a language introduction. The study also provides some useful insight into student contexts, schooling history and their perceptions of being taught in their vernacular. Further the study shows the inconsistent use of isiZulu words to translate basic Physics words motivating the need to establish a common vocabulary for Physics in isiZulu.

Project 2: Amidst a critical national shortage of qualified black graduates in the pure and applied sciences, the University of KwaZulu-Natal has responded to a direct call from government for redress by launching the BSc4-Augmented programme in Physics. This research focusses on the methods employed to foster learning and to encourage student success in the Physics programme. The use of Problem Based Learning and a holistic learning policy that focuses on the emotional, physical and knowledge development of the student is considered in light of increasing throughput in the undergraduate program in physics. These initial analyses pave the way for a course designed to benefit the student and improve throughput. Further these methods are not unique to Physics but can in general be adapted for any module in any country.

Material Science and Device Physics

Group Leader: Prof. Genene Tessema Mola
(mola@ukzn.ac.za / Tel.: 033 260 5350)

Overview of the research field

My research group deals with the investigations and characterization of semiconductor materials which have potential application for photonic and electronic devices. It is to be noted that semiconductors have wide range of technological importance in the area of communications, solar energy conversion, medicine etc which have positively transformed our style of life at present. The search for new materials and methods for device fabrications is the ultimate goal of material research with the view to improve device performance. Our group particularly interested in organic semiconductors that have potential application for solar energy conversion. Some of the attractive features of organic semiconductors are the ease process ability, flexibility and low device production cost. The design of device structure and the synthesis of polymers play a critical role in the determination of power conversion efficiency of organic photovoltaic cell (OPV). The photoactive layers of the OPV devices are often composed long chain polymers, fullerenes, carbon nanotubes, Nanostructured semiconductor metallic oxides, etc

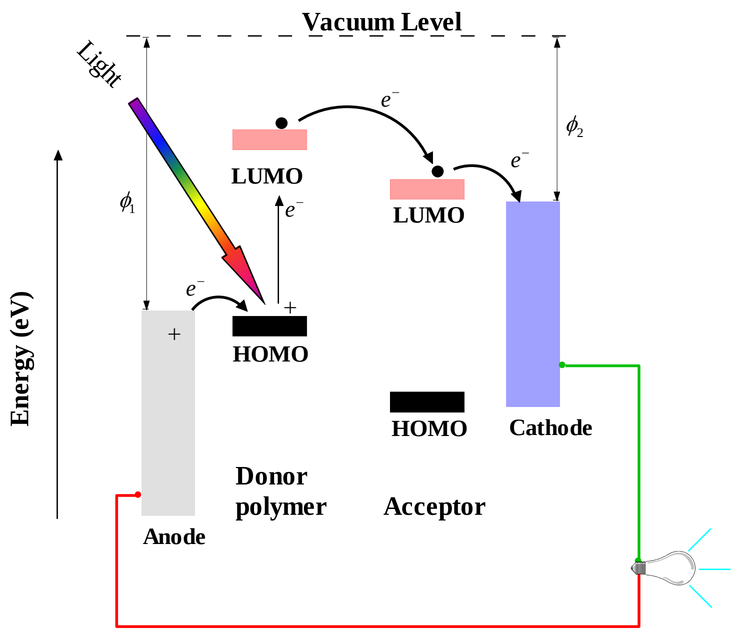


Figure: Solar energy conversion process at molecular level

My group also involves in research that deals with preparation and characterization of transparent metallic oxides thin film using electrochemical deposition. This research is aimed at producing transparent and conducting electrodes for the fabrication of organic photovoltaic cell. The nano-morphology of the film requires better understanding the behaviour of the elements as well as accurate determination of deposition parameters. Several postgraduate students are currently involved in the investigations of OPV.

Figure: Partial view of the available facility

Research Facilities: Edward Auto 306 vacuum deposition unit, AAA50SS Solar simulator, Spin coater, I-V measuring system, High temprature furnace etc

Postgradute students: Currently, there are seven post graduate students working in our group towards their degrees. It includes, PhD, MSc, and Honours

Collaborations: We have fruitful research collaborations with iThemba LABS Cape Town, University of Pretoria, University of Linkoping, Addis Ababa University.

Prevous Honours Project

THE EFFECT OF INTERFACIAL BUFFER LAYERS IN BULKHETEROJUNCTION ORGANIC SOLAR CELL

Abstract

The effect of charge transport buffer layers in organic photovoltaic cell was studied using solution processed P3HT:PCBM blend bulk-heterojunction solar cell. The devices were prepared under ambient laboratory condition. The electrical properties of the devices were studied both under illumination and dark conditions using Keithely 4200 source meter under AM1.5 solar simulator with integrated power density of $100mWcm^{-2}$. The performance of devices fabricated without buffer layers were compared with standard type device structure, and found the former less effective in the charge transport process. The charge carrier mobility (μ_0) found in this experiment was $1.5719 \times 10^{-10} cm^2V^{-1}s^{-1}$ and the results are discussed.

Honours Project titles for 2016

1) The effect of Nitrogen environment annealing on the preparation of Organic solar cell.
2) Charge transport study across bulkheterojunction organic solar cell.