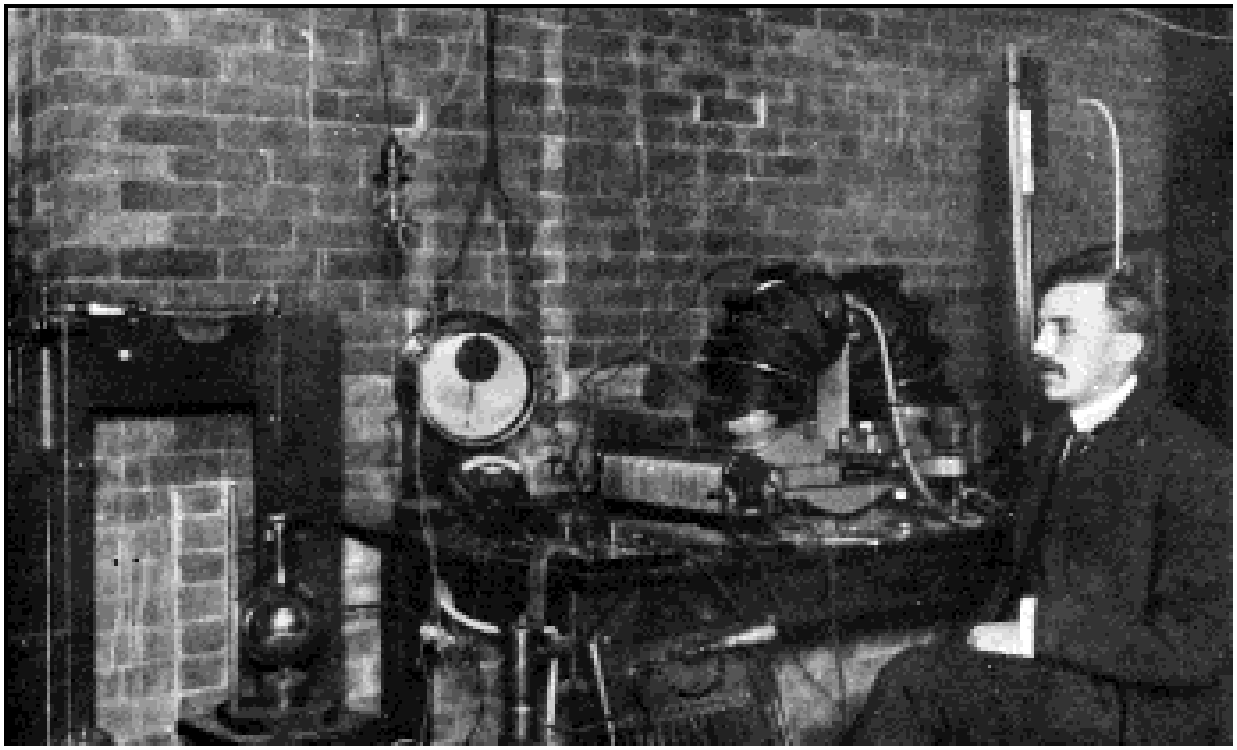
DEPARTMENT OF PHYSICS & ASTRONOMY
College of Science

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

25th DEPARTMENTAL CONFERENCE

Tuesday 26th August and Wednesday 27th August 2008
MATH031



Programme

Tuesday 26th August

10.30 – 11:25 MORNING REFRESHMENTS - MATH101

Session 1	**Chairperson:**	***Juergen Meyer***
	Welcome	**Roger Reeves**
11.30 – 11.45	Clare Worley	**Chemical abundances of light and heavy s-process elements in 47 Tuc, NGC 362, NGC 6388 and M15 using SALT and VLT data**
11:45 – 12:00	Jeffrey Simpson	**Elemental abundance determination using Fabry-Perot interferometers**
12:00 – 12:15	Judy Mohr	**Optical turbulence profiling at Mount John University Observatory**
12:15 – 12:30	Florian Maissoneuve	**Asteroseismology: Probing the interior of stars by analyzing non-radial pulsations**

12:30 – 1:30 LUNCH -

Session 2	**Chairperson**	***David Mackenzie***
1:30 – 1:45	Giles Reid	**Explaining Neutrino Oscillations Using Spin Precession**
1:45 – 2:00	Veronica Miller	**A search for transiting extrasolar planets in the Galactic Plane**
2:00 – 2:15	Cheng-Yang Lee	**Non-standard quantum field construct of spin-j**
2:15 – 2:30	Mohammad Zeidan	**Measuring the Mean Glandular Dose (MGD) by Using Thermolminescent Dosimetry TLD**
2:30 – 2:45	Stephanie Hickford	**Hadronic Cascades in IceCube**
2.45 – 3.00	Michael Lee	**Random Sequences**

3:00 – 3:30 AFTERNOON REFRESHMENTS MATH101

Session 3	**Chairperson:**	***Clare Worley***
3.30 – 3.45	Jochen Butzer	**MARS – a 3D x-ray imaging device based on Medipix**
3.45 – 4.00	Joseph McCartin	**Analysis of cascades with the IceCube neutrino detector**
4:00 – 4.15	Andrew Blair	**Radiation Skin Dose Assessment for Cardiology Patients**
4.15 – 4.30	Greg Betzel	**Suitability of synthetic diamond films as x-ray detectors for clinical applications**
4.30 – 4.45	Robert Hurst	**The possibility of measuring the Lense-Thirring effect of the rotating Earth with a terrestrial ring laser gyro.**
4.45 – 5:00	Peter Cottrell	**R Coronae Borealis stars and related objects - a longitudinal study**

END OF DAY ONE

Wednesday 27th August

Session 1	**Chairperson:**	***Greg Betzel***
9:30 – 9:45	Juergen Meyer	**An adaptive tumour tracking system**
9:45 – 10:00	Andolsa Arevalo	**What I did to get to New Zealand????**
10:00 – 10:15	Karen Pollard	**Songs of the Stars (of the astrophysical kind)**
10:15 – 10:30	Nikolai Kruetzmann	**Application of complexity measures to geophysical systems**

10.30 – 11:00 MORNING REFRESHMENTS – MATH101

Session 2	**Chairperson:**	***Giles Reid***
11:00 – 11:15	Richard Graham	**Ring Laser**
11:15 – 11:30	Florentina Baluti	**Investigation of Monte Carlo parameters in the design of CVD diamond detector**
11:30 – 11:45	James Talbot	**A Patient Position Guidance System in Radiation Therapy Using Augmented Reality**
11:45 – 12:00	Anas Sedayo	**Multi energy x-ray imaging in medicine**
12:00 – 12:15	Rachel Soja	**Searching for Resonance Effects in Meteoroid Streams using Meteor Radar Data**
12:15 –12:30	Adrian McDonald	**Mixing Antarctic Cocktails**
12:30 – 12:45	Mita Brierley	**Creating High Resolution Spectral Models for Globular Clusters**

12:45 – 1:45 LUNCH

Session 3	**Chairperson:**	**Mita Brierley**
1:45 – 2:00	Vincent Thompson	**A Study of Southern Spectroscopic Binaries**
2:00 – 2:15	Daniel Robertson	**Temperature Dependent Phenomena in Bismuth Thin Films**
2:15 – 2:30	Scott Joon Choi	**What do I do when I am bored with Spectroscopy of Eu^{3+} in CaF_2:Eu-CdF_2 Superlattices?**
2:30 – 2:45	Martin Henseler	**The Optoelectronic Structure of ZnO**
2.45 – 3.00	David Mackenzie	**Germanium Atomic Clusters: Production and Electrical Properties.**
3:00 – 3:15	Peter Smale	**The Cosmic Microwave Background in an Inhomogeneous Universe**
3:15 – 3:45	Adrian McDonald	**The PhD Student Experience in Physics and Astronomy: How can we improve?**
3:45 – 4:00	Peter Cottrell	**Conference wrap up and discussion**

CONFERENCE CLOSES

Retire to Staff Club for end-of-conference function and presentation of prizes.

ABSTRACTS

Tuesday 26th August

Clare Worley

Chemical abundances of light and heavy s-process elements in 47 Tuc, NGC 362, NGC 6388 and M15 using SALT and VLT data

The observed chemical abundances of light and heavy s-process elements in globular cluster stars are indicative of the type of enrichment that is occurring within a globular cluster (GC). Key high resolution studies to-date have reached varied conclusions, either indicating that s-process element abundances are homogenous within a cluster (James et al, A&A,v427,825,2005), or that abundance variations have been observed (Wylie et al, ApJ,649,2006). This research seeks to extend the number of stars analysed for s-process element abundances for the globular clusters: 47 Tuc, NGC 362, NGC 6388, and M15, using data obtained from the newly commissioned Southern African Large Telescope (SALT) and also data from the Very Large Telescope (VLT). The data obtained from SALT was of medium resolution (R~5000) using the Robert Stobie Spectrograph (RSS) to test the capability of that instrument to carry out a medium resolution survey of s-process element abundances in giant branch stars in 47 Tuc (Worley et al, PASA,v25,53,2008). The data obtained from the VLT is high resolution data from UVES for a programme to observe giant branch stars in five separate globular clusters for mass loss and chemical abundance analysis (McDonald & van Loon, A&A,v476,1261,2007).

Jeffrey Simpson

Elemental abundance determination using Fabry-Perot interferometers

My research is investigating the use of Fabry-Perot interferometers for elemental abundance determination of globular cluster stars. It has particular focus on the Fabry-Perot of the Robert Stobie Spectrograph on the Southern African Large Telescope. By using the Fabry-Perot we aim to determine the abundance of barium in several hundred stars without a priori knowledge of the field of view. In this talk I will discuss Fabry-Perot interferometers, some simulations and results found so far.

Judy Mohr

Optical turbulence profiling at Mount John University Observatory

To compensate for the induced aberrations in real-time it is vital to have an accurate model of turbulence strength, $C_n^2(h)$, and the average wind velocity, $V_w(h)$, above a given site. To that end, a bread-board based SCIntillation Detection and Ranging (SCIDAR) system was developed for the Mount John University Observatory (MJUO), located in New Zealand. The system, constructed from commercially available off-the-shelf components, provides the flexibility to capture simultaneous pupil-plane and generalised SCIDAR. Measurements taken at MJUO, using the purpose-built instrument over the last few years, indicate the presence of very strong near-ground turbulence and at least two high altitude layers (approximately 6 km and 11km above sealevel). Presented are the $C_n^2(h)$ trends from 2005 – 2007 and the $V_w(h)$ trends from 2007.

Florian Maissoneuve

Asteroseismology: Probing the interior of stars by analyzing non-radial pulsations

In a continuation of the work of W. Zima and D. Wright, my research will (in a first part) be about performing spectroscopic analyzes on variable stars and determining their pulsation mode(s). From there I will fit complete stellar models to these non-radial pulsations, therefore obtaining a guess on the internal structure of the observed star.

Giles Reid

Explaining Neutrino Oscillations Using Spin Precession

Although their interactions are very weak, neutrinos are extremely important in many astrophysical processes, such as stellar cores, supernovae and the early universe. Neutrinos were proposed by Wolfgang Pauli in 1930 to explain the apparent violation of energy and momentum conservation in beta decays, but it is only in the last decade or so that many of their properties have been measured accurately. These measurements suggest that neutrinos can behave in strange ways in dense media, despite their extremely low interaction cross-sections. I will explain the mechanics of neutrino flavour oscillations using an analogy with spin precession in a magnetic field, and discuss the implications for a few different astrophysical environments where the matter and neutrino density can have a strong influence on neutrino behaviour.

Veronica Miller

A search for transiting extrasolar planets in the Galactic Plane

The basis for my thesis is a deep survey for transiting extrasolar planets in a field in the Galactic Plane. I present here information about transiting extrasolar planets, details of the analysis and initial results from the survey.

The dataset contains 267 mosaic images from the WFI camera, each composed of 8 4k by 2k CCD chips. The dataset is made up from two observing runs, one in 2002, the second in 2005.

Image subtraction is performed on the images and the resultant lightcurves then de-trended.

A transit search algorithm is then used on the lightcurves. The algorithm calculates a maximum test statistic based on three parameters for each lightcurve. Other techniques are used to detect variable stars.

We are currently in the process of searching the database for variable stars and transit candidates. The variable stars will then be characterised and catalogued and the transit candidates analysed. We expect up to 10 transiting planets to be discoverable in the sample.

Cheng-Yang Lee

Non-standard quantum field construct of spin-j.

Introduction

In 1928, Dirac wrote down his famous “wave equation” for the electron and laid the foundation for the Standard Model of particle physics. However, mathematicians knew the Dirac equation almost fifteen years earlier due to the work of Cartan. Through the seminal work of Wigner, we now know that the Dirac field (general solution to the Dirac equation) belongs to a larger family of unitary representations of the Lorentz group. By studying the representation, one can develop formalism for constructing various quantum field theories.

Cheng-Yang Lee (cont’d)

The conventional wisdom in quantum field theory tells us that the Dirac construct is the only possible field theory from the Lorentz group for a particle of spin-half. Recent works by Ahluwalia has unearthed new possibilities and suggests there are other “non-standard” construct in the Lorentz group for fields of higher spin. The construct of Elko, a spin-half quantum field, as a dark matter candidate is a direct counter-example to the present paradigm.

In this talk, we extend this work to higher spin fields and provide a conjecture on the number of field theories with different physical properties for a given representation of the Lorentz group.

Methods & Materials
The analysis we carried out closely follow the approach given in *The Quantum Theory of Fields* by Steven Weinberg. The plan is to study the representation of the Lorentz group and construct all possible fields.

It is important to note, in this formalism, we do not start by assuming a Lagrangian; instead, we construct the field by the demand of Lorentz invariance and micro-causality. Only then, do us to *derive* the propagator, equations of motions and the corresponding Lagrangian.

Results
Here we provide a conjecture. The representation of the Lorentz group with spin greater than j>1/2 have 2j+2 physically distinct quantum fields of definite spin-j.

Discussion & Conclusion
The fields we have constructed are part of the unitary representation of the Lorentz group. The fact that we do not observe these fields may be an indication that the conjecture is incorrect or these particles carry heavy masses. On the other hand, they might be dark matter candidate, which would explain the lack of observational evidence.

One possible explanation is that these fields violate one or more well established theorems in the literature thus could not be realised in nature.

Mohammad Zeidan

Measuring the Mean Glandular Dose (MGD) by Using Thermolminescent Dosimetry TLD

Introduction: Mammography refers to the x-ray examination used for the human breast to diagnose breast disease. The female breast is a radiosensitive organ and when using the x-ray for examination, there is a small but significant risk of radiation induced carcinogenesis. The most radiosensitive part of the breast structure is the mammary glands, as these are considered as the place that the breast cancer frequently occurs. The estimation of the absorbed dose by the breast is an important part for the quality control program of the mammography. Therefore, accurate assessment of the surface exposure levels is considered a first step. Additionally, the relationship between the surface exposure and the absorbed dose to tissue as a function of depth is also important. The breast surface exposure is typically translated into a Mean Glandular Dose (MGD) to access the radiation risk within the mammary glands. Method: Even with the International Commission on Radiological Protection (ICRP, 1986), and other protocol agreements of using MGD to measure the risk of exposure to the breast, measuring MGD directly is currently impossible because the glands are inside the breast. There are two methods of measuring the MGD: using the breast phantom or indirect measurements from the surface exposure to the patient. In this research the breast phantom is used, enabling us to have wide range of breast composition and thicknesses, which are the main two factors that affect the MGD value. The phantom mixture (composition) will be used is 50 glandular tissues/ 50 fat tissues. This type of phantom considered to be as a standard phantom for mammography test. Using the phantom, the effect of different thicknesses on the MGD value will also be tested; the phantom designed on slabs (rectangular) shape with different thicknesses (0.5cm, 1cm, 2cm) will be used to reach 6.5cm as a maximum thickness for this research. Holes will be milled on the 0.5cm slab to place the Thermoleminunce Dosimeters TLDs. The TLDs are used due to their tissue equivalent properties, high sensitivity, energy and dose response, and small size. In this research different mammographic x-ray tubes are used in terms of target/filter combination; Molybdenum/ Molybdenum (Mo/Mo), and Molybdenum/Rhodium (Mo/Rh) under KVp range 25-35. Results: Currently, the set-up of the phantom and measurements is starting in August 2008 at Christchurch Hospital. The expectation from these measurements is to find the MGD at different depth in the breast not just at a fixed depth (standard depth) by applying a range of KVp using two different phantom composition and different x-ray tubes target/filter materials. These measurements will be used to estimate the radiation dose values that are necessary for quality control and optimization. Discussion: Of the results will be presented.

Stephanie Hickford

Hadronic Cascades in IceCube

The IceCube neutrino telescope is currently under construction at the South Pole in Antarctica. This project aims to detect neutrinos originating from galactic sources.

When neutrinos are detected under the ice, they have two distinct light patterns. These light patterns are tracks from long range muons, and spherical signals from hadronic cascades. These cascades are harder to distinguish from background noise, and it is difficult to attribute directionality to the incoming neutrino.

This talk will show that these hadronic cascades should be able to be detected by IceCube due to the number of atmospheric and solar muon tracks already seen. Furthermore, it may be possible to infer directional information about the incoming neutrino, and hence its origin, using long range muons produced within the cascade. These will be muons that have been produced from the decay of particles such as pions and kaons in the hadronic cascade.

Future work will be discussed including a cascade analysis which is being undertaken currently. This will be an analysis of IC40 data from 2008.

Michael Lee

Random Sequences

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Jochen Butzer

MARS – a 3D x-ray imaging device based on Medipix

Purpose
We've constructed a novel 3D x-ray spectroscopic scanner for biomedical x-ray imaging. The scanner has the unique ability of providing spatial and energy information from a single scan. The device, entitled MARS (Medipix All Resolution System), will be used to collect real data from small animal and pathology specimens. Thus it provides data to evaluate the potential clinical applications of spectroscopic imaging. Groups within the Medipix collaboration as well as suppliers of medical x-ray systems have recently published methods of material reconstruction. Datasets from our scanner will enable to further enhance those.

Methods and Materials
The scanner combines a broad spectrum micro focus x-ray tube and the energy selective x-ray detector Medipix-2. This detector has an energy resolution of approximately 2.5 keV. We designed and built a gantry and control electronics so that the detector and x-ray tube are rotated around an object of up to 90 mm diameter. This setup enables us to image living and especially wet specimens at 43 micron spatial resolution, and a choice of spectral energy bins. The dataset for each energy bin is processed to correct for unbalanced pixel responses and intensity fluctuations. A cone beam filtered back projection is used to create 3D spectral datasets. With the Medipix 3 chip, it will acquire images simultaneously in 8 energy bins and only one source of Poisson noise.

Results
Measurements of a range of small objects, including several mice, were successful.
Experiences and feedback from evaluation of the first data lead to a review of the design and motivated an upgrade of the setup and improvements of software and methods.

Conclusion
The scanner is able to provide 3D spectroscopic x-ray images of small animal and pathology specimens. Image processing and display techniques for the novel energy information can now be developed. Clinical applications can be investigated using pathology specimens, mouse and rat models of diseases. Work has begun on evaluating the spectral dataset and spectroscopic material reconstruction.

Joseph McCartin

Analysis of cascades with the IceCube neutrino detector

Cascades of charged particles are produced when a neutrino interacts via the Electroweak force with a nucleon in the ice. These cascades form a distinct, almost isotropic distribution of scattered Cerenkov light from the point of origin, that we detect with the optical modules deployed in the ice. The analysis of these cascades is important for the IceCube neutrino telescope, as it can help us to determine the relative flux of electron neutrinos with respect to the muon and tau neutrinos that are incident to the detector. However, IceCube is constantly saturated by muons produced in the atmosphere, so it is necessary to learn how to distinguish between cascades, and this background. The uniqueness in light distribution for cascades plays an important role in helping us to reconstruct the information from events caused by the flashing of in situ light sources, which will then allow us to test and develop efficient background rejection techniques for use in the future.

Andrew Blair.

Radiation Skin Dose Assessment for Cardiology Patients

Introduction
Patients who undergo complex interventional procedures may potentially suffer radiation damage to their skin. The complex nature of the procedure makes it difficult to predict maximum skin dose and localisation even more so. Currently a cumulative dose area product is recorded which offers no spatial information and may not be a good indication of deterministic effects.

Method & Materials
To measure the true dose and dose distribution to a patients skin we decided to use large sheets of Gafchromic XR-RV2 radiochromic film. Radiochromic film darkens upon irradiation in proportion to the absorbed dose in the film. Importantly they are not affected by visible light like conventional films which greatly simplifies handling. Some time was spent characterising these films to ensure suitability for this project. Some characteristics to consider were; dose range, sensitivity, energy response and exposure growth. Other effects of lesser consequence were also investigated such as; polarisation, uniformity corrections and spectral sensitivity.

Results
The dose range of the film was nearly three orders of magnitude and sensitive to doses between approximately 1cGy and 1000cGy. The sensitivity of the film was largely influenced by the choice of scanner. A high quality document scanner provided the highest sensitivity of the various scanners tested when analysed using the red colour channel.
A large energy dependence was observed over the 60 – 120kVp range. The variation was as much as 25% at low doses and decreased to 7% at high doses. Exposure growth was found to be approximately logarithmic but minimal.

Discussion
While the dose range of the film is approximately 1-1000cGy, the most sensitive portion of the film lies in the area of logarithmic response between 10 – 300cGy. This is fortuitous as most procedures should have dose distributions within this range. It is also able to predict early transient erythema with good accuracy which occurs around 200cGy. Measurement of doses which would result in more serious effects above 400cGy are also possible but with reduced accuracy. The energy dependence of the film gives rise to an unavoidable uncertainty in dose measurement. For this reason a less energy dependent film such as EBT may be used if higher accuracy is required. Positioning of the film has been an issue for some studies. For example the patient may move the film, or the operator may use an unfavourable combination of highly angulated views. The film will not collect lateral exposures however this is or less concern as lateral exposures do not contribute to high skin doses for the studies chosen.

Conclusion
Gafchromic XR-RV2 film is suitable for measuring peak skin doses in cardiology. It has a wide dose response, sufficient to cover the range of exposures observed in cardiology including high dose high risk procedures. Energy dependence is a barrier to achieving high accuracy.

Greg Betzel

Suitability of synthetic diamond films as x-ray detectors for clinical applications

Introduction: Modern techniques in a clinical environment such as radiation therapy demand superior instrumentation in order to assure that the radiation that patients receive is optimal. A promising material for radiation detection is the use of diamond, primarily due to its near-tissue equivalence (carbon), and that it is chemically inert, non-toxic and highly resistant to radiation. Unfortunately, the advantages of natural diamonds are offset mainly by their high cost as well as poor reproducibility due to the scarcity of suitable gems of consistent quality. Recent progress in synthetic diamonds obtained by chemical vapour deposition (CVD) poses to eliminate such dilemmas. The focus of the current project is to evaluate the suitability of CVD diamonds as radiation detectors and to validate them for use in a clinical setting.

Methods: Several prototype detectors have been fabricated in order to test various device parameters relevant to clinical dosimetry. Perspex build-up caps and wax were used to encapsulate the metallized films and these were irradiated in a Solid Water phantom using a 6 MV photon beam from a Varian 600C Clinac. Relative dose linearity and sensitivity of response were investigated to quantify characteristics and comparisons against a 0.6 cc Farmer ion chamber in a Solid Water phantom. Photocurrents were typically integrated over small time intervals using a 2570/1 Farmer Dosemeter. A Keithley 6430 SourceMeter using LabVIEW was also used for a variety of other, more precise measurements.

Results: Fig. 1 illustrates some results from a 200-µm polycrystalline film with a sensitive volume of 0.63 mm^3 that was exposed to 6 MV photons at 2.5 Gy/min at 90° or an "edge-on" configuration. Fig. 1(a) shows both the measured current as well as leakage (dark) current versus cumulative dose. Fig. 1(b) illustrates the resulting net average current from Fig. 1(a) as well as average sensitivity versus cumulative dose. Current and sensitivity were averaged over 2.4 second intervals. Dependence on dose rate, incident angle and applied electric field for film thicknesses of 100, 200 and 400 µm have also been investigated but are not illustrated here.

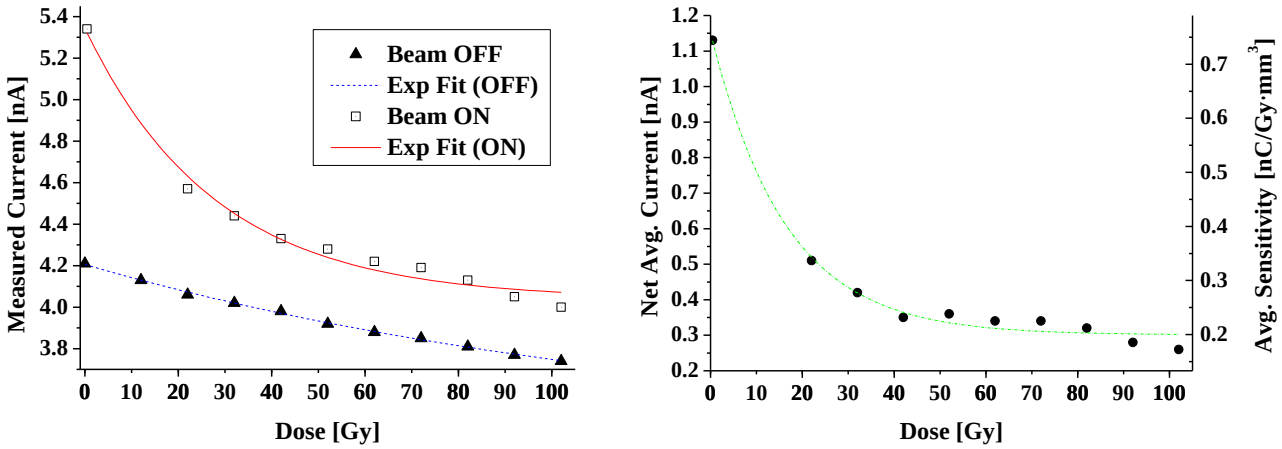


Fig. 1: (a) Measured current [nA] vs. Dose [Gy]; (b) Net Average Current [nA] & Avg. Sensitivity [nC/Gy·mm^3] vs. Dose [Gy]. Exponential fits were plotted with all data. Current was averaged over 2.4 s intervals at 247.75 V.

Discussion: Exponential saturation of dose was observed during repeated exposures. Priming of about 40 Gy was needed in order to achieve some sort of stability, but was expected given the overall quality of the sample. The exponential rise or decay of sensitivity also changed in behaviour and magnitude as a function of applied electric field, where different rise times and an initial "overshoot" of photocurrent were observed. The relationship between the net average current *I* and dose rate $\dot{D}$ followed a known power law equation $I \alpha \dot{D}^{\Delta}$. Dependence on incident angle was found to be insignificant.

Conclusions: Experimental results have been encouraging. An assessment of a variety of films and their consequential responses will continue in order to identify and mitigate or ideally eliminate inherent shortcomings.

Robert Hurst

The possibility of measuring the Lense-Thirring effect of the rotating Earth with a terrestrial ring laser gyro.

The Lense-Thirring (LT) effect is a very slow rotation of inertial frames near a rotating massive object. In the case of the Earth it is a few parts in 1010 of the Earth rotation rate. The Gravity Probe B experiment was intended to measure this using orbiting mechanical gyros, but latest news indicates the results are disappointing. Satellite laser ranging measurements claim detections but their uncertainties have been challenged and may be as large as tens of percent. Two years ago there appeared the possibility that a hugely anomalous LT effect might be measurable using a spinning superconducting mass. That hope has now faded, with a null measurement by our group.

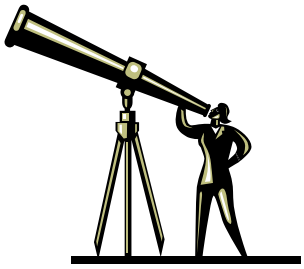
It is now worth considering the possibility of terrestrial measurement of the LT effect of the rotating Earth, with a suitable inertial rotation sensor such as a ring laser gyro. Superficially it may appear impossible to achieve measurement of an absolute rotation rate to ~1 part in 1010 or better, but many tricks can be exploited. Starting with the formula for Sagnac frequency, $fs = 4A\Omega \cos\theta / \lambda P$, (A=area, P=perimeter, $\Omega \cos\theta$=projected rotation rate) we stipulate that θ=0, that the laser is square with side L (i.e. A=L2, P=4L), and $P=N\lambda$ with N a (large) whole number. Then the Sagnac formula becomes simply $fs=N\Omega$. Errors in squareness and θ contribute only second-order errors to fs and it should be practicable to control these parameters at the level of 1 part in 105 or better. Possibilities exist for determining N exactly in a real laser. Measurement of fs to parts in 1012 should be possible with suitable good clocks. Effects such as backscatter coupling between the laser beams, dispersion in the gain medium, finite beam widths, phase changes in reflection, multilayer mirrors, etc that may cause systematic departures from the Sagnac formula must be carefully considered. If these can be kept under control sufficiently well the LT rotation may be measurable.

Peter Cottrell

R Coronae Borealis stars and related objects - a longitudinal study

Since first arriving at the University of Canterbury in May 1982 I became involved in the acquisition and analysis of photometric and spectroscopic data on the highly variable R Coronae Borealis (RCB) stars and related objects.
In this talk I will present a potpourri of our work from the earliest times on the brightest examples of the RCB stars in our Galaxy using the facilities at Mt John, through to the latest photometric work on RCB stars in the Magellanic Clouds using the Southern African Large Telescope (SALT) and our plans for extended campaigns using the University of Canterbury's guaranteed access to SALT. These stars are continuing to provide fertile areas for research.

This work would not have been possible without the large number of project and graduate students (12 to date), the on-site Mt John observers, Mike Clark, Alan Gilmore and Pam Kilmartin and collaborators in New Zealand, Australia, North America, Europe and Africa.



ABSTRACTS

Wednesday 27th August

Juergen Meyer

An adaptive tumour tracking system

Introduction: Lung cancer accounts for most cancer related deaths in the developed world. One of the challenges in treating lesions in the lung with high energy photon beams is to compensate for breathing induced movement of the tumour.
Methods: A robotic adaptive tumour tracking system is presented, which, in real-time, tracks lung tumours during radiation treatment and adjusts the patient position accordingly. The talk includes topics such as signal & image processing, imaging, mathematical modelling, infra-red tracking, optimization and robotics.
Results: Tests with the prototype system have demonstrated that it is indeed feasible to freeze the mean position of lung tumours in 3D space such that they remain fixed with regards to a stationary radiation beam. For continuous motion compensation a reduction of tumour motion of up to 68% of the original amplitude was obtained.
Discussion/Conclusions: When tracking the tumour and compensating for its motion the irradiated treatment volume is greatly reduced. The benefits of this approach are 2-fold: the side-effects for the patients are reduced and the total dose that can be safely delivered to the tumour is increased.

Andolsa Arevalo
What I did to get to New Zealand???

Karen Pollard

Songs of the Stars (of the astrophysical kind)

Many stars, including our own Sun, 'ring' like bells and show patterns on their surfaces like those on a drum that has been struck by a drumstick. The pattern of surface vibrations is governed by the internal properties of the star and results in each star having a unique musical 'voice'. The analysis of these tiny surface vibrations, used to deduce the internal structure of the star, is known as *asteroseismology.* In this talk I will describe how we are using spectroscopic observations obtained at the Mt John Observatory to analyse various non-radially pulsating stars.

Nikolai Kruetzmann

Application of complexity measures to geophysical systems

After having established the Rényi entropy (RE) statistical measure as a useful complexity measure in the context of atmospheric dynamics during my Master's thesis, I will now apply it to more observational data from satellites and further extend its utility for atmospheric analysis, during my PhD. Initial results using two years of EOS-MLS observations of nitrous-oxide are presented. Additionally, a climatology of RE calculated from 20 years of model simulation data is shown to compare well with the results of other studies of atmospheric mixing.
Furthermore, I aim to use the RE for analysing the properties and stratification of multi-annual snow pack. The RE will be tested as a tool for detecting different layers in ground-penetrating-radar measurements of the top 10-20 meters of snow cover on the Ross Ice Shelf and the slopes of Mt. Erebus, Antarctica.

Richard Graham

Ring Laser

Over the life of the ring laser project the general direction has thus far been toward building larger and more accurate instruments. Recently we have come to a limit in this direction, imposed by current mirror technology and geometrical stability.

The next generation of large interferometers for gravity wave detection require extremely precise active alignment control. In sensing rotation, the ring laser gyro has unmatched performance at very low frequency and is a candidate for sensing in such a control system, potentially allowing alignment control in all degrees of freedom. Implementation of such a system would require achieving similar performance to our very large gyros, though with a much smaller device.

Richard Graham (cont'd)
An approach to progressing in both cases is to look to avoiding the problems imposed by mirror technology and geometric stability through novel and alternative ways of running a ring laser. In this talk I will briefly detail some of my ideas to this end; namely single-mode filtering, split-mode seeding/locking and differential transverse-mode operation.

Florentina Baluti
Investigation of Monte Carlo parameters in the design of CVD diamond detector

Introduction: Measurement of the dosimetric characteristics of small diameter radiation beams require the use of small volume detectors in order to achieve high spatial resolution and to minimize the effect that the lack of lateral electronic equilibrium has on the measured dose. Radiation dosimetry based on artificial diamond made by chemical vapour deposition (CVD) presents a growing interest due to the availability of relatively cheap synthetic diamond materials with respect to the expensive natural diamond. Development of a CVD diamond detector suitable for use in small radiation fields is in process at the University of Canterbury.
Materials and Methods: Monte Carlo (MC) methods were employed to examine optimal physical properties of the detector, such as size and shape, doping impurity in the CVD, materials. DOSXYZnrc code, an accompanied MC code for EGSnrc, was used to investigate the dosimetric characteristics of the CVD diamond detector with thicknesses of 100□m for the carbon and 0.1□m for

the electrodes. DOSXYZnrc can simulate variable voxel sizes in a phantom. By varying the voxel size, the minimum voxel dimensions that can be simulated with low statistical uncertainty were determined.
For validation against experimental data, a 30x30x30 cm3 uniform water phantom of 1x1x0.2 cm3 size water voxels were simulated in a 6 MV photon beam with a field size of 10x10 cm2 perpendicular to the (X, Y) plan incident to the phantom. The simulation of the silver/carbon/silver detector structure of 1x1x0.3 cm3 were performed in a homogeneous water phantom at a 5 cm depth for a photon beam energy of 1.24 MeV on the Z direction, with 10x10 cm2 field size.
Results: Both simulation of the 6MV beam (Fig 1a) and for the CVD diamond detector (Fig 1b) are in good agreement with measured and published data, respectively. These results confirm the feasibility of the approach.
Conclusion: Monte Carlo parameters and water phantom geometry have been successfully optimized for precise simulation of the synthetic diamond detector. Further work will focus on detector geometry and structure.

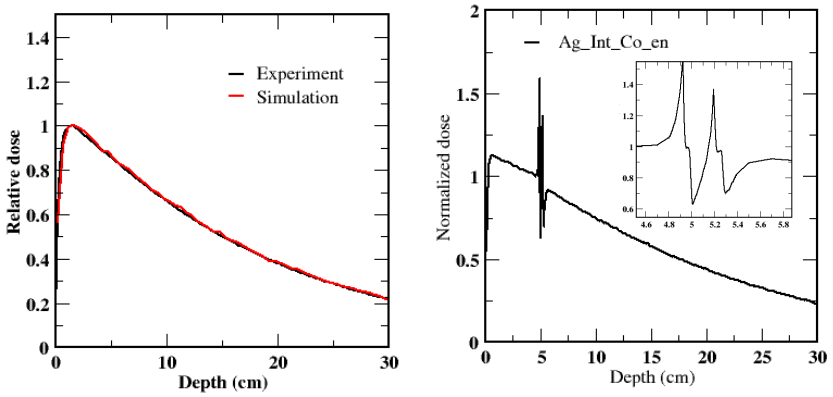


Fig. 1: (a) Dose depth comparison for simulations and experimental data for the 6 MV beam (b) Dose variation through the diamond detector

James Talbot

A Patient Position Guidance System in Radiation Therapy Using Augmented Reality

Introduction: In radiation therapy, accuracy in patient setup is essential so that dose to cancer cells is maximised and healthy tissue spared as much as possible. With the increased precision provided by highly conformal techniques such as intensity modulated radiation therapy (IMRT), the requirement for accuracy in positioning for treatment is emphasised. Traditionally, the patient is positioned through the use of room lasers and portal imaging, and recently cone-beam CT integrated linacs have become commonplace for IMRT. A significant shortcoming involved with these methods is that they do not take setup deformations to the patient into account.

Methods: In conjunction with HITLabNZ, we are developing a system that utilises augmented reality (AR) to allow the radiation therapist to visually guide the patient during positioning for treatment. AR involves the addition of computer generated 3D objects to a real environment in order to provide additional information to the user. This program superimposes a 3D surface contour of the patient (obtained from the planning CT) over a real-time image to assist the RT with position guidance. The coordinates of the 3D contour are chosen to precisely replicate the position in the planning CT.

Results: In trials of the AR system with a 30 cm wooden phantom, deformations to its position have been easily apparent and corrections can be administered with accuracy on the order of millimetres. Although the system has yet to be tested in a clinical environment, it is expected that it will operate with similar accuracy.

Discussion: A focus on simplicity has been prominent in the development of this system. It will be easy to use and inexpensive to set up, and will take up little space in a linac room. Simplicity has been emphasised because the system is not intended as an alternative to current methods of position guidance, but as a supplement for the RT to refer to for verification.

James Talbot (cont'd)

Conclusions: This system utilises augmented reality to aid radiation therapists in patient position guidance. The surface contour of the patient is obtained from the planning CT, which is displayed on a live image during treatment so that the exact position of the patient is replicated. It has so far shown excellent results with a small scale phantom, and provides a high degree of accuracy, as is required in radiation therapy. It is expected that similarly pleasing results will be obtained when it is trialed with real patients.

Anas Sedayo

Multi energy x-ray imaging in medicine

X-ray systems are used for various purposes. One such purpose is to generate dual energy images of a portion of a patient. Dual energy imaging involves acquiring two x-ray images by generating two exposures at different energy levels. The two images are acquired sequentially through use of an x-ray detector. The two images can be subtracted to create the tissue image and the bone image.

Rachel Soja

Searching for Resonance Effects in Meteoroid Streams using Meteor Radar Data

Resonance effects are observed in many forms throughout the solar system – from the Earth-Moon system, to the Asteroid Belt, and even within meteoroid orbits. Photographic meteor data has been used to show the presence of resonant gaps and concentrations in well-populated meteoroid streams such as the Perseids. Yearly comparisons of collated Taurid data have shown resonant effects exist in this complex also. The question now arises as to whether recently collected large meteor radar orbit datasets also can be used to identify such effects. Additionally, recent studies of methods of identifying clustering structure within meteor orbit data have shown the power of wavelet coefficient analysis for identifying stream structure.

Large datasets (of order 106 orbits) exist from the Advanced Meteor Orbit Radar operated by this department at Birdlings Flat, Christchurch, and the Canadian Meteor Orbits Radar of the University of Western Ontario's Department of Physics and Astronomy, London, Ontario. Though of similar size and with similar errors, these provide very different information on the meteoroid dust distribution – due to factors such as their different latitudes of observation, and their different limiting magnitudes (+13 for AMOR, +8 for CMOR), and thus mass sensitivities.

As an example, a search for resonant effects in distributions of Perseid meteors was conducted. However, the small numbers of Perseids within these datasets and the large errors for this stream mean no conclusive results were obtained, though statistical indications of six features were found. A set of appropriate streams have now been selected, dependent on resonant characteristics and radar limitations. The hope is now to apply techniques involving distributions of various observed and derived parameters, and to utilise wavelet methods, to determine whether resonance effects can be extracted in the mass regime of radar datasets.

Adrian McDonald

Mixing Antarctic Cocktails

It is well established that the large magnitude of the springtime ozone depletion in the Antarctic polar stratosphere depends on the ability of the Antarctic polar vortex (a region of strong eastwards wind in the stratosphere which encircle the Antarctic) to inhibit mixing. In particular, the vortex acts to isolate ozone poor polar air from ozone rich subtropical air. During winter, sharp transition regions in the concentrations of chemical compounds develop on the edge of the polar vortex as a result of weak exchange between the vortex and the mid-latitudes. A large number of methodologies have been developed to quantify this mixing. The vast majority of these techniques require trajectory modelling simulations and because of the uncertainty in the atmospheric velocities used can potentially provide biased results.

Adrian McDonald (cont'd)
This study examines simple analogues of the Antarctic polar vortex system, basically strong jet structures perturbed by wave-like motions, to examine the applicability and utility of various mixing measures in an idealised model environment. This study also examines the utility of a new mixing measure which relies on measuring the statistical complexity of the fields which result from mixing. Results from a number of high resolution simulations of mixing scenarios are discussed. The applicability of these models to other fields, such as oceanography, is also addressed.

Mita Brierley

Creating High Resolution Spectral Models for Globular Clusters
Globular star clusters are excellent tracers of the chemical evolution of large galaxies and so determining their properties and chemical abundances is of great importance to astronomers. For galaxies beyond the immediate vicinity of the Milky Way, we cannot resolve the light of individual stars in these clusters and can only observe the combined output of the stellar components. I am currently creating high resolution spectral models to compare to integrated-light cluster spectra in order to determine their global properties and abundances. I will describe here the construction of the models and present some initial results from comparisons to Milky Way globular clusters.

Vincent Thompson

A Study of Southern Spectroscopic Binaries
Many southern spectroscopic binaries have only poor orbital solutions, which were determined before the advent of the CCD and vacuum echelle spectrographs. Spectroscopic orbital solutions are important for accurately determining stellar mass, which is an important parameter in predicting a stars structure and evolution.
The use of the HERCULES spectrograph and the Spectral Instruments CCD in conjunction with the 1-metre McLellan telescope allowed precise radial velocity measurements of SB's (weather permitting!) which were be used to find orbital solutions.
Orbital solutions were determined for two (possibly three) single-lined SBs and the mass ratios were calculated. The determined orbital solutions were a large improvement, but with many nights unusable, the amount of quality data was less than desirable.
Also studied was the system HIP 61910, which comprises two spectroscopic binaries that form a visual pair. With very little separation between the HD 110317 and HD 110318, weather played a large role, making getting spectra that were uncontaminated difficult. Much of the data was unusable and the process of finding usable data and determining orbital solutions a challenge. A solution for the single-lined SB was determined and the double-lined SB solution is still underway.

Daniel Robertson

Temperature Dependent Phenomena in Bismuth Thin Films

Although the study of bismuth thin films is not new at UC, there has not been a great focus on the temperature dependence of the film's behaviour. It has been found that rod growth, island shape and density, instabilities, critical island size and film ripening changes with temperature. During the talk I present a phenomenological look at these areas and how they are affected by temperature. An understanding of the processes can provide a better control of the assembly of devices. The films have been grown using high purity bismuth clusters which are deposited onto highly oriented pyrolytic graphite (HOPG). The samples are prepared by cleaving them in air and placed onto a copper platform attached to two heaters inside the chamber. The chamber is then pumped down to high vacuum while the heaters heat the sample overnight to remove impurities. The heaters are then cooled to growth temperature and crucible heated to produce the flux required. The parameters used for the growths in question are a flux of ~0.18As-1, coverages of 1-5ML and temperatures of 30-160C. The samples are then imaged ex situ using the SEM and AFM. It will be shown that the following occurs with increasing temperature: rod aspect ratios and instabilities increase, island densities decrease hence critical island size increases and island fractality decreases hence ripening decreases. These effects occur due to the interplay between kinetics and thermodynamics in the different diffusion processes. A higher growth temperature means that the atoms are more able to

Daniel Robertson (cont'd)
rearrange themselves, or desorb, due to their higher energies. A higher growth flux means atoms have less time to rearrange themselves and they get 'pinned' by incoming atoms. Film ripening is a thermodynamic effect but oxygen is also theorised to play a role in the process.

Scott Joon Choi

What do I do when I am bored with Spectroscopy of Eu^{3+} in CaF_2:Eu-CdF_2 Superlattices?

Europium (Eu) defect centres in nano structures such as CaF2-CdF2 superlattices (SL's) provide an opportunity to elucidate physical properties of the host. It is due to their effectiveness to react to incoming electromagnetic radiations, such as laser excitations, Eu ion form themselves as optical probes to their host materials. However Eu3+ energy levels are discrete which requires a tunable dye laser (liquid state laser) to exactly excite particular levels. Unfortunately when the dye solution is dying it can be frustrated in operation of the laser. On the other hand Eu2+ ions do not require dye laser excitation and are still present in CaF2:Eu-CdF2 SL's. Unlike Eu3+ transitions which take place within the f shell, Eu2+ undergoes f-d transition upon UV laser excitation and interacts with crystal environment. Hence photoluminescence (PL) of Eu2+ is influenced by crystal environment. In this talk optical probing of epitaxial strain introduced SL's using Eu2+ is discussed. Also some interesting bleaching effects of Eu2+ PL are discussed. PL bleaching is best described as bi-exponential decay. Tunnelling and trapping of electrons from Eu2+ are considered here.

Martin Henseler

The Optoelectronic Structure of ZnO

ZnO has the potential to act as a key material for UV-photodetectors and emitters, gas sensors, piezo-electronics and spintronics. These devices most often require the fabrication of thin films, which can be achieved with growth techniques such as PLD and MBE.
Recently though, bulk ZnO with compelling crystal and electronic qualities has become commercially available. These high quality crystals open a new pathway for gaining a better understanding of the material properties of ZnO itself, helping to reliably relate the rather strongly varying properties of ZnO thin films grown under various conditions.
I will present an insight into the reflective and photoconductive properties of ZnO, and show how carrier concentration and crystal polarity can influence surface properties. As part of this study, unannealed pieces of bulk ZnO were investigated by modulated photoconductivity spectroscopy at low temperatures. In the high quality bulk material, additional fine structure can be seen next to the distinct bandedge features at the onset of photoconductivity that can be seen for MBE-grown films. A comparative study of spectral photoconductivity, reflection and photoluminescence allows the attribution of free excitons to some of the features observed.

David Mackenzie

Germanium Atomic Clusters: Production and Electrical Properties.

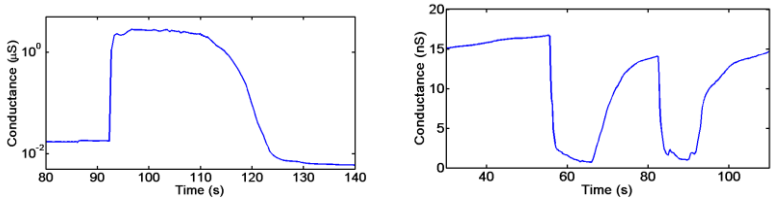
One of the main goals of the MacDiarmid Institute is to analyse the novel properties of materials whose physical dimensions fall between bulk-material and atoms. Atomic clusters are ideal for applied nanotechnology because of their nanodimensions, ease of size selection and size-dependant properties [1].

Germanium clusters were produced using an inert-gas-aggregation source [3]. The cluster diameter could be controlled by varying the source temperature and/or the inert-gas flow-rate; the range of cluster diameters was 20-70nm. Clusters were deposited onto quartz or silicon/silicon nitride substrates with lithographically-defined electrical contacts. During deposition, the conductance between the contacts was monitored; substrates were isolated from the cluster source when a non-zero level of conductance was measured.

David Mackenzie (cont'd)

The cluster films were electrically characterized whilst in vacuum. The temperature dependant conductance was measured from liquid nitrogen to room temperatures and exhibited typical behaviour for a semiconductor with a transition from intrinsic to extrinsic conduction occurring at ~220K.

As the sample was vented to atmosphere, the electrical conductance of the film increased by two orders of magnitude to 10nS at 5V. The increase in conductance was caused by surface-states being induced by oxygen. The films then acted as gas sensors; exposure to a dry gas (helium) produced surface-states and hence conduction to decrease while exposure to wet air produced an increase in surface-states and conduction. The responses for dry and wet gas are shown in Figure 1.



Peter Smale

The Cosmic Microwave Background in an Inhomogeneous Universe

Abstract

This research aims to investigate the effect of large-scale structure formation on the light we receive from the CMB. Ultimately, the aim is to recalibrate the CMB numerical codes according to the Fractal Bubble (FB) inhomogeneous cosmological model (Wiltshire, 2007). In general terms, this work addresses questions regarding the homogeneity of the universe, the nature of dark energy, and the possibility of incorporating complicated matter distributions into cosmological models.

Large-scale galaxy distribution surveys show that the universe is inhomogeneous up to observable limits (~500 Mpc). However, the uniformity of the Cosmic Microwave Background (CMB) shows that the early universe was close to homogeneous and isotropic. So we see the universe as lumpy on smaller scales, but we also have very good reason to believe it is homogeneous and isotropic on the largest scales. There is much debate over where the scale of homogeneity may lie. It seems natural to ascribe the departure from homogeneity to gravitational clumping and the evolution of large-scale structure sometime between the inception of the CMB at z~1100 and the current limits of the large-scale surveys at z~3. There is also much debate over whether the observed inhomogeneity might be sufficient to affect cosmic expansion.

High precision CMB temperature measurements provide a rigorous objective standard against which to test cosmological models. The computer codes for numerically computing the CMB temperature anisotropy power spectrum are calibrated to a homogeneous (FLRW) cosmological model and allow only some constant, global curvature value. Beyond the surface of last scattering, the validity of this approximation is uncertain.

The two-scale fractal bubble (FB) cosmological model of Wiltshire (2007) accounts for the evolution of cosmic structure into the void-dominated situation we observe today. I would like to see if it will be possible to incorporate the FB geometry into the CMB codes. Essentially, this amounts to looking in detail at how the formation of large-scale structure affects the way we see the CMB (the integrated Sachs-Wolfe effect).

In this talk, I will explain a few features of the power spectrum of the CMB temperature fluctuations, with particular reference to the Sachs-Wolfe effect, and then explain why it could be very important to take adequate account of the complicated matter geometry that has been revealed to us over the last ten years.

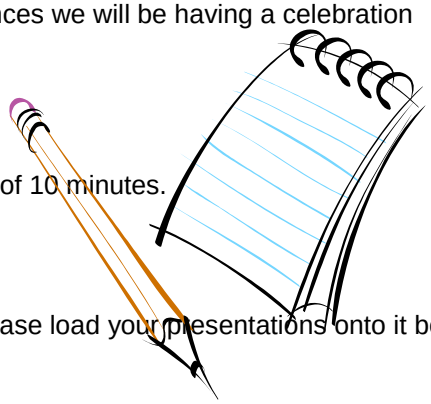
Adrian McDonald (Postgraduate Coordinator)

The PhD Student Experience in Physics and Astronomy: How can we improve?

This presentation will describe the results of the recent UCTL survey on the PhD experience in the College of Science and particularly the results for Physics and Astronomy. This talk will identify the strengths and weaknesses of the department in the students view and also ask for comments/suggestions on how the department might operate more effectively to help our postgraduate students. This is your chance to tell us how to improve your postgraduate experience!

OPENING

As this is our 25th Anniversary of our Departmental Conferences we will be having a celebration morning tea on the first day at 10:30am. All welcome.



NOTES FOR SPEAKERS

1. Please keep your presentation to the allocated time of 10 minutes.

   5 minutes is allowed for discussion after your talk.

2. A computer and data projector will be available. Please load your presentations onto it before the start of your session from a memory stick or CD.

3. Talks will be recorded for educational and historical purposes. If you do not want your talk recorded please let the chairman of your session or Juergen Meyer know as soon as possible.

RESEARCH STUDENT TALKS

The B.G. Wybourne prize will be awarded for the best research student talk while the Department will be awarding prizes for 2nd, 3rd and 4th placed research student talk. This year's judges will be our Erskine visitors Doug Hamilton and Lewis Ryder plus Graeme Plank and Juergen Meyer.

Last year the B G Wybourne Prize went to Nikolai Kruetzmann and the Department prize was shared by James Flewellen, Clare Worley and Paul Miller.

AFTER CONFERENCE GATHERING

Members of the Department are all welcome to attend the end-of-conference BBQ and prize-giving to be held at the Staff Club following the last talk.