DEPARTMENT OF PHYSICS & ASTRONOMY
College of Science

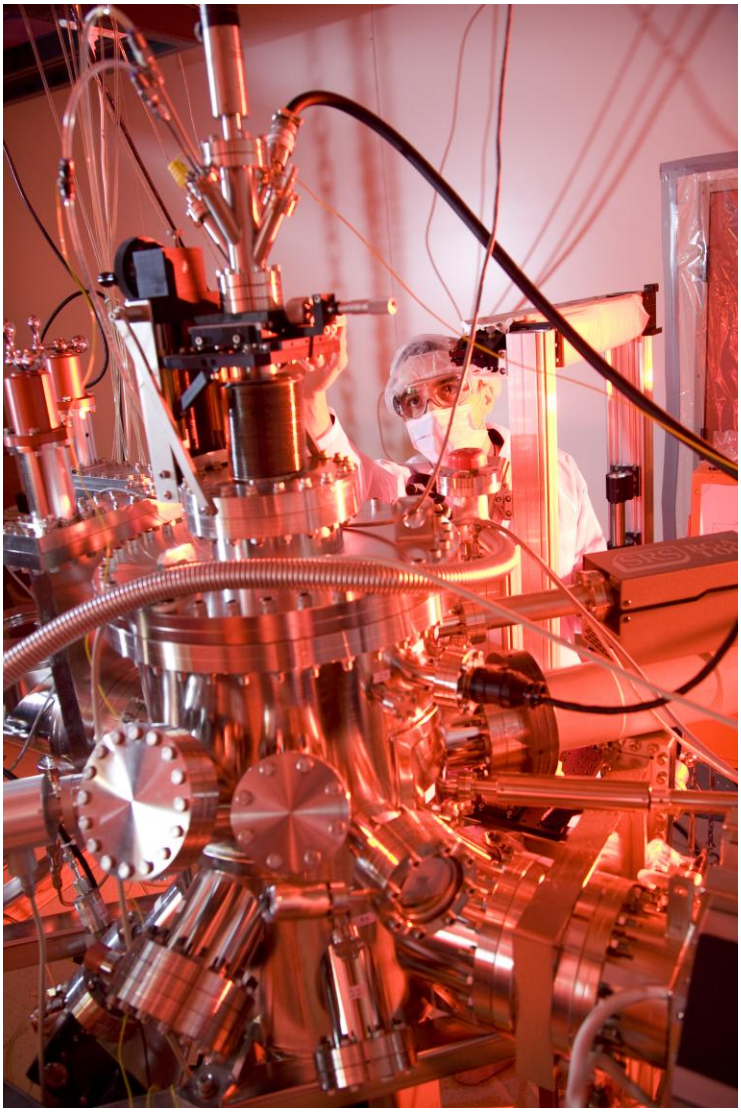
UC
UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

28TH DEPARTMENTAL CONFERENCE

Tuesday 23th August and Wednesday 24th August 2011

Eskine031

PROGRAMME



Tuesday 23rd August

10.30 – 10:55 MORNING REFRESHMENTS – MATH101

10:55	Welcome	Jenni Adams
Session 1	***Chairperson:***	***Jack Baggaley***
11:00	Roger Reeves	Photoluminescence properties in bulk ZnO
	PhD in 3 Dept Heats	
11:15	Nish Rabeendran	Progress toward a solid state ring laser gyroscope
11:25	Emily Brunsden	The Music of the Stars - Astroseismology is the study of vibrational physics in stars
11:35	John Holdaway	Canterbury Earthquakes: Using Ring Lasers for Seismology
11:45	Simon Parsons	Future Weather Patterns in New Zealand: Changes in the Frequency of The Kidson Types
12:00	Young-Wook Song	Photoluminescence study of Molecular Beam Epitaxy grown Mg-doped InN thin films
	Full Presentations	
12:10	Nikolai Kruetzmann	Application of complexity measures to geophysical systems
lunch		
Session 2	***Chairperson:***	***Raja Aamir***
1:30	Robert Doesburg	The MARS Camera: a digital colour x-ray camera using the Medipix family of photon counting chips
1:45	Oscar Macias-Ramirez	Electroweak Constraints on an anomaly-free Little Higgs model with $SU(4)_L \otimes U(1)_X$ gauge symmetry
2:00	Alistair McDougall	Early Microlensing Event Detection
2:15	Abdul Sattar	IV characteristics and quantized conduction in Sn percolating films
2:30	Dimitri Schritt	Gravity – finding a unified theory within an algebraic approach
2:45	Teyu Chyou	A 3D Vision Approach for Correction of Patient Pose in Radiotherapy
pm tea		
Session 3	***Chairperson:***	***Ian Farrell***
3:30	Cheng-Yang Lee	A new generation of quantum field theory
3:45	Alicia Cavan	Initial investigation of digital holographic interferometry as a pseudo-calorimetric dosimetry method for microbeam radiotherapy (MRT)
4:00	Peter Smale	Rough with the smooth

Wednesday 24h August

10.30 – 10:55 MORNING REFRESHMENTS – MATH101

Session1	***Chairperson:***	***Kane O'Donnell***
11:00	Anthony Brown	Gamma-ray astronomy at UC
11:15	Alex Salkeld	Modelling of Trap-Liberation Processes In Excitonic Lanthanide-Doped Crystals
11:30	Adrian Reynolds	Dynamic processes in the line-shift and line-width of alkaline earth fluoride crystals doped with Er^{3+}
11:45	Hamish Silverwood	Supersymmetric Dark Matter in IceCube
12:00	Raja Aamir	Characterization of Si and CdTe sensor layers in Medipix assemblies using microfocus x-ray sources
12:15	Andrew Dallow	ν Octantis: a close binary with a possible planet
lunch		
Session 2	***Chairperson:***	***Giles Reid***
1:30	Konstantin Ivanovskikh	Spectroscopy and dynamics of excited states of lanthanide ions under excitation with synchrotron radiation
1:45	Ahsan Nazer	The Cosmic Microwave Background Radiation
2:00	Daniel Robertson	The Plausibility of Quantum Realism
2:15	Shawn Fostner	Controlled nanoscale device fabrication on insulators in UHV
2:30	Jeffrey Simpson	Stellar parameters and barium abundances in ω Centauri GB by spectral matching
2:45	John Holdaway	Canterbury Earthquakes: Using Ring Lasers for Seismology
3:00	Ojas Mahapatra	Bright beaches of near Fermi energy electron density on the edges of bismuth islands on HOPG

CONFERENCE CLOSES

5:15 pm onwards — Retire to Department Seminar Room 701, Rutherford Building for end-of-conference function and presentation of prizes.

Pizza and refreshments will be available from 5:15 p.m.

Tuesday 23th August

Roger J. Reeves

Photoluminescence properties in bulk ZnO

ZnO is a wide-bandgap semiconductor that is experiencing a resurgent interest as applications in optoelectronics become apparent. To fully realize its potential an understanding of its doping and defects is required. Bulk samples in the form of thick wafers are now becoming available from several suppliers using different growth techniques. Such samples provide platforms to analyse the intrinsic properties of ZnO as well as characterizing the different impurities that are incorporated during growth.

Our experiments use photoluminescence (PL) to examine the optical performance of bulk ZnO samples from several suppliers. More than 10 different excitonic features have been identified in low-temperature PL where the electron hole-pairs are either bound to different impurities or there are other second order exciton effects.

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'PhD in 3' – Department Heats

Nishanthan Rabeendran

Progress toward a solid state ring laser gyroscope

Currently we are much closer to building a solid state gyroscope than ever before. This talk will cover the progress of the gyroscope development, from a linear laser to the recently built ring laser. Initial efforts used erbium and ytterbium-doped phosphate glass material as the gain medium. This material proved to be fragile and difficult to pump. Lately we have concentrated on neodymium-doped glass.

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Emily Brunsden

The Music of the Stars - Astroseismology is the study of vibrational physics in stars.

Gravity-modes of pulsation in Gamma Doradus stars are of particular interest as they probe deep into the stellar interiors. My PhD thesis deepens our understanding of these modes under the influence of stellar rotation. I will share the mode identification of frequencies found in the slow-rotating star HD135825 and fast-rotating HD12901 and what this means to us.

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John Holdaway

Canterbury Earthquakes: Using Ring Lasers for Seismology

A ring laser is essentially a gyroscope which is used to measure fluctuations in the rotation rate of the Earth to a high degree of accuracy. The cavity of a ring laser supports two independent, oppositely directed travelling waves in closed paths: one beam traverses the cavity clockwise, while the other simultaneously travels in the anticlockwise direction. The optical frequencies of these two waves are dependent on the speed with which the cavity rotates in inertial space. For a ring laser cavity on the rotating Earth, there will be a difference in the oscillation frequency of the two waves due to a slight path length difference upon each circuit of the cavity; measuring this frequency difference (the Sagnac frequency) allows precise measurements of the rotation rate of the Earth.

The UG3 ring laser at the Cashmere Caverns laboratory has gathered useful data from many hundreds of mid-range earthquakes (magnitudes ~2-5) since September 2010. When an earthquake occurs, the surface of the Earth in the vicinity of the epicentre is warped by a very small but detectable amount. With knowledge of factors such as the magnitude, distance, depth and orientation of the quake relative to the UG3 ring laser, it is possible to determine information about the permanent rotation shifts that result from these distortions. Prior to September 2010, we had never had a sufficiently large amount of earthquake data from Canterbury to allow for a statistically significant analysis; however, with the swarm of earthquakes over the past year this is no longer the case. In this talk I will discuss some of the findings from the analysis of ring laser earthquake data to date.

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Simon Parsons

Future Weather Patterns in New Zealand: Changes in the Frequency of The Kidson Types

Understanding climate change and variability at a regional level is a significant challenge for the current generation of global climate models. In particular, circulation patterns at a synoptic level need to be well resolved. The overarching goal of this research is to explore and understand regional climate variability over New Zealand. Quantifying the potential effects of climate change, to aid informed decision-making by policy makers. This research expands on the methodology and work of Kidson's, synoptic classification system, known as "Kidson types". The frequency of the present day synoptic scale features (Kidson Types) are compared against the frequency of future types using reanalysis (NCEP/NCAR and ERA40) and IPCC AR4 GCM (20c3m and A1B emission scenarios) data over New Zealand (domain of latitude 25°S-55°S and longitude 160°E-175°W).

A high level of confidence is required in the GCMs ability before it can be used in a predictive capability. Therefore, an initial study has been undertaken to determine the suitability of this methodology and test the GCM's ability to resolve synoptic circulation patterns over New Zealand. Early results show that GCM (20c3m runs) echo the reanalysis data and reinforce the results of previous studies. However, further investigation has revealed that the type frequency appears to be insensitive to change and results from a sensitivity analysis are used to demonstrate this lack of acuity. Further work will focus on the level of forcing required to significantly perturb the Kidson type frequencies.

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Young-Wook Song

Photoluminescence study of Molecular Beam Epitaxy grown Mg-doped InN thin films

In the past decade, considerable research progress has been made to control electron affinity in acceptor doped InN which allows the growth of high quality single crystal thin films of infrared bandgap semiconductors. This enables a more detailed understanding of its nature which is of interest in its own right in addition to being relevant to the potential In-rich InGaN alloy based electronics. Still, the presence of an electron accumulation layer on all surfaces regardless of the polarity is problematic. Owing to this ever-present surface layer, the deliberate attempt to achieve a direct electrical p-type contact is yet to be accomplished. In optical properties by contrast, pronounced improvements have been made recently in terms of luminescence efficiency and quality. Of the potential acceptor candidates, magnesium (Mg) is well known to be the most suitable material for *p*-InN, having sufficient incorporate acceptors to compensate native n-type impurities. A careful selection of substrate and employed templates minimize the hetero-epitaxial lattice mismatch. This often contributes the presence of native defects such as nitrogen vacancies and dislocation through a wide range of background concentrations. Applying those factors in practice, producing the band-to-band and excitonic luminescence lines near band-edge are now feasible. Furthermore, a systematic excitation intensity and temperature-dependent photoluminescence study of MBE grown Mg-doped InN thin films has been undertaken and compared with theoretical expectations. In order to support the preliminary interpretation, Variable field magnetic Hall (VFH) measurements were performed in parallel to corresponding observations.

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Nikolai Kruetzmann

Application of complexity measures to geophysical systems

After having established the Rényi entropy (RE) statistical measure as a useful complexity measure for identifying tracer gradients related to mixing barriers in the stratosphere in 20 years of model simulation data, I intended to also use it for analysis of high frequency (500 MHz) ground penetrating radar (GPR) surveys of Antarctic snow. However, the amplitude gradients caused by reflections from layers of different density in dry snow turned out to be too weak to be successfully identified with the RE. Instead, an alternate processing methodology, the deterministic Fourier deconvolution, was successfully applied to consecutive GPR measurements made one year apart, allowing estimates of compaction rates within the snow pack. Also, the RE is useful as a pseudo gain-function for lower frequency (25 and 50 MHz) GPR profiles that contain few but strong reflections, e.g. from the bottom of an ice shelf or the bed of a glacier.

Finally, I will also show the results of applying the RE to seven years of observational data from the EOS-MLS satellite. Depending on the chemical tracer used (e.g. carbon-monoxide or nitrous-oxide) mixing barriers can be identified at various altitudes in the stratosphere and mesosphere and large-scale dynamical process such as the development and break-up of the polar vortices throughout the winter seasons can be observed.

Supervisors: Dr. Steve George (University of Tasmania), Dr. Adrian McDonald (Physics & Astronomy), Dr. Wolfgang Rack (Gateway Antarctica)

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Robert Doesburg

The MARS Camera: a digital colour x-ray camera using the Medipix family of photon counting chips

Semiconductor radiation detectors developed at CERN have proven useful beyond high energy physics, and CERN encourages technology transfer through collaborations such as the Medipix Collaboration. The MARS Project plays an active role in the Medipix3 (MP3) collaboration in the application of Medipix, a novel spectral x-ray imager, to biological CT.

The MP3 chip is an array of 256x256 pixels, each 55um square, with energy thresholding and coincidence detection of x-ray photons in the clinical diagnostic range from 10 to 120 keV. Sensor layers of several types of semiconductor material properties can be bonded to the pixel electronics ASIC.

The latest generation of the MARS camera utilises a tiled array of MP3 chips. It is designed for use in the MARS-CT scanner, the first commercially available spectral CT system for use with small animals, developed by researchers in Christchurch. My work contributes to the design, debugging and integration of the electronic and software systems of the MARS camera and Medipix chip carriers with the MARS-CT system. I will introduce the principles of spectral x-ray imaging, focus on its implementation in the Medipix chip and MARS camera, and show some recent results of research by the MARS team.

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Oscar Macias-Ramirez

Electroweak Constraints on an anomaly-free Little Higgs model with $SU(4)_L \times U(1)_X$ gauge symmetry

We calculate the tree-level contributions to electroweak observables in the context of a simple group little Higgs model with approximate [SU (4)/SU (3)]^4 global symmetry and with anomaly-free embeding of the $SU(2)_L \times U(1)_Y$ electroweak gauge group into $SU(4)_L \times U(1)_X$. By performing a global fit to 22 observables we bound the $Z - Z'$ mixing angle θ, and obtain lower bounds on the mass of the corresponding physical new neutral gauge boson Z_2, and on the parameter scale f associated to the SU (4) → SU (2) breaking. Electroweak precision data produce the constraints $2.4 \times 10^{-5} \leq \theta \leq 1.3 \times 10^{-3}$, $M_{Z2} \geq 1.83$ TeV, and $f \geq 2.34$ TeV.

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Early Microlensing Event Detection

Alistair M^c^Dougall

Microlensing is an astronomical effect predicted by Einstein's General Theory of Relativity. A microlensing event is caused when the light from a source star passes very close to another star (the lens star), which results in a magnification of the total amount of light observed from Earth. But what happens when the lens star is not on it's own, could it be a binary star system, or possibly a planet orbiting the star?

Survey telescopes operate every night (weather permitting) identifying events of interest for follow up telescopes to focus on, this produces a large amount of data but unfortunately this also contains bad data points. Current ad-hoc methods are used to remove this bad data, but not without introducing new problems. The method I will present is used to model the data without the need to remove any bad data points, and I will show how this new method is being developed for an automated early event detection system.

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Abdul Sattar

Abdul Sattar, Pierre Y. Convers and Simon A. Brown

IV characteristics and quantized conduction in Sn percolating films

Nanowires and thin percolating films formed by atomic clusters have unique properties, making them suitable for various electronic devices. Such devices include non-volatile memories based on nanostructures, which have gained a lot of attention recently. In particular, switching devices based on memristors and atom-mechanics have shown promising results.

In this study, conductance variations of Sn nanocluster films are investigated under different applied voltages and at various temperatures. Sn films show interesting I-V behaviour showing switch-like properties, with quantized conductance. These properties could prove useful as a basis of a memory device. Clusters of ~7 nm diameter were deposited on SiN substrates with prefabricated NiCr/Au electrodes. Cluster films with thickness of the order of 2 ML were formed with a deposition rates of ~0.15 Å/s. The I-V characteristics of Sn cluster films were measured *in situ*. The conductance changes in a stepwise fashion as the voltage is swept from -10V to 10V. The conductance jumps between discrete levels. Similar steps were observed in Bi cluster films. The Sn clusters coalesce into larger interconnected islands of ~200 nm which form a percolating network. The conductance of the film is due to the current paths through these islands and is limited by the necks between them.

The step behaviour is temperature dependent: no steps are observed when the films are cooled down to 77K. Initial data suggests that the temperature dependence of the conductance is smaller compared to the expected variation in a thin film of similar dimensions. This is consistent with a model of quantized conduction through small necks in the film formed between percolating conducting paths (which have temperature dependent conductance).

Further investigations of Sn cluster films show that the step behaviour is quantized, similar to that of break junctions. Peaks in histograms near multiples of the quantum conductance are observed. The slight shift from exact values of G_0 is likely to be due to disorder in conducting channels.

The switching behaviour in Sn cluster films may be due to electromigration-like effects which result in forming and breaking the necks between conducting islands. It can be speculated that the necks between clusters are similar to break-junctions. Moreover, the quantum effect is clear evidence for presence of nanowire-like current pathways in the cluster films.

MacDiarmid Institute for Advanced Materials and Nanotechnology, Physics & Astronomy Department, University of Canterbury

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Dimitri Schritt

Gravity – finding a unified theory within an algebraic approach

Much of the successes of modern physics can be traced back to two algebras: the Lorentz algebra and the Heisenberg algebra. As the names suggest, the former underlies special relativity and electromagnetism while the latter provides the foundation of quantum mechanics. The attempt to formulate a theory consistent with both special relativity and quantum mechanics led to the development quantum field theory. A big question remains, what is gravity and where does it come from? We here seek to outline the problem of finding a unified theory of nature within an algebraic approach and provide an overview of how one might attempt to address the issue.

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Teyu Chyou

A 3D Vision Approach for Correction of Patient Pose in Radiotherapy

Quantitative evaluation of the accuracy of patient positioning and posture correction will require the knowledge of coordinates of the patient contour. When a three dimensional object is viewed through a standard camera, the depth information along the axis parallel to the line of sight is lost. With the aid of a projected structured light codification pattern, 3D coordinates of the scene can be recovered from a 2D image. This form of 3D vision is known as active stereo with structured light.

From the intrinsic parameters of a calibrated camera, a vector in camera coordinates representing the direction of the incident light can be calculated for every camera pixel. In a similar way, stripes projected by a projector can be thought of as planes of light in 3D space. An equation of plane in camera coordinates can be calculated for every projector rows and columns from calibration data. By solving for the point of intersection between a plane and a line, the 3D coordinates of points in the codified scene can be recovered.

Two codification strategies, spatial encoding, and temporal encoding, were examined. Spatial encoding methods requires a single static pattern to work, thus enabling dynamic scenes to be captured. Temporal encoding methods require a set of patterns to be successively projected onto the object, the encoding for each pixel is only complete when the entire series of patterns has been projected. Initial trials of the temporal method on a realistic phantom have shown high sensitivity to surface features even under the light condition of a typical office.

If found sufficiently accurate, the 3D vision technique can then be integrated with augmented reality, the combination of the two can provide both a virtual contour of optimal patient position for visual guidance, and quantitative measurements of offsets from actual patient contour.

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Cheng-Yang Lee

A new generation of quantum field theory

An important chapter in the development of modern quantum field theory begins with Wigner's 1939 paper. He showed that particle states in the Hilbert space can be characterised by their mass and spin. A systematic formalism to describe the Wigner states quantum field theoretically was developed in a series of papers by Weinberg in the 1960s and were later brought together in his classic monograph on the quantum theory of fields.

However, the Wignerian demand of unique mass and spin for the particles as incorporated in the work of Weinberg leads to the limitation that the resulting quantum field does not naturally allow the observed phenomena as neutrino flavour oscillations. We propose a new generation of quantum fields which allows for particle states that do not have definite mass and spin. The application to the vector bosons of the Standard Model are given as evidence in support of this program.

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Alicia Cavan

In collaboration with Richard Watts, University of Vermont, Burlington, VN, USA and Juergen Meyer, University of Canterbury, Christchurch, New Zealand

Initial investigation of digital holographic interferometry as a pseudo-calorimetric dosimetry method for microbeam radiotherapy (MRT).

Microbeam radiotherapy using synchrotron generated microbeams is a promising technique for cancer treatment. A current limiting factor in its clinical application is the need for accurate determination of the peak-to-valley dose ratios experimentally. This proof-of–principle work aims to use optical interferometry to perform pseudo-calorimetry to characterize the dose profiles of the microbeam array.

The fundamental idea is to infer the absorbed dose deposited by the radiation beam to a water phantom by measuring the change in refractive index of the absorbed media as a result of a small increase in temperature.

Our initial approach is to use a lensless Fourier Digital Holography set-up, with a HeNe laser and a CCD camera to measure small refractive index variations in simplified phantoms. The holographic interferograms are reconstructed to measure and visualise this variation. One of the challenges with this method is the thermal diffusion in the phantom. To investigate this, the first step is to simulate the dose/temperature profile at a macroscopic level in a phantom, producing a high temperature gradient profile, and the resultant thermal diffusion after the initial heating period can then be examined.

Initial results show successful reconstructions of objects from the experimental interferograms, and work is ongoing to acquire phase information from these in order to be able to measure the small variations in path length difference that will be required. Further implementation of this method has potential for use to measure the distinctive dose profile of synchrotron produced microbeams.

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Peter Smale

Rough with the smooth

The scatter of galaxy distances versus their redshifts in the local universe ($z < 0.1$) is small enough for Hubble to have discerned that galaxies recede from us at a rate proportional to their distance. This shows that the local universe cannot deviate much from homogeneity (Sandage et al., 1972). But surveys of large-scale structure show that nearby matter is also strongly clustered (de Vaucoleurs, 1970), which suggests that local motions should be so great as to swamp the signal from global cosmic expansion. This question has been dubbed the *Sandage-de Vaucoleurs* paradox, after the two main protagonists. In this talk I will illustrate this paradox, and discuss how the theoretical preference for uniformity in cosmology, so strongly vindicated by the cosmic microwave background from the early universe, is being confronted by observations of hierarchical clustering on ever-increasing scales.

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DAY TWO

Wednesday 25th August

Anthony Brown

Gamma-ray astronomy at the University of Canterbury

The field of astroparticle physics aims to understand the high energy processes in our Universe through the use of neutrino, gamma-ray and cosmic ray observatories. Each of these observing techniques give us a unique view of the Universe and when deployed in a Multi-Messenger approach, allow us to probe objects and physical processes we would have otherwise been blind to. Through the IceCube Collaboration, the University of Canterbury has a strong on-going contribution to our understanding of the neutrino Universe. However the University's contribution to the field of astroparticle physics now includes gamma-ray astronomy through my work with the Fermi Gamma-ray Space Telescope. In this talk I will review and discuss this on-going work with Fermi.

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Alex Salkeld

Modelling of Trap-Liberation Processes In Excitonic Lanthanide-Doped Crystals

Analysis of the structure and behaviour of excited states of the ytterbium-doped crystals, CaF2 and SrF2, is the focus of ongoing two-colour excitation experiments being conducted by Jon-Paul Wells, Pubudu Senanayake, and Mike Reid. Initial UV excitation of these crystals causes a valence electron to become delocalised from its host ytterbium ion, forming a stable exciton state bound to the lanthanide defect. A tunable IR excitation is then used to probe the structure of excited states within the bound exciton state by measurement of emission enhancement. In addition, this IR radiation can be of sufficient energy to liberate electrons from trap states caused by defects in the crystal lattice. The effects of the liberation of these trapped electrons can be observed in the decay rates of the emission.

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Adrian Reynolds

Dynamic processes in the line-shift and line-width of alkaline earth fluoride crystals doped with Er^{3+}

In this experiment we study the temperature dependence of the line-width and line-position of Er^{3+} doped CaF_2, BaF_2, SrF_2 and $CsCdBr_3$. This is done by studying the infrared absorption spectra at a range of temperatures. The transitions are then assigned by comparing them to theoretical models and previous studies, and the line-position and line-width are plotted. These plots then have a curve fitted according to the theory, taking into account direct single-phonon processes as well as Raman scattering. This helps to show which processes are dominant in which transitions, giving a better understanding of the systems.

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Hamish Silverwood

Supervisors: Jenni Adams, Anthony Brown

Supersymmetric Dark Matter in IceCube

Evidence from galactic rotation curves and gravitational lensing suggests that a large proportion of our universe is made up of 'dark matter' that interacts only very weakly with the regular matter we are accustomed to. The nature of this dark matter is currently unknown - there are several theoretical candidates but none have been experimentally verified. One such candidate is supplied by a theory known as Supersymmetry (SUSY), which posits that all the particles we currently know have superpartners that are too massive to have been created and then detected at previous particle accelerators. SUSY not only solves several problems currently facing particle physics but also provides a dark matter candidate, known as the Lightest Supersymmetric Particle (LSP). These particles only interact very weakly with regular matter, and so are very hard to detect. However over time they will accumulate in the centre of massive celestial bodies such as the Sun, where their increased density will increase the rate of self annihilation, which in turn produces a flux of high energy neutrinos. These high energy neutrinos can potentially be detected with the IceCube Neutrino Telescope in Antarctica. Consisting of a cubic kilometer of ice instrumented with thousands of sensitive photomultiplier tubes, IceCube can detect the tiny flashes of light emitted by neutrinos when they interact with the ice. By analyzing the amount and distribution of light we can reconstruct where the neutrino came from and how much energy it had.

The aim of this research is to utilise Monte Carlo methods to search through the SUSY parameter space looking firstly for points that satisfy current experimental observations and then to simulate the signals they produce in IceCube. These simulated signals will be later utilized to find and analyze dark matter signals in IceCube data.

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Raja Aamir

R Aamir, N G Anderson, A P H Butler′, P H Butler, S P Lansley, R M Doesburg, J L Mohr, M F Walsh, S J Nik, R Zainon

Characterization of Si and CdTe sensor layers in Medipix assemblies using microfocus x-ray sources

We report here on our characterization of high-Z semiconductor sensor bump-bonded to Medipix ASIC, when used as detectors built into an x-ray spectral CT scanner of our design. This scanner, dubbed MARS (Medipix All Resolution System), has provided energy selective images of small animal and pathology specimens.

The best understood sensor is silicon but silicon sensors are transparent above 30keV. Distinguishing higher-Z contrast agents such as gold (incorporated into nanoparticles) and gadolinium requires the use of x-ray energies upwards of 100keV and thus higher-Z semiconductor sensors. Higher energy is also essential for full body CT.

Si and CdTe sensors bump-bonded to Medipix detector ASICs are characterized by imaging flat fields (i.e. without an attenuating specimen between the x-ray source and the detector) using the MARS-CT scanner system.

For CdTe, the majority of the 512×256 pixels exhibit a signal within 10% of the mean response across all pixels. However, a ring of higher sensitivity pixels has been observed around the edge of the detector. Zero sensitivity regions have also been found, surrounded by high and low sensitivity pixels. The high sensitivity observed in these regions and those around the edge of the detector probably results from larger collection volumes contributing to the signal of these pixels. A texture pattern is also observed on overall detector.

Once the detector is characterized, the MARS scanner can be used to give spectral CT images of small animal and pathology samples.

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Andrew Dallow

ν Octantis: a close binary with a possible planet

The ν Octantis spectroscopic binary consists of a 1.4 $M_{\odot}$ (primary) with a 0.5 $M_{\odot}$ (secondary) orbiting 2.55 AU from the primary every 2.9 years. Ramm (2009) discovered a 52 m/s radial velocity (RV) perturbation with a period of 417 days in this system. Pulsations, rotation, and star spots have been ruled out by looking at photometric stability, wavelength dependent trends and bisector analysis. A possible cause of this perturbation can be a 2.5 $M_{Jupiter}$ planet with a semi major axis of 1.2 AU. However, when assuming a “normal” prograde coplanar orbit, celestial mechanics predicts this orbit is unstable, contradicting the observed stability.

Simulations by Eberle and Cuntz (2010) showed a retrograde orbit for the planet to be stable for at least 1×10^7yr. They also show that the stable orbit region for a retrograde orbit is just under double that of a prograde orbit for at least 10,000 yr, but fail to explain why this occurs.

In this project, we performed a 2×10^7 yr simulation of the retrograde orbit on UC's bluefern super-computer, and found it remained stable. Longer simulations of 1×10^8 yr are currently underway.

The 5:2 period resonance of the binary orbit to the planetary orbit was investigated to determine if this was the key to the retrograde orbit stability and if other resonances exist. Simulations over semi-major axes range of 1.22 - 1.8 AU showed that no other resonances are present. However, more simulations need to be done at different masses, eccentricities, and inclinations to get a better understanding.

If resonance is not the key a possible theory of relative velocities between the two orbit configurations could explain the increase in the range of stable orbits, whereby, the gravitational perturbation of the secondary acts on the planet over a shorter time interval in a retrograde orbit, therefore, destabilises the planetary orbit a lot less. This is currently being investigated.

Confirmation of the existence of this perturbation will be done using spectroscopic data collected over the period 2009 - now, which incorporates an iodine cell to correct for instrument effects in the RV profile. Using Iodine, radial velocity precision is approx. 3 ms^{-1}, as opposed to 16 ms^{-1} without it. These data will be used to determine if the planet's phase has remained the same and if there are any other planets within the system previously undetectable.

References:

Eberle, J., & Cuntz, M., 2010, The Astrophysical Journal 721: L168.

Ramm, D.J., Pourbaix, D., Hearnshaw, J.B., & Komonjinda, S., 2009, Monthly Notices of the Royal Astronomical Society 394: 1695.

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Konstantin Ivanovskikh

Spectroscopy and dynamics of excited states of lanthanide ions under excitation with synchrotron radiation

Insulator materials doped with lanthanide ions find numerous applications in modern optical, lighting, scintillator, electronic technologies, etc. Successful application of existing materials and development of new ones is irrespectively connected with deep understanding of energy level structure of lanthanide ions and processes related to relaxation dynamics of excited states and interactions between the lanthanide ion and electronic states of host material.

As soon as insulator materials of interest possess wide band gap (7-9 eV), the development of an adequate model, describing the intrinsic and impurity electronic excitation and its subsequent relaxation, requires performing an experimental research in a broad spectral range from the visible to VUV (up to 30 eV). This may allow the investigation of processes related to the creation and relaxation of low- and high-energy excited 4f and 5d states of RE^{3+} ions and internal defects (4-9 eV) and states related to autoionization states of RE^{3+} ions, RE^{3+} traped excitons, electron-hole pairs, etc. Moreover, since many relaxation processes have a very short characteristic time of 10^{-10} - 10^{-5} s, it is required to employ pulsed excitation and time resolution in the sub-ns range. These requirements can be successfully met by employing a synchrotron radiation source as an excitation source.

This talk will outline possibilities and advantages of applying the synchrotron radiation for spectroscopic and dynamics study of lanthanide doped materials. Moreover, some recent experimental results will be demonstrated.

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Ahsan Naser

The Cosmic Microwave Background Radiation

The Cosmic Microwave Background Radiation (CMBR) is relic radiation from a time when the Universe was about three hundred thousand years old. The CMBR can be used to extract information about the geometry, age and the proportions of dark matter and dark energy contents of the universe. The cosmological parameters obtained from the CMBR serve to test different cosmological models. In this talk I will give an outline of how the Timescape model can be tested against the CMBR data.

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Daniel Robertson

The Plausibility of Quantum Realism

In the first half of my thesis I argue that Arthur Fine is justified in his analysis of the scientific realism debate because of his in-depth knowledge of the history and philosophy of quantum mechanics. However, I think that Fine's position, the Natural Ontological Attitude, is only a precursor to possible quantum realism and so I spend the second half of the thesis analysing the plausibility of quantum realism. In the last main chapter especially, I focus on what quantum physics can give us in the way of answering questions about scientific realism by considering the following two questions:

- Does it mean anything to speak of the individuality of a quantum particle?
- What does quantum physics tell us about what is real?

The first question is important since the most promising form of quantum realism hinges on this question, while the second is important because under the Copenhagen interpretation, reality does not exist until measured. Throughout the talk, I will give answers to these questions as well as possible directions for new inquiry.

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Shawn Fostner

S. Fostner [1], J. Topple [2], A. Tekiel [2], P. Grütter [2]

Controlled nanoscale device fabrication on insulators in UHV

Our aim is to use an ultra high vacuum atomic force microscope (UHV-AFM) to image the atomic structure of electrically contacted molecules on insulators. This is particularly critical for molecular electronics measurements where a detailed knowledge of both the contact geometry and chemical nature are crucial to critically test theoretical models. In order to make this connection from the macroscopic realm to the nanometer scale of individual molecules we use a combination of techniques, including micrometer scale stenciling techniques, electromigration of nanoscale wires, and field assisted deposition of metallic atoms from metallic scanning probe tips. It is this final aspect of the process that I will discuss here.

Scanning probe AFM is a powerful technique for imaging and manipulating individual atoms on the atomic scale with high precision. It has also been demonstrated that under the right configurations it is possible to use these tips to not only manipulate the existing surface structure, but to potentially deposit metals or molecules.

We have succeeded in using field assisted metal deposition using sharp scanning probe tips to deposit metal atoms on an insulating surface in a unique geometry using nearby metallic surface electrodes to provide sufficient potential drop between tip and surface. I will discuss some of the applications of this process to our device fabrication as well as the basic deposition procedure. Additional insight into the parameters controlling this field emission process are gained from electrostatic modeling using finite element methods over an insulating surface with a nearby metallic film as a counter-electrode in an attempt to calculate barrier heights for the deposition process. The calculated barrier heights roughly agree with the observed deposition characteristics and lead us to suggest further improvements in the reliability of the process.

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Jeffrey Simpson

Stellar parameters and barium abundances in ω Centauri GB by spectral matching

We have been using 2dF spectral data (R∼2000) of ω Cen to extract s-process elemental abundances, focusing on barium using the 4554 A line. At the resolution of the spectra, the aim is to make an order of magnitude assessment as to whether the star has no enhancement, some or up to +1 dex [Ba/Fe]. There is evidence that there is a trend in [Ba/Fe] across the RGB from the blue to red edges. The blue edge of the RGB displays no barium enhancement, while the red-side is +1 dex.

This work has involved determining temperatures using 2MASS photometry and spectral fitting to find the log(g), [Fe/H] and [Ba/Fe]. This has been done using a χ^2 fitting process. We will present aspects of the technique used and the astrophysical results in this presentation.

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John Holdaway [full presentation]

Canterbury Earthquakes: Using Ring Lasers for Seismology

A ring laser is essentially a gyroscope which is used to measure fluctuations in the rotation rate of the Earth to a high degree of accuracy. The cavity of a ring laser supports two independent, oppositely directed travelling waves in closed paths: one beam traverses the cavity clockwise, while the other simultaneously travels in the anticlockwise direction. The optical frequencies of these two waves are dependent on the speed with which the cavity rotates in inertial space. For a ring laser cavity on the rotating Earth, there will be a difference in the oscillation frequency of the two waves due to a slight path length difference upon each circuit of the cavity; measuring this frequency difference (the Sagnac frequency) allows precise measurements of the rotation rate of the Earth.

The UG3 ring laser at the Cashmere Caverns laboratory has gathered useful data from many hundreds of mid-range earthquakes (magnitudes ~2-5) since September 2010. When an earthquake occurs, the surface of the Earth in the vicinity of the epicentre is warped by a very small but detectable amount. With knowledge of factors such as the magnitude, distance, depth and orientation of the quake relative to the UG3 ring laser, it is possible to determine information about the permanent rotation shifts that result from these distortions. Prior to September 2010, we had never had a sufficiently large amount of earthquake data from Canterbury to allow for a statistically significant analysis; however, with the swarm of earthquakes over the past year this is no longer the case. In this talk I will discuss some of the findings from the analysis of ring laser earthquake data to date.

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Ojas Mahapatra

Collaboration with Pawel J Kowalczyk, Simon A Brown

Bright beaches of near Fermi energy electron density on the edges of bismuth islands on HOPG

The surface of Bismuth (110) is a striking example of the possible differences between surface and bulk properties because the surface is much more metallic than the bulk due to existence of electronic surface states [1]. We describe the formation of islands of Bi (110) on HOPG (highly oriented pyrolytic graphite) substrate. The islands exhibit tiered structure with paired layers on top of a 3 ML base.

We demonstrate via STM imaging performed at 50 K, sharply defined linear protrusions at the edges of the islands (which we refer to as bright beaches) when scanned under bias voltages <100 meV. The enhanced tunneling current is observed on most of the monolayers of bismuth which constitute the island. Similar features were reported by Yin et al [2] on potassium islands formed on graphite and Ludwig et al [3] on isolated straight edges of Cu (111) which were related to the well known surface state oscillations.

We speculate that contrary to the observations in literature, the bright beach phenomenon observed in our data could have a different origin. The paper discusses various factors which could be responsible for ‘bright beach’ effect using STM, STS, XPS (X ray photoelectron spectroscopy) and TEM (transmission electron microscopy) techniques.

[1] Yu. M. Koroteev, G. Bihlmayer, E. V. Chulkov, S. Blügel, Physical Rev. B 77 (2008)045428
[2] F. Yin, J. Akola, P. Koskinen, M. Manninen, R. E. Palmer, Physical Rev Letters 102 (2009)106102
[3] Ludwig Bartels, S. W. Hla, A. Kuhnle, G. Meyer, K.-H. Rieder, J. R. Manson, Physical Rev B 67(2003) 205416

Abstracts for presentation later this year

Domagoj Belić

Domagoj Belić[1], Simon Brown[1]

Ag-Au nanoclusters: structure and phase segregation

[1]The MacDiarmid Institute for Advanced Materials and Nanotechnology, Department of Physics and Astronomy, University of Canterbury, Christchurch 8140, New Zealand

We show that Ag-Au nanoclusters exhibit size-dependent icosahedral and decahedral motifs and are initially fully and homogeneously alloyed. We then present evidence that over a period of up to 2 years, the nanoclusters undergo remarkable structural transitions into phase-segregated core-shell and Janus particles with Ag-Au cores and AgxG shells (G = O, S). Larger Janus particles undergo a surprising ripening process which results in division into separate Ag-Au-rich and Ag_2G-rich particles. We discuss the role of oxidation and sulfidation on the observed phenomena.

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Christoph Bergmann

Finding Earth-mass planets around α Centauri

Our neighbouring star system α Centauri is an exciting and auspicious target for scientific research. Not only is it very close (d =4.37 ly), but it is also a triple system, whose main components α Centauri A and B are stars similar to our Sun. It has been found that no giant planets exist in the α Centauri AB binary system, yet several theoretical studies of planet formation in this system predict the existence of smaller planets with a few Earth masses. We are continuosly taking spectra of α Centauri with the 1m-McLellan telescope together with the HERCULES spectrograph at Mt. John University Observatory (MJUO) to measure the radial velocities (RV) of both stars. Our goal is to detect the tiny Doppler wobble (~ 0.1 ... 1m/s) that a planet of a few Earth masses would induce on its host star. I will present an approach to increase the accuracy of the radial velocity (RV) measurements, which will potentially also enable us to take twice as many observations in the same time. The idea behind this approach is to include template spectra of both stars during the modeling of the observation. Therefore the radial velocities of both stars can be obtained contemporaneously for every observation. This is also especially useful for observations taken during bad seeing conditions, when some amount of light from the other star enters the fibre and contaminates the desired spectrum. We can then determine the amount of contamination and hence use the correct template flux ratio for the modelling. This method can then also be applied to other double lined spectroscopic binaries (SB2s), to search for planets orbiting these systems. This opens up a new window in the parameter space of planet search programs, as SB2s have usually been excluded from planet searches due to the difficulties that come along with blended spectra. Another possible application of the above mentioned method are daytime observations of α Centauri (or any other very bright star), where the second spectrum is essentially the Solar Spectrum scattered in the Earth's atmosphere.

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Naomi Flatman

Collaborating with the University of Washington.

An analysis into the role of positron emission tomography in the treatment of cervical cancer through the use of Bayesian networks.

Positron emission tomography (PET) imaging has been shown to be a more sensitive and specific imaging modality than both computed tomography (CT) and magnetic resonance imaging (MRI) in the assessment of disease progression in cervical cancer. This introduces the question as to whether or not the additional information gained from PET images affects treatment decisions, potentially

improving the clinical outcome of patients. The impact of PET imaging on detecting the presence of disease, specifically in lymph nodes, can be incorporated into a model of the clinical situation. This model can describe the probabilistic connection of the elements used in the treatment decision making process by use of Bayesian statistics forming an influence diagram. An introduction to Bayesian networks will be presented, highlighting the benefit of their use in medical decision making. The construction process and methods used to validate models will also be discussed, using the network currently being constructed to model cervical cancer as an example.

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Kaidi Liang

Fibre optics approach to radiation dosimetry

The challenge in radiation therapy is to deliver a precise dose of radiation to the target. Several dosimetric techniques are available to measure the ionizing radiation, but they have limitations. In particular, the non-tissue equivalence of the detector housing and the sensitive volume leads to perturbations of the beam fluence and necessitates correction factors. Another constraint placed on the conventional dosimetric techniques is the limited resolution. The above are an issue in small field dosimetry or when high dose gradients are presents, such as in e.g. micro beam radiotherapy. The aim of this project, as a proof of principle, is to develop a fibre optics setup that accurately measures the radiation beam profile and the absolute radiation energy imparted in the given sample. The approach is quasi-calorimetric in nature and is based on one fundamental principle; the energy imparted by the radiation beam is converted into heat in the medium and as the temperature increases, the optical properties of the water also change - effectively a change in the refractive index. The goal then is to determine the refractive index change through the change in the detected phase of the image in order to find the difference in the optical path length. If the relationship between the temperature and refractive index is known then the absolute change in refractive index can be related to the temperature change, hence the radiation dose delivered into the phantom. This refractive index can be measured through interferometry by passing a laser beam through the irradiated medium and combined with a reference arm to form an interference pattern to determine the change in the optical path length of the laser beam. Current progress shows that visible markers and its phase information can be clearly distinguished in the recordings and further efforts are being made to detect less visible differences in an object in order to extract the phase information to determine the optical path length.

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Pubudu Senanayake

Two colour excitation experiments on Ytterbium doped Fluoride crystals.

We have studied an array of host crystals doped with Ytterbium under two colour excitation experiments involving a pulsed UV laser and the Dutch Free Electron Laser, FELIX (Free Electron Laser for Infrared eXperiments). Of particular interest has been hosts that display anomalous emission under excitation into the 5d energy state, whose origin has been identified as impurity trapped excitons. Our experiments have focused on probing the structure of these excitons directly utilizing the tunability of FELIX. Here we will present the results obtained throughout the last year of these experiments as well as a conceptual explanation of the observed phenomena. In particular we will focus on presenting two cases of observations, namely, Ytterbium doped Calcium Fluoride and Strontium Fluoride.

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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 and test it to check software compatibility.
3. Talks will be recorded for educational and historical purposes. If you do not want your talk recorded please let the chairperson of your session or Graeme Plank know as soon as possible.
   Note: you must use the wireless lapel microphones as this is the source for the recordings.

RESEARCH STUDENT TALKS

This year as we are running the 'PhD in 3' Department heats in conjunction with standard research presentations. Book vouchers will be awarded to first and second places in both competitions.

In the full presentation section The B.G. Wybourne prize ($200 book voucher) will be awarded for first place and the Department will award second prize of $150.00. Prizes to the same value will be awarded to first and second by the Department in the 'PhD in 3' competition

Last year (2010) the B G Wybourne Prize went to Sebastian Horvath and the Department prizes were shared by Pubudu Senanayake, Emily Brunsden and Ojas Mahapatra

- $200 book vouchers (B.G. Wybourne prize) - 1st Sebastian Horvath
- $150 book vouchers (2nd) - Pubudu Senanayake
- $100 book vouchers (3rd) - Emily Brunsden
- $50 book vouchers (4th) - Ojas Mahapatra

AFTER-CONFERENCE GATHERING

Students and staff members of the Department are all welcome to attend the end-of-conference gathering and prize-giving to be held in the Department's Seminar Room 701 from 5:00 p.m.