16th National Congress 2005

AUSTRALIAN INSTITUTE OF PHYSICS

Physics for the Nation

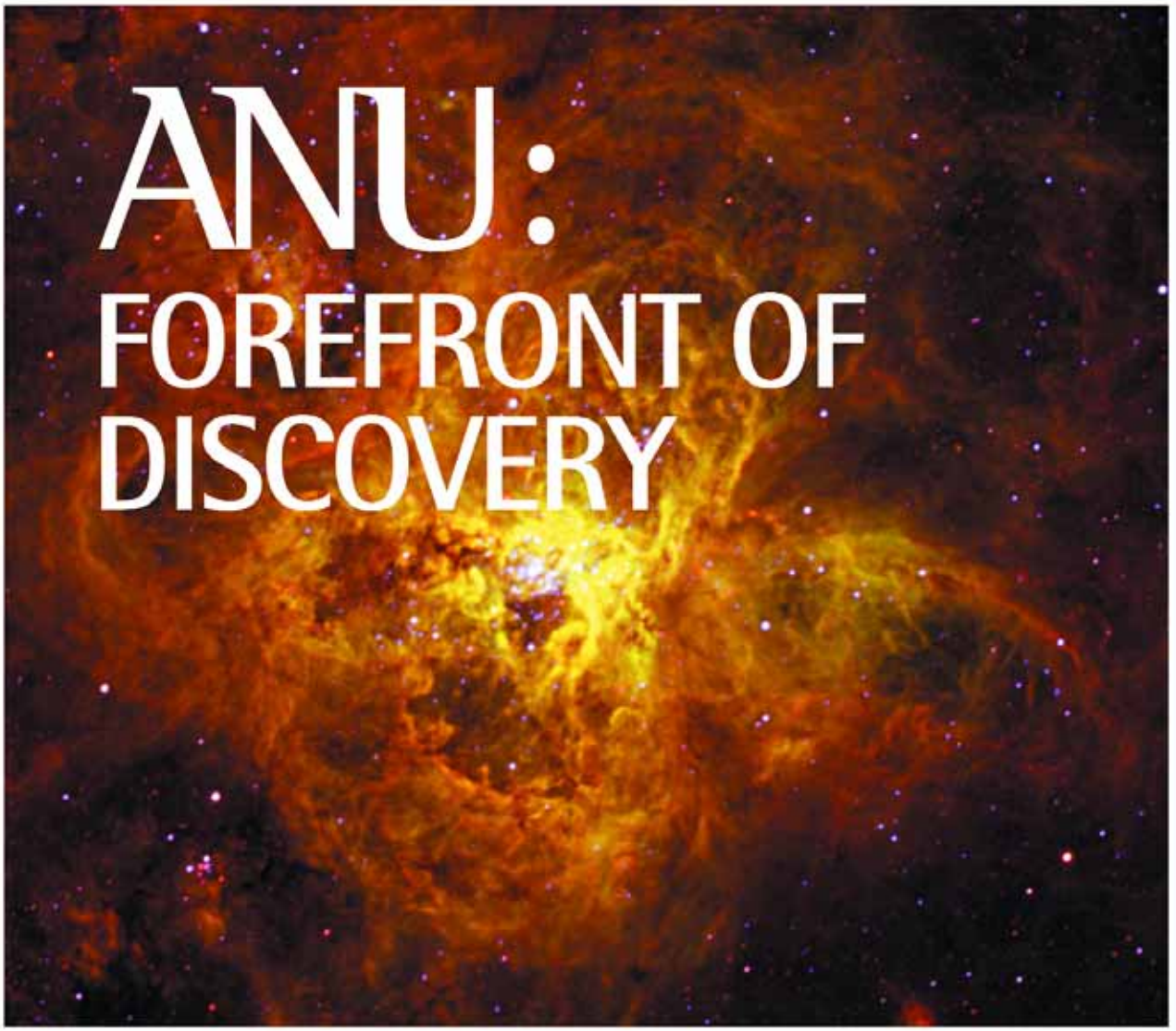


Manning Clark Centre
Australian National University Canberra

Sunday 30 January to Friday 4 February 2005

Congress Proceedings Handbook and Abstracts

http://aipcongress2005.anu.edu.au



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- Australian Optical Society
- Australian Society of Exploration Geophysicists

Associated Conferences

- Australian Institute of Physics (AIP)
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  —Physics Education Group (PEG)
  —Women in Physics Group (WIP)
- Astronomical Society of Australia (ASA)
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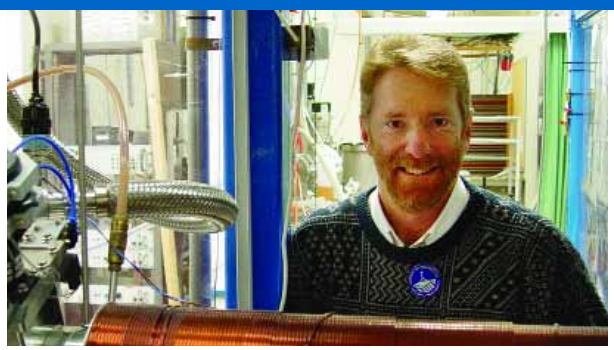

Welcome from the Congress Chair

Dear Colleagues,

In this, the 2005 International Year of Physics declared by the UN, the AIP Congress will bring together for the first time15 Physics-based societies and topical meetings to commence celebrations for the 2005 IYP in Australia. With over 750 abstracts received and more than 850 participants, this will be the largest ever gathering of Australian physicists.

In the 100 years since Einstein's miraculous discoveries, Physics has changed our lives. Australia has made an important contribution to this change, and we have exemplified this in the Congress theme *Physics for the Nation*.

During the Congress, we hope that you will contribute to this process and hear of the exciting advances made by our colleagues, and by the stellar cast of international speakers. I hope that you will also be able to participate in the Congress Dinner in the magnificent setting of the Great Hall of Parliament House, and witness the presentations there on the benefits Physics has brought to Australia's economic, cultural and environmental wellbeing.

The quality of the scientific and social programme for the Congress has only been made possible through the major financial backing of our Congress sponsors and exhibitors. Many of them are also contributors to the Congress theme, so I invite you to view their technical presentations at the Congress Exhibition and at the Great Hall.

This theme is also being brought to the general public through our Outreach Programme in which I would encourage you all to participate. This includes the William Sutherland lecture on Monday, the National Press Club lunch on Tuesday, the Outreach sessions on Wednesday afternoon, and the public lecture on Thursday evening.

I hope you will enjoy the week's events, and welcome to the 16th Biennial Congress of the Australian Institute of Physics!

Ken Baldwin
CONGRESS CHAIR

Welcome from the Programme Chair

Dear Colleagues,

The Congress programme covers almost all aspects of Physics, and we are pleased that so many associations have chosen to hold their annual meetings as part of the Congress. This ensures that we have a representation from many disciplines, and it offers you the opportunity to find interesting, new information outside your own subject.

The plenary sessions in the mornings will give you overviews in a wide spectrum of topical issues, ranging from fundamental to Applied Physics. Further detailed topic areas are covered in six parallel sessions—with over 70 keynote speakers. For your convenience they appear either at the beginning or the end of session, so you can change from one topic to another and sample a wide variety of keynote addresses. Please celebrate the achievements of Physics in all its different forms.

The topics represent all the traditional areas, but also span wider topics, such as Quantum Physics or Complex Systems, which are included in many of the sessions. Many of the presentations have been included as proceedings on the CD that you have received with this handbook.

The poster sessions provide a forum of discussions, with up to 50 posters per topic area where you will find many interesting ideas and enthusiastic presenters. Enjoy this opportunity to show your work and find out information in detail through personal contact.

We are pleased to find such strong support from Europe and the US for our sessions. This merges well with the excellent work we are producing in Australia. In many categories the selection has been very competitive, and this shows the lively activity in the Australian Physics community.

Hans Bachor
PROGRAMME CHAIR

Welcome from the AIP President

Dear Colleagues,

On behalf of the Australian Institute of Physics (AIP) I should like to welcome you to the 16th Biennial Physics Congress in Canberra. The AIP supports and promotes Australian Physics and physicists and this Congress is an important element of this mission. This year's Congress will also launch the AIP's celebration of the centenary of Einstein's 'miraculous' year, the year in which he laid the foundations for much of modern Physics.

The AIP Congress is the largest domestic Physics conference in Australia and the 2005 meeting will see around 800 delegates meet in Canberra to present and discuss the latest developments in their specific fields. The programme will include some 750 oral and poster presentations, an impressive list of keynote speakers and an outstanding collection of national and international plenary speakers, including two Nobel Prize winners. A dedicated outreach session for students and the general public is also scheduled for Wednesday afternoon and will officially begin the AIP's 'International Year of Physics (IYP2005)' activities.

The Congress also provides an excellent opportunity to publicly acknowledge the contributions of outstanding individuals and will include the presentation of AIP prizes and awards. These will be presented at a special ceremony on Friday afternoon, and will include: the 2003 Bragg Gold Medal for the best PhD thesis (Dr Michael Bromley—CDU), the 2004 Alan Walsh Medal for service to industry (Dr Brian Sowerby and Dr James Tickner—CSIRO), the inaugural AIP Education Medal (Dr Mario Zadnik—Curtin), the 2004 Walter Boas Medal (Prof. George Dracoulis—ANU), the 2004 Women-in-Physics Lecturer Award (Dr Nanda Dasgupta—ANU), and the Harrie Massey Medal, a joint IOP-AIP award for outstanding contributions to physics (Prof. Peter Drummond—UQ).

Finally, I should like to take this opportunity to thank all those who have contributed their time and effort to ensuring the success of the 2005 Congress. This includes members of the Organising and Programme Committees, the Congress secretariat, and the many others who have made formal and informal contributions. However, special thanks are reserved for Dr Ken Baldwin, the Chair of the Organising Committee, and Prof. Hans Bachor, the Chair of the Programme Committee for their prodigious efforts in coordinating the overall event.

I hope you enjoy the AIP's 16th Biennial Congress.

Robert G. Elliman

Robert Elliman
AIP PRESIDENT

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- **Nuclear & Particle Physics (NUPP)** Aidan Byrne, Faculties/RSPhysSE, ANU
- **Optics, Photonics, Lasers (AOS)** Neil Manson, RSPhysSE, ANU
- **Plasma Physics (PP)** Jeff Harris, RSPhysSE, ANU, John Howard, RSPhysSE, ANU
- **Relativity and Gravitation (ASGRG)** David McClelland, Faculties, ANU
- **Renewable Energy (RE)** Andrew Blakers, CSES, Engineering, ANU
- **Solar, Terrestrial & Space (STSP)** Iver Cairns, University of Sydney
- **Synchrotron Science (ASRP)** Mark Ridgway, RSPhysSE, ANU
- **Women in Physics (WIP)** Anna Wilson, RSPhysSE, ANU

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Events Programme

Physics in Industry Forum
Sunday 30 January

1000–1800 hrs

Manning Clark 1 (MC1), ANU

In keeping with the Congress theme *Physics for the Nation*, the Physics in Industry Forum aims to highlight the application of Physics in the economy. In consultation with industry, a range of Physics contributions with commercial outcomes will be presented, with discussion on enhancing commercialization prospects.

0930–1000	**Registration and morning tea**
1000–1015	**Opening and Welcome**

MORNING SESSION
Chair: Mark Ridgway

1015–1030	*Richard Garrett*—"Introduction to Synchrotron Radiation and the Australian Synchrotron—a 10 Minute Primer"
1030–1115	*Liz Towns-Andrews*—"Industrial Applications of the Daresbury Synchrotron Radiation Source (SRS)"
1115–1145	*Gerry Roe*—"The Australian Synchrotron—Industry Engagement through the Physics Community"
1145–1215	*Chris Davies*—"Synchrotron Radiation Investigation of Twinning in Extruded Magnesium Alloy AZ31"
1215–1330	**Lunch**

AFTERNOON SESSION
Chair: John Love

1330–1400	*Grant Griffiths*—"What is Industrial Physics in the 21st Century?"
1400–1430	*Tony Farmer*—"Sub-Surface Radar—From Coal to SiroPulse II"
1430–1500	*Tony Lindsay*—"Self-Organising UAV Formations—DSTO R&D"
1530–1600	**Afternoon tea**

EVENING SESSION
Chair: David Thorncraft

1600–1630	*Martin Elias*—"Manufacturing Photonic Components"
1630–1700	Bluescope Steel—*Bryan Scott*—"From Innovation to Application—a Case Study in Iron Making"
1700–1730	*Davies Collison Cave*—"Patents and The Real World"
1800	**Welcome Reception**

1030–1115 hrs Liz Towns-Andrews

CCLRC—Daresbury Laboratory, Warrington, Cheshire, UK, e.towns-andrews@cclrc.ac.uk

Industrial Applications of the Daresbury Synchrotron Radiation Source (SRS)

The SRS provides state-of-the-art analytical techniques from infrared to hard X-ray wavelengths. The characteristics of synchrotron radiation are ideal for analytical problems that require high spatial or temporal resolution or problems that are simply intractable using conventional instruments. An increasing number of large scale facilities exist worldwide, but are traditionally used by universities and higher education institutions for pure R&D. In recognition of the needs of commercial customers, Daresbury Laboratory has established DARTS (Daresbury Analytical Research and Technology Service). DARTS offers unique services tailored to the needs of the customer, allowing access to synchrotron analytical facilities and also the significant expertise and knowledge of staff on site. The analytical portfolio offered by DARTS encompasses imaging, spectroscopic and structural characterisation techniques. The nature of problems and issues solved by DARTS is varied and includes: investigations of product failure and non-conformance, manufacturing issues, basic R&D and information used in expert witness cases. This presentation will outline the concept of DARTS and the approach taken at the SRS towards industrial customers. It will provide practical examples and case histories of how an analytical service such as DARTS can help to improve industrial processes in a range of business sectors.

1115–1145 hrs Gerard Roe

Australian Synchrotron Project
Department of Innovation, Industry and Regional Development (Victoria), Melbourne VIC
gerry.roe@iird.vic.gov.au

The Australian Synchrotron—Industry Engagement through the Physics Community

The Australian Synchrotron will be a national facility that will provide world class capability to a broad cross-section of Australian scientists and technologists, including the physics community. A synchrotron light source provides the capability to access and manipulate a major part of the electromagnetic spectrum, enabling new research, development and innovation. The Australian Synchrotron Project is committed to driving processes that enable industry users to generate valuable outcomes by engagement with the facility.

Events Programme

The central feature of a synchrotron is an electron storage ring that produces electromagnetic radiation (light) that is many orders of magnitude more intense than from conventional laboratory sources. The light is directed down beamlines to endstations where samples are analysed. The Australian Synchrotron will have capacity for as many as 35 beamlines operating simultaneously and independently. Available measurements will include X-ray absorption spectroscopy, X-ray fluorescence, X-ray diffraction, small angle X-ray scattering, X-ray imaging electron emission and infrared spectroscopy. These techniques can be used to characterise composition and structure, from the atomic level through to the macroscopic, and so a synchrotron provides tools to elucidate relationships between structure, composition, properties and function of samples.

In order for the physics community to deliver value to industry, there must be engagement between the public and private sectors. Communication must be encouraged, and the types of opportunities discussed must be proactively pursued. The Australian Synchrotron will provide a unique forum where scientists and technologists from across sectors and disciplines will interact, and industry programmes will be driven forward. The physics community is a key stakeholder group, and physicists will play crucial roles in the development of this national collaborative research infrastructure.

1145–1215 hrs Chris Davies

C.H.J. Davies[*‡], *S. Yi*[§‡], *J. Bohlen*[‡], *K.U. Kainer*[‡], *H.-G. Brockmeier*[§‡].
** School of Physics and Materials Engineering, Monash University, Victoria, Australia; § Institut für Werkstoffkunde und Werkstofftechnik, der Technischen Universität Clausthal, Germany; ‡GKSS-Forschungszentrum, Geesthacht, Germany.*
Chris.Davies@spme.monash.edu.au

Synchrotron Radiation Investigation of Twinning in Extruded Magnesium Alloy AZ31

If predictions are to be believed, the use of wrought magnesium is set to increase dramatically over the next five to ten years as auto manufacturers and others seek to lightweight components. However, this increased use will rely in part on improved understanding of the deformation of these metals. Many alloys with a hexagonal close packed crystal structure show a marked anisotropy of yield when comparing compression with tension, and while the cause of this anisotropy is known in a qualitative sense, the effect has yet to be adequately quantified. The importance of this can be illustrated by imagining a car component made from magnesium. In an impact the component will typically have a tensile and a compression face, and in magnesium—unlike aluminium and steel—differential yielding will occur, with the compressive face yielding first and a consequent shift in the neutral axis of the component. Car designers must be able to model such behaviour if magnesium is to be used in large volumes in automotive applications.

AZ31 is a commercially available magnesium extrusion alloy containing 3 wt% aluminium, 1 wt% zinc and 0.3 wt% manganese. The initial texture of the bar is one in which the hexagonal unit cell c axes are principally normal to the extrusion direction, but with a slight spread in the extrusion direction, coupled with a component with a significant spread towards the transverse direction. Using synchrotron radiation with an energy of 70 keV, and wavelength 0.196Å, *in situ* room temperature tension and compression tests were conducted at HASYLab in Hamburg. The results of these experiments are presented for each orientation, and the implications for the anisotropy of yield in textured magnesium alloys is discussed.

1330–1400 hrs Grant Griffiths

Assistant Chief, CSIRO Industrial Physics, Lindfield NSW, grant.griffiths@csiro.au

What is Industrial Physics in the 21st Century?

Grant will highlight some of the significant changes that have taken place in CSIRO in the last two years and the new directions for the Industrial Physics division. He will explore some of the exciting physics-based research and current innovation in the organisation and look forward to how this work will have its impact on industry.

1400–1430 hrs Tony Farmer

CSIRO Industrial Physics, Lindfield NSW, tony.farmer@csiro.au

Sub-Surface Radar—from Coal to SiroPulse II

The techniques of Sub-Surface Radar, SSR, (or Ground Probing Radar, GPR) have been applied to many practical problems since the middle of the 20th century and CSIRO Industrial Physics has been an active player in this field since the 1980's. Our research has covered a wide variety of potential application areas and this presentation will attempt to trace the path of technology development leading to commercial products. The range of research problems will be discussed along with some of the difficulties encountered in commercialising scientific research.

Events Programme

(cont.) The success of our current product in the market-place will be presented along with future prospects in a range of application spaces.

1430–1500 hrs Tony Lindsay

Electronic Warfare and Radar Division,
Defence Science and Technology Organisation,
Edinburgh SA
tony.lindsay@dsto.defence.gov.au

Self-Organising UAV Formations—DSTO R&D

Uninhabited Aerial Vehicles (UAVs) have found increasing utility in Defence and security applications. Technology advances that enable smaller and cheaper payloads (including sensors, processors and communications systems) are stimulating totally new concepts and opportunities. Investigating the trade-offs for utilising small, expendable formations of cooperating vehicles versus large, multifunction vehicles is an area rich in R&D challenges including payload design (eg miniaturisation and system-on-chip integration concepts), autonomous agent algorithms for "swarm" control, technologies for distrbuted data fusion and algorithms for network optimisation (scheduling strategies for space, time, frequency, . . . (n-dimensional) coverage).

This talk will describe the R&D being undertaken in the field of distributed UAVs for electronic warfare, and the role being played by Australian industry in turning the modelling and simulation into reality.

1600–1630 hrs Martin Elias

Technical Director, AOFR Pty Limited
Canberra BC ACT Australia
martin.elias@aofr.com, www.aofr.com

Manufacturing Photonic Components

The resurgence of the telecommunications industry is generating increasing demand for fibre optic network components. AOFR has been developing and manufacturing photonic components for 20 years using proprietary equipment designed for high volume, low cost production. The design of the products includes a number of features that ensure high reliability under harsh environmental conditions. Automated manufacturing equipment and processes enable close control of the optical characteristics of the products and flexibility in meeting a wide variety of specifications. The presentation will cover some key aspects of product and process design that enable the company to meet the evolving demands of the market.

1630–1700 hrs Bluescope Steel

Bryan Scott, Senior Development Engineer,
Ironmaking Technology & Development,
Bluescope Steel, Port Kembla

From Innovation to Application—a Case Study in Iron Making

There is no single clear path from research innovation to industrial application. Academia is at the forefront of discovering new knowledge, often outside the context of real-world problems and oblivious to potential applications. Industry is in the business of addressing and solving challenging real-world problems, but is often blind to potential solutions already existing in the academic world. Clearly stronger interaction between academia and industry would benefit both parties.

This presentation describes the evolution of an "innovation-to-application" pathway between the Australian National University and Bluescope Steel, in relation to the development of coherence imaging systems , a spin-off from basic plasma physics research, for high-temperature pyrometry within the heavy industry environment of an integrated steelworks. The role of industry in providing focused application (direction) for further development of academic innovation is discussed, together with the equally important and complementary requirement for academia to showcase innovation in a readily accessible and "industry-friendly" way.

1700–1730 hrs Leon Allen

Davies Collison Cave, Melbourne, VIC
mail@davies.com.au, http://www.davies.com.au

Patents and The Real World

A practical look at the monopoly conferred by patents focusing on the importance of the wording of patent claims and how they are interpreted by the courts. The factors that can determine the final form of claim wording and the consquences for the resulting protection will be examined through some case studies.

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Current and emerging research themes

- Defence and homeland security related areas
- Astrophysics and optics
- Complex adaptive systems
- The economic/religion interface
- Environmental modelling and engineering
- Hypersonics
- Image and video processing
- Labour movements
- Knowledge transfer and innovation
- Leadership
- Management and economic issues
- Materials science
- Photonic quantum information technologies
- Uninhabited aerial vehicles and control

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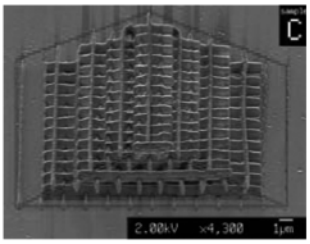
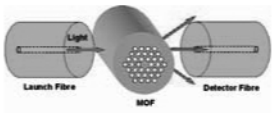
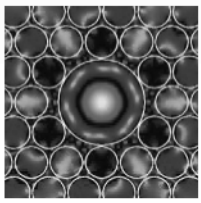
The aim of the **Microphotonics** project is to design, fabricate, characterize and model 3-D polymer-based photonic crystal structures. The demonstration of a photonic crystal superprism is of particular interest because of its startling optical properties.

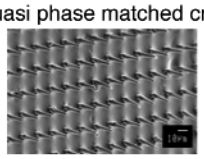


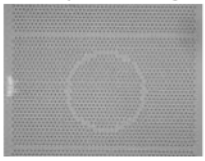
The **Micro-structured Optical Fibre (MOF)** project explores novel MOF designs for use in photonic device applications. MOFS are being explored for device applications and optical interconnects to provide efficient connections from standard single-mode fibers and planar waveguides.



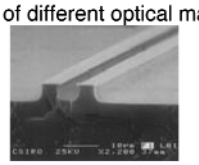


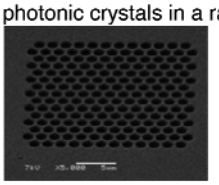
The **Laser Micro-Machining** project develops processes for laser-based micro-structuring of a range of linear, non-linear and high-gain optical materials, to produce photonic structures including waveguides in bulk glasses, 2-D photonic crystals and quasi phase matched crystals.



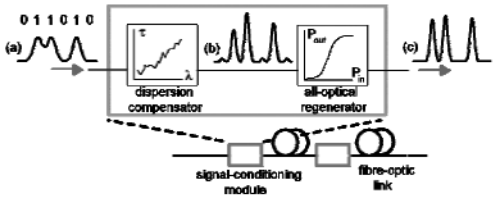


The aim of the **Photonic Integrated Waveguides and Circuits** project is to design, fabricate and characterise planar silicon optical waveguides and 2D photonic crystals in a range of different optical materials.

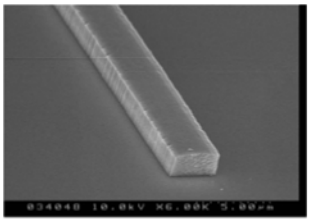




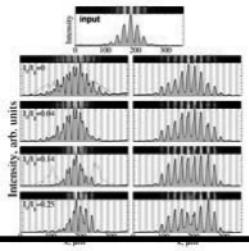
The **Optical devices and Applications** project develops all-optical signal processing functions including regeneration, wavelength conversion and amplification.

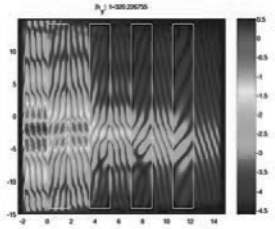


The aim of the **Non Linear Materials** project is to develop high nonlinearity chalcogenide glasses leading to novel nonlinear photonic devices including planar photonic crystals. .

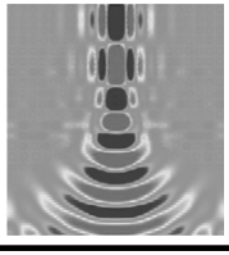


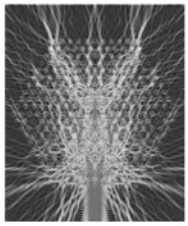
The **Non Linear Photonic Crystals** project studies the generation and propagation of nonlinear localized modes and all-optical switching in periodic photonic structures and waveguide circuits.



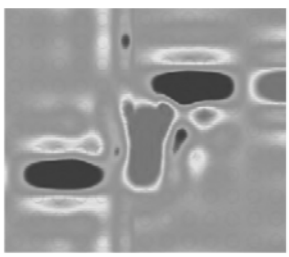


The **Computational Modelling** project provides computational modelling and visualisation techniques through generic modelling tools, new methods for modelling photonic structures and devices, and expertise in visualisation.

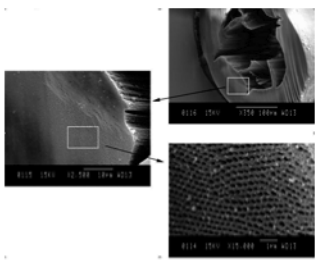




The **Photonic Circuits** project aims to find the best way to achieve tight guidance of light in optical circuits and to optimize photonic circuit features for Fresnel losses, radiation losses and impedance mismatches.



The aim of the **Radiation Dynamics** project is to explore radiation dynamics in microstructured photonic crystal materials. We aim to identify bandgap structures and use quantitative structural information to predict their optical properties.



Events Programme

Young Australian Physics Researchers' Forum
Sunday 30 January

1020–1800 hrs

Manning Clark 2 (MC2), ANU

A group of Australia's best and brightest postgraduate students will showcase their research in a series of presentations organized by the students themselves that will complement the main Congress programme. The cost of attending is included in all Congress registration fees.

0930–1020	**Registration and Morning Tea**
1020–1030	**Welcome Opening**
1030–1100	*Anne Barnett (Macquarie University)* "Optical Micro-characterisation Research Group"
1100–1130	*Elizabeth Angstmann (University of New South Wales)* "Constraining Variation of Fundamental Constants"
1130–1200	*Andrew Wroe (University of Wollongong)* "A New Millennia of Medical Physics Research at the CMRP"
1230–1330	**Lunch**
1330–1400	*Rebecca Scott (University of Melbourne)* "Nuclear Physics in the Modern World"
1400–1430	*Benjamin Johnston (Macquarie University)* "Laser Assisted Fabrication of Periodically-poled Optical Crystals"
1430–1500	*Ilana Klamer (University of Sydney)* "Galaxies at the Edge of the Universe"
1500–1530	*Ryan Springall (RMIT University)* "Dispersion Interactions and the Adiabatic Connection"
1530–1600	*Peter Brooke (Macquarie University)* "The Physics behind the Quantum Computer"
1600–1630	**Afternoon Tea**
1630–1800	**Discussion Forum** Prominent international and local scientists will discuss the topic "Australia as a Global Leader in Research".

1030–1100 hrs Anne Barnett

Physics Department, Macquarie University, Sydney
e-mail: anneb@ics.mq.edu.au

Optical Micro-characterisation Research Group

As science and technology moves into the 21st century, an important focus is the ability of scientists from all areas to create new and exciting research opportunities through the merging of fields and interdisciplinary co-operation. With this in mind our research group has focused on the development and refinement of optical micro-characterisation techniques and their application to state-of-the-art technologies. Our specific focus is on techniques aimed at the characterisation of spectroscopic information from physical, chemical and biological systems on the micrometre and nanometre scales. Our ability to marry pure physics research with applications in the frontier of biotechnology, along with strong collaborative links, has placed Australia as a front-line player in these new and exciting fields.

1100–1130 hrs Elizabeth Angstmann

School of Physics, University of New South Wales, Sydney NSW, lizb@phys.unsw.edu.au

Constraining Variation of Fundamental Constants

Theories beyond the standard model, such as grand unified theories, predict the variation of fundamental constants. Our group performs calculations that place limits upon the variation of fundamental constants such as the fine structure constant (α), the binding energy of deuterium, and the ratio of the quark mass to the QCD scale (m_q/Δ_{QCD}). These limits are derived from primordial Big Bang nucleosynthesis, the Oklo natural nuclear reactor, quasar absorption spectra, and atomic clock experiments. We have already found hints that α and (m_q/Δ_{QCD}) may vary. The improved precision of future experiments and calculations will allow the placement of more stringent limits on the variation of constants.

1130–1200 hrs Andrew Wroe

Centre for Medical Radiation Physics, University of Wollongong, NSW
ajw16@uow.edu.au

A New Millennia of Medical Physics Research at the CMRP

As we move into the new millennium, the use of radiation within our society is ever increasing and so must our knowledge of this important medical and scientific tool. The Centre for Medical Physics (CMRP)

Events Programme

(cont.) at the University of Wollongong, is conducting valuable and innovative research into many aspects of the use of radiation within medicine and science. This ground-breaking research is being conducted in a number of areas including the measurement of radiation effects on a cellular and DNA level, medical imaging, space exploration and improvements to radiation therapies including magnetically enhanced radiotherapy, brachytherapy, intensity modulated radiotherapy (IMRT), microbeam radiation therapy using synchrotron radiation and proton therapy. Many of these projects utilise novel detection methods and instrumentation as well as Monte Carlo simulation studies to achieve an outcome that will be beneficial to the wider society.

1330–1400 hrs Rebecca Scott

School of Physics, University of Melbourne, Parkville VIC, r.scott@unimelb.edu.au

Nuclear Physics in the Modern World

In Australia, and around the world, the face of nuclear physics is changing fast. As technology advances rapidly, many new and exciting areas of research are being born, and the line between nuclear physics and other branches of physics is becoming blurred. Measurements on exotic halo nuclei, experimental tests of the standard model and land mine identification are just some of the exciting areas that are currently being researched by the Photonuclear Group at the University of Melbourne. Our group is also developing novel detector signal digitisation and analysis techniques that will have a significant impact on the path of nuclear physics in the coming decade.

1400–1430 hrs Benjamin Johnston

Physics Department, Macquarie University, Sydney benjamin@physics.mq.edu.au

Laser Assisted Fabrication of Periodically-poled Optical Crystals

Periodically poled optical materials have become popular over the past decade as media for achieving efficient quasi-phase-matched frequency conversion of laser light. The materials used for periodic poling are generally ferroelectric optical crystals such as lithium niobate and its isomorphs. Lithography is commonly used to lay down the electrode patterning used when periodically poling ferroelectric crystals. We have explored an alternative method that uses laser direct write methods to fabricate a topographical electrode pattern which guides the domain pattern. The use of periodically poled materials is an innovative means of furthering the field of non-linear optics in spectroscopy, laser displays and all-optical-processing in future optical networks.

1430–1500 hrs Ilana Klamer

School of Physics, University of Sydney. Sydney, NSW, klamer@physics.usyd.edu.au

Galaxies at the Edge of the Universe

Powerful radio emission from a galaxy points to the presence of a central supermassive (> 1 billion solar masses) black hole, and is the most efficient tool for finding galaxies at the edge of the Universe. We have recently embarked on the first large scale search in the Southern Hemisphere for the most distant radio galaxies in the Universe, which, due to the finite speed of light, are also those which existed when the Universe was barely 10% of its current age (13 billion years). In this talk, I will outline the search technique we use and the results thus far, including the discovery of at least nine new radio galaxies more than 10 billion light years away. I will show how observations like these constrain the physics of black hole and galaxy formation and discuss the direction that Australian Astronomy needs to be heading in the next decade to enhance its reputation for doing world-class research.

1500–1530 hrs Ryan Springall

Computational and Condensed Matter Physics Group, Department of Applied Physics, RMIT University ryan.springall@rmit.edu.au

Dispersion Interactions and the Adiabatic Connection

In this recently funded ARC project, some of the most accurate calculations ever performed will be used to study in detail the effects of electron correlation beyond the 2 body Coulombic interaction. Electron correlation is seen as being responsible for van derWaals interactions in condensed matter systems, and current non-perturbative models are unable to account for this. Further, an understanding of the non-asymptotic behaviour of these forces is seen as a primary constituent in the modeling of technologies in the nanoscale regime. Powerful theoretical methods will be employed to achieve this, including the adiabatic connection formula, where the non-interacting system is mapped onto a fully interacting system, extracting all electron correlation, and the Quantum Monte Carlo code developed at Cavendish laboratory, Cambridge.

Events Programme

1530–1600 hrs Peter Brooke

Centre for Quantum Computer Technology, Department of Physics, Macquarie University, Sydney
pgb@ics.mq.edu.au

The Physics behind the Quantum Computer

Utilising quantum states as a basis for information processing, storage, and transfer has shown that, in some cases, quantum information (QI) has significant advantages over its classical counterpart. However, it also has real disadvantages, namely, decoherence, gate implementation, and readout. Here, at Macquarie University, the physics research concentrates on the trying to overcome the disadvantages. Specifically, we are performing a comprehensive study (with Dr K-P Marzlin, University of Calgary, and R. Karasik, UC Berkeley) of decoherence-free subspaces, without any restrictive physical assumptions. This is a much needed examination of the limitations imposed by purely physical contraints on QI processing. The results also help quantify the difficulty of constructing a large QI processor, and, if a such a processer is to built, show a need for physicists, both in Australia and worldwide, to examine mathematical results from a physical perspective.

Welcome Reception
Sunday 30 January

1800–2000 hrs

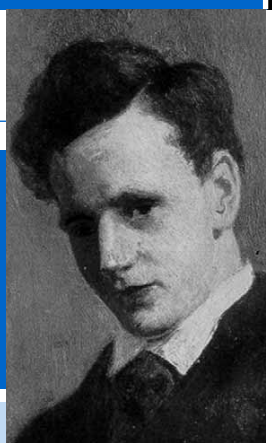
Melville Hall, ANU

SPONSORED BY Institute of Physics

The Congress Welcome Reception is sponsored by Institute of Physics (UK) and will be held in the trade exhibition and poster venue in Melville Hall at the Australian National University. The cost of attending is included in the registration fees for full registrants and exhibitor aides. The cost for day-only registrants and delegates' guests is $35.

This is a great chance to catch up with colleagues and meet new contacts in your area—a terrific networking opportunity.

Sutherland Lecture
Monday 31 January



1300–1400 hrs

Manning Clark 1 (MC1), ANU

Presenting Author: R. W. Home

R.W. Home was Professor of History and Philosophy of Science at the University of Melbourne, 1975–2003, and is now Professor Emeritus. He has written extensively on the history of physics, especially on eighteenth-century theories of electricity and magnetism and on the history of physics in Australia. He is a Fellow of the Australian Academy of the Humanities and a member of the International Academy of the History of Science. In 2004 the Australian Academy of Science awarded him its Academy Medal for his contribution to the Academy as editor since 1984 of the journal *Historical Records of Australian Science.*

Speculating about Atoms in Early 20th-century Melbourne: William Sutherland and the 'Sutherland-Einstein' Diffusion Relation

R.W. Home

Department of History & Philosophy of Science, University of Melbourne, Melbourne
home@unimelb.edu.au

In his biography of Einstein, *'Subtle is the Lord…'*, Abraham Pais noted, while describing Einstein's route to his well-known diffusion relation, that the same relation had been discovered 'at practically the same time' by the Melbourne physicist William Sutherland, following similar reasoning to Einstein's, and had been submitted by him for publication shortly before Einstein completed the doctoral thesis in which he first announced the relation. Pais therefore proposed that the relation be called 'the Sutherland-Einstein relation'.

In this paper I discuss Sutherland's research programme that led him to the diffusion relation, and comment on structural factors within the international physics community of the day that led to his work being over-shadowed by Einstein's and soon forgotten.

Events Programme

National Press Club Luncheon Address:

Professor Graeme Pearman

Tuesday 1 February

1200–1400 hrs

National Press Club, Barton
Cost $55

Plenary speaker **Professor Graeme Pearman** will be presenting an address at the National Press Club on Tuesday 1st February as part of the Congress Outreach Programme. This is a prestigious occasion and will generate considerable media coverage. Delegates are invited to attend the luncheon to hear a prominent speaker on this important topical issue.

Tickets for the lunch will be available from the Congress registration desk for $55 and must be booked and paid for in advance. Buses from the Congress will depart from outside Llewellyn Hall at 1200 hrs sharp to reach the Press Club at 1215 hrs in time for guests to be seated for lunch by 1230 hrs. The address will commence at 1300 hrs and buses will return delegates to the Congress at 1400 hrs to arrive by 1430 hrs.

From Physics to Policy: The Science of Climate Change Underpinning Private and Public Policy Decisions

Analyses of countries around the world demonstrate a growing need through this century for energy in response to increasing life-style expectations and population. At least for some time, these needs can be met only by a continued utilisation of fossil-fuel energy that in turn results, with current technologies, in the emission of carbon dioxide.

The accumulation of this gas in the earth's atmosphere has already changed the climate of the earth and more change is likely. In 2001, the international science community reported it is now clear that the earth warmed through the last century; most of this warming was likely due to increasing levels of greenhouse gases; the demand for energy will ensure that carbon dioxide continues to accumulate in the atmosphere and thus the climate warm through this century; and there are many observed and anticipated impacts of this warming on natural ecosystems and human activities around the world.

Since that time, the science has progressed further and here in Australia, evidence for warming, other climatic changes and impacts is growing.

So what is the solution to this apparent conflict for the future? Is it in new technologies? Is there a single response that will save the day? Or is there a demand for a new portfolio of energy production and utilisation technologies that meet the demands for the amenity that energy delivers, but does not compromise the future?

Are there economic gains to be made through early engagement in a new vision of energy futures? Can we usefully extrapolate our existing energy systems into the future? Or is the solution in behavioural change, and new expectations for economic growth and social security?

Graeme Pearman will outline some of the more recent evidence for climate change; address the issue of how much change might turn out to be "dangerous"; discuss the dynamic between a still incomplete and developing science and the perceived need for intervention and legislative action to deal with climate change; and the risks that this imposes on the operating environment of the commercial and industrial world, both through the impact of climate change itself and through the need for adaptive and mitigative responses to the issue.

He will discuss also the nature of a new paradigm for the development of policy, both private and public, that maximise delivery of these needs.

Events Programme

Outreach Programme
Wednesday 2 February

1330–1830 hrs

Llewellyn Hall, ANU

A Congress highlight will be the Outreach Programme on Wednesday afternoon, open to school students, the general public and Congress delegates. It will demonstrate the wide-ranging benefits of Physics to science, the economy, and the community. This special session will feature outstanding individuals with a background in Physics including Nobel Prize winners, who have gone on to make important contributions to the advancement of knowledge and society. The speakers have been selected for their ability to articulate the benefits of Physics both to experts and to a general audience, highlighting the energy and dynamism which motivates Physics and physicists. A special celebration of 100 years since Einstein's achievements will highlight the 2005 International Year of Physics. The Outreach Programme will be hosted by *ABC Catalyst* presenter Karina Kelly.

The Outreach Programme will commence with a presentation by His Excellency Major General Michael Jeffery AC CVO MC, Governor-General of the Commonwealth of Australia, who will present the ANZAAS Medal to Professor David Blair (*see Medalists section*).

1330–1430	**Physics in 100 Years' Time** Find out what physics will be like in 100 years' time. Together with Nobel Prize winners and other famous physicists, the panel will discuss the future with the four school finalists of the NIPS Physics Time Warp competition.
1430–1530	**Entertaining Physics** Experience interactive demonstrations provided by Questacon.
1530–1630	**Physics as a Life Skill** Hear from prominent Australian physicists, Nobel Prize winners and others with a Physics background about how Physics has enlightened their career and prepared them for all walks of life.
1630–1730	**Entertaining Physics** More entertaining Physics activities with Questacon.
1730–1830	**Public Lecture—Einstein's Revolution** Discover how we test Einstein's theories in modern Physics and how this will lead to new technologies such as quantum computing.

The cost of attending the above sessions is included in all full Congress registration fees.

Congress Dinner
Wednesday 2 February

1900 for 2000 hrs

Great Hall, Parliament House

A highlight of the Congress will be the Congress Dinner in the magnificent Great Hall at Parliament House. The Dinner will reflect the Congress theme *Physics for the Nation* and will highlight—in the meeting place of the nation's leaders—the many contributions that Physics has made to this country. A high-quality poster presentation by our major sponsors will demonstrate the many benefits that Physics provides in the modern world.

Delegates will have a chance to mingle with "Parliamentarians and with opinion leaders in the science arena over a fine meal in a magnificent setting. Dinner "tickets must be purchased from the Congress organisers at the registration desk.

Please check the notice board for dinner transfer times from Congress hotels. Entrance is by ticket only.

Questacon Public Lecture: Professor Helen Quinn
Thursday 3 February

1900 hrs

Questacon Science Centre

One of the plenary speakers, Helen Quinn will give a public lecture at Questacon—The National Science and Technology Centre on Thursday 3 February at 1900 hrs as part of the Congress Outreach Programme. Helen Quinn works extensively with secondary school teachers in California to make physics fun and exciting for students and accessible to the broader community.

The public lecture provides an opportunity for the students, parents and members of the Canberra community to understand something of the fundamental nature of matter and energy and the important role of physics in modern life.

The Mystery of Missing Antimatter: The Asymmetry Between Matter and Antimatter in the Universe and in the Laws of Physics

A major outstanding puzzle at the intersection of particle physics and cosmology is the asymmetry between matter and antimatter. The Universe contains significant amounts of matter and an insignificant amount of antimatter. The puzzle is how this can occur when the laws of physics for matter and antimatter are very close to identical. Unless it arises from a very finely tuned initial condition that is maintained by an absolute conservation law, the matter–antimatter asymmetry of the Universe can only occur due to an asymmetry between matter and antimatter in the laws of physics.

Events Programme

AIP AGM and Medal Ceremony

Friday 4 February

AGM 1300–1330 hrs

The AIP AGM will be held in Manning Clark 1 (MC1).

Medal Ceremony 1330–1400 hrs

The Congress will highlight discipline contributions to *Physics for the Nation* through the awarding of prizes for excellence. The AIP will have a special awards ceremony immediately preceding the closing Plenary session, and will present the Massey, Boas, Education, Bragg and Walsh medals, together with the Women in Physics Lecturer award. The individual discipline societies will be encouraged to present their awards within the discipline sessions. All winners of Australian medals (including those awarded by the AIP) will have their presentations highlighted at the Opening Ceremony.

Laboratory Tours and BBQ

Wednesday 2 February

1530 hrs

and

Friday 4 February

1530 hrs

Physics Department, the Faculties, and the Research School of Physical Sciences and Engineering

The experimental Physics facilities of the ANU will be open for inspection.

A BBQ will follow the Friday afternoon tour at the Research School of Physical Sciences and Engineering at around 1800 hrs.

The cost of the tours and the BBQ is included in all Congress registration fees. However, you need to sign up for the laboratory tours and for the BBQ with the Congress organisers at the registration desk.

Society Meetings

Humboldt Society

Sunday 30 January
0900–1400 hrs
Manning Clark 6 (MC6)

AIP Council

Monday 31 January
1800–2000 hrs
Manning Clark 4 (MC4)

AMOS

Wednesday 2 February
1220–1330 hrs
Manning Clark 5 (MC5)

ITER Forum

Wednesday 2 February
1230–1330 hrs
Manning Clark 6 (MC6)

AOS Council

Wednesday 2 February
1530–1700 hrs
Manning Clark 6 (MC6)

Thursday 3 February
1230–1400 hrs
Manning Clark 6 (MC6)

AIP Physics Education Group (PEG)

Thursday 3 February
1220–1400 hrs
Manning Clark 4 (MC4)

STSP Group

Thursday 3 February
1300–1400 hrs
Manning Clark 5 (MC5)

COSNet Systems Meeting

Friday 4 February
1230–1330 hrs
Manning Clark 6 (MC6)

AIP AGM and Medal Ceremony

Friday 4 February
1300–1330 and 1330–1400 hrs
Manning Clark 1 (MC1)

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Key contacts:

Australian Synchrotron Project
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Ph: 03 9655 3315
Email: contact.us@synchrotron.vic.gov.au
Web: www.synchrotron.vic.gov.au

ASRP
Richard Garrett, Facility Director
Ph: 02 9717 9012
Email: garrett@ansto.gov.au
Web: www.ansto.gov.au/natfac/index.html

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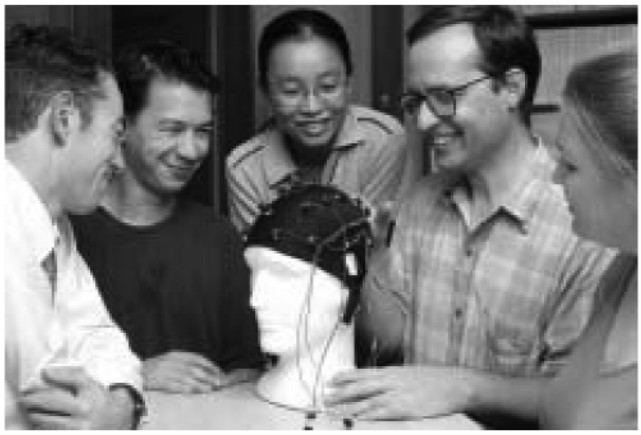
School of Physics, University of Sydney

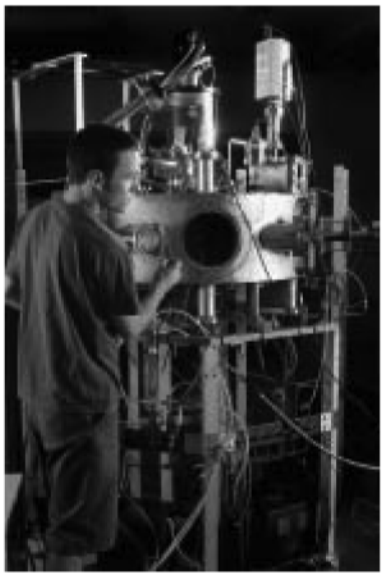
The School of Physics at the University of Sydney is one of the biggest Physics departments in the Southern Hemisphere – with more than 20 academic staff teaching more than 1200 undergraduates, 60 research only staff, including 4 Federation Fellows and 4 Australian Professorial fellows, and approximately 85 postgraduate research students mostly doing PhDs.

The School's research areas include:

Applied Physics, Astronomy, Astrophysics, Biological Physics, Biophysics, Brain Dynamics, High Energy Physics, Materials Science, Medical Physics, Optics & Photonics, Plasma Physics, Space & Solar Physics, Sustainable Energy, Theoretical Physics, Wave Physics.

The School is the main node for CUDOS, the Centre for Ultrahigh-bandwidth Devices for Optical Systems.





The School offers Honours scholarships worth $3000 plus relocation allowance, Australian Postgraduate Award top-up scholarships, as well as its own postgraduate research scholarships.

In 2004 the School established a provisionally accredited Master in Medical Physics program.

For further information contact the Head of School:
Associate Professor Brian James
School of Physics A28
University of Sydney NSW 2006
hos@physics.usyd.edu.au

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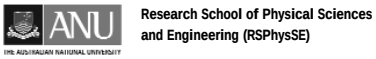

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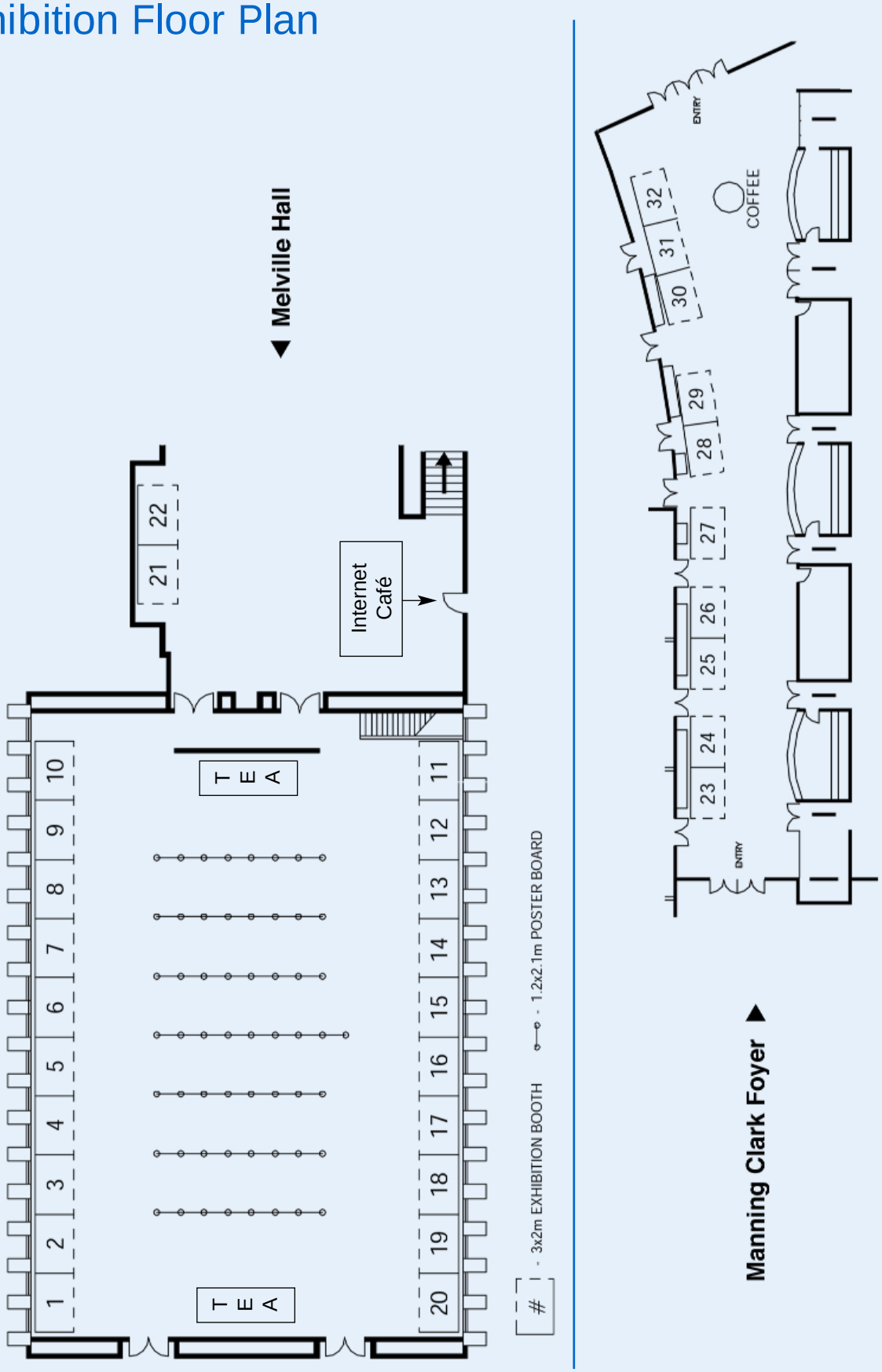
Exhibition Opening Hours

Sunday 30 January	1800–2000 hrs
Monday 31 January	0830–1830 hrs
Tuesday 1 February	0830–1830 hrs
Wednesday 2 February	0830–1400 hrs
Thursday 3 February	0830–1630 hrs

Exhibition Floor Plan



Exhibitor Contact Details

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Knoxfield VIC 3180 Australia
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Email sales@javac.com.au

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CSIRO Industrial Physics
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PO Box 218
Lindfield NSW 2070 Australia
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Fax +61 2 9413 7631
www.cip.csiro.au

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www.thermo.com

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Australian Institute of Physics

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Booth 21

Australian Nuclear Science & Technology Organisation
Private Mail Bag 1
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Email neutrons@ansto.gov.au
www.ansto.gov.au

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Fax +61 3 9570 2337
Mobile 0405 622 623
Email tandf@bigpond.net.au
www.tandf.co.uk

General Information

Registration at the Congress

The Congress registration desk will be located in the foyer of the Manning Clark Centre and staffed during the following times:

Sunday 30 January	0930–1830 hrs
Monday 31 January	0730–1815 hrs
Tuesday 1 February	0800–1815 hrs
Wednesday 2 February	0800–1800 hrs
Thursday 3 February	0800–1815 hrs
Friday 4 February	0800–1530 hrs

Registration Desk Contact Details

The Congress registration desk staff will take messages for delegates during the registration desk opening hours.

Tel +61 2 6125 3905

Please check the message board adjacent to the Congress registration desk daily for messages.

Name badges

Please wear your name badge to gain access to all Congress sessions, exhibition and social functions.

The coloured category slips indicate under which registration code the delegate is attending the Congress.

Blue	Full delegate *(Member, non-member, student/teacher/retiree)*
Blue	Committee
Red	Exhibitor aide
Red	Media
Red	Visitors
Red	Physics in Industry only
Green	Monday
White	Tuesday
Orange	Wednesday
Purple	Thursday
Yellow	Friday
Pink	Congress Staff

Internet Facilities

Internet access for delegates is provided by National Instruments, sponsor of the Internet Café in Melville Hall. Alternatively, delegates can use computer lab G016 in the Crisp Building (see map on page 25).

NATIONAL INSTRUMENTS

Speaker Information

SPEAKERS' PREPARATION ROOM

The speakers' preparation room will be located in Hanna Neumann G064 (Crisp Building) and will be open during the following times:

Sunday 30 January	0930–1800 hrs
Monday 31 January	0800–1800 hrs
Tuesday 31 January	0800–1800 hrs
Wednesday 1 February	0800–1530 hrs
Thursday 2 February	0800–1800 hrs
Friday 3 February	0800–1400 hrs

ORAL PRESENTATIONS

It is important that all speakers check in at the speakers' preparation room at least two hours prior to the commencement of their allocated session. An audiovisual technician will be available to assist with data projection or other technical requirements. If you require assistance from a technician, please ensure you arrange this during one of the breaks prior to your presentation. Speakers in early morning sessions should check in at the speakers' preparation room the day/afternoon prior to their session.

POSTER SESSIONS

Poster presenters must check the notice board adjacent to the Congress registration desk for directions to their allocated poster area and to collect velcro and/or pins (if required). Presenting authors must be present at their posters during their allocated poster session on either Monday 31 January, Tuesday 1 February or Thursday 3 February from 1930 hrs to 2130 hrs to answer any questions. On Wednesday 2 February the poster session is scheduled for 1330 hrs to 1530 hrs.

Posters can be on display from 1230 hrs and removed by 1030 hrs on the following day or they will be removed by Congress staff.

Transport

AIRPORT TO CITY

Services depart the airport from 0715 to 1800 hrs.

CITY TO AIRPORT

Services depart the city (Civic interchange, platform 6) from 0730 to 1830 hrs.

Telephone enquiries: +61 2 6299 3722.

CITY TO ANU

To catch the bus from the City Interchange to the ANU, take Action Bus 34. It stops at various points along Lennox Crossing, Liversidge St, Garran Rd and Daley Rd and returns along the same route.

Information about bus timetables is available at Action Bus Services, telephone 13 17 10

Car Parking

Parking is limited on the campus. There are public 'pay and display' parking areas on Childers and Hutton streets within a short walk from Manning Clark Centre and Melville Hall. Access to these parking areas is off Barry Drive or Marcus Clark Street.

Accommodation

Novotel ★★★★

65 Northbourne Avenue

Distance to Congress venue: 20 minute walk

Tel +61 2 6245 5000
Fax +61 2 6245 5100

Rydges Lakeside ★★★☆

London Circuit

Distance to Congress venue: 20 minute walk

Tel +61 2 6247 6244
Fax +61 2 6257 3071

University House ★★★☆

Cnr Balmain Cr & Liversidge St, ANU Campus

Distance to Congress venue: 10 minutes walk

Tel +61 2 6125 5211
Fax +61 2 6125 5252

Ursula Hall

Building 50, Daley Road. ANU Campus

Distance to Congress venue: 10 minutes

Tel +61 2 6279 4300
Fax +61 2 6279 4320

John XXIII College

Building 51 Daley Road, ANU Campus

Distance to Congress venue: 10 minutes

Tel +61 2 6279 4999
Fax +61 2 6248 6734

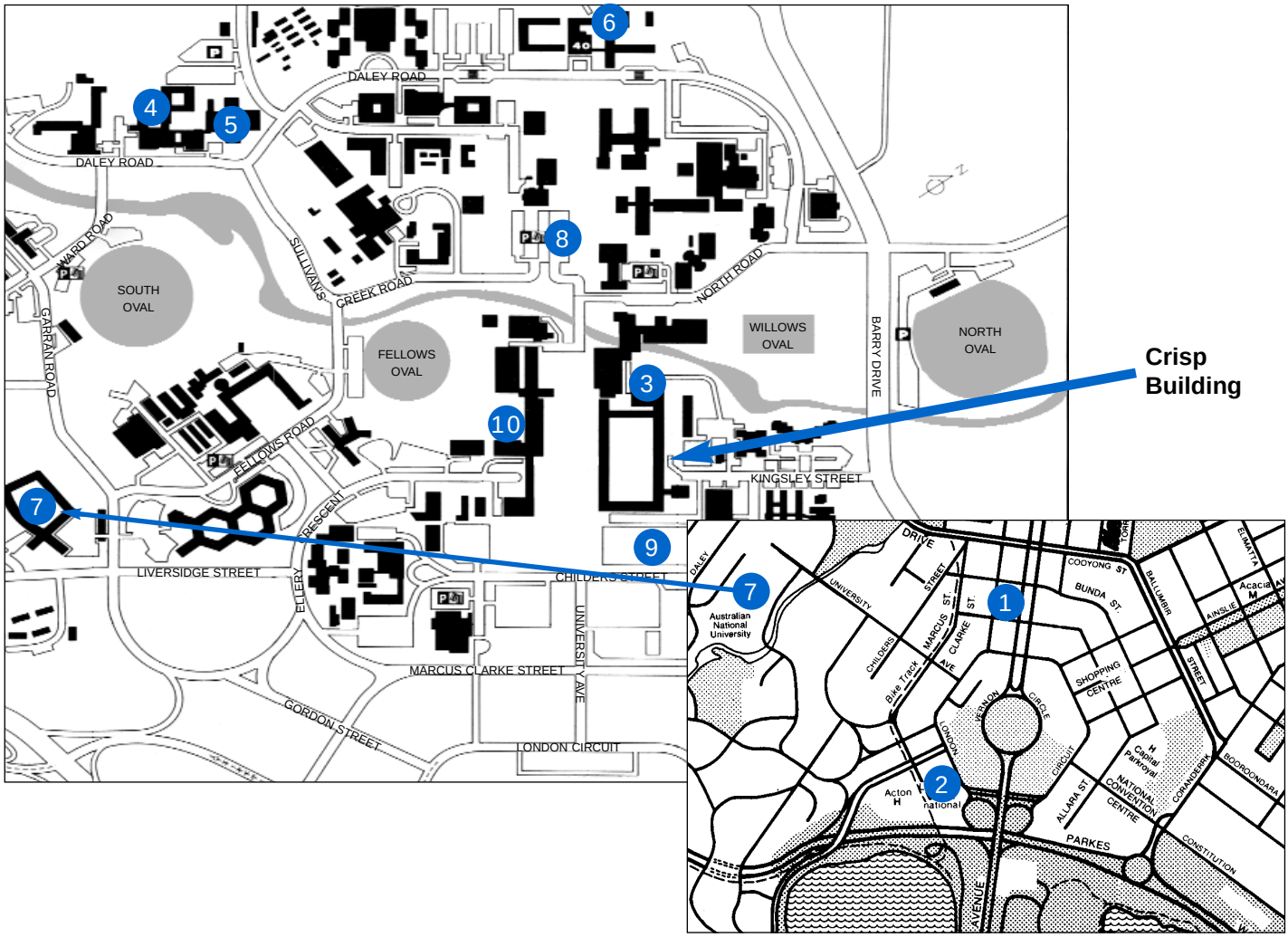
Bruce Hall

Building 40, ANU Campus

Distance to Congress venue: 10 minutes

Tel +61 2 6125 6007
Fax +61 2 6125 6010

1. **Novotel**
2. **Rydges Lakeside**
3. **Manning Clarke Centre**
4. **John XXIII College**
5. **Ursula Hall**
6. **Bruce Hall**
7. **University House**
8. **Sullivan's Creek Carpark**
9. **Public Carpark**
10. **Melville Hall**



Programme and Abstracts Contents

The Australian Institute of Physics

What the Australian Institute of Physics means to you

Physics is an enabling science that provides the basis for much of our current understanding of the world in which we live as well as underpinning many established and emerging technologies. As such it is of critical importance to Australia's cultural and economic development.
Since its beginnings in 1963, The Australian Institute of Physics has served the needs and interests of professional physicists, and those with an interest in physics, by:

- fostering a strong professional identity and fellowship among physicists by providing a forum for their views and enabling them to meet with their colleagues on a regular basis
- helping to maintain the standards of physics qualifications through the review and accreditation of tertiary physics courses
- expressing the views and interests of physicists to government bodies and other employers
- promoting the value and interest of physics as a discipline
- holding regular conferences and publishing the views of members along with other matters of interest
- supporting and promoting women in science through the Women-in-Physics workgroup and the Women-in-Physics lecture series
- encouraging excellence in research and teaching with prizes and awards
- encouraging outstanding students with awards and prizes
- providing a broad range of member benefits, including discounted membership of related societies, such as the IOP, lifetime email addresses, financial support for conferences, and others.

What you mean to the Australian Institute of Physics

- Physicists with the concern and commitment to take an active interest in their profession are the lifeblood of the Institute.
- A broad cross-section of members provides the diversity of ideas and opinions that stimulate healthy debate and maintain the vitality and relevance of the Institute
- Ensuring that the majority of Australian physicists are members of the Institute increases its effectiveness as a professional society.

Whatever your professional involvement or interest in physics, your participation in the Institute is actively sought and welcomed.
For more information see the AIP website at: www.aip.org.au

Monday 31 January

	MC1	MC2	MC3	MC4	MC5	MC6
0830–0915	**Congress Opening**					
0915–1000	**Plenary:** (*Chair:* K. Baldwin) Cold Dilute Alkali Gases—Bose Condensation Meets Cooper Pairing—*Leggett*					
1000–1040	Morning Tea					
	AOS/spectroscopy	**STSP**	**ASRP**	**NUPP**	**AMOS**	**BMP**
	Chair: N. Manson	*Chair:* I. Cairns	*Chair:* R. Garrett	*Chair:* L. Peak	*Chair:* R. Griffiths	*Chair:* S-H. Chung
1040–1100	MOA11 **van Stryland**	MOB11 **Basu**	MOC11 **Boldeman**	MOD11 **Urquijo**	MOE11 **England**	MOF11 Schoenborn
1100–1120						MOF12 Krausz
1120–1140	MOA13 He	MOB13 Reid	MOC13 Peele	MOD13 Parslow	MOE13 Hughes	MOF13 Powell
1140–1200	MOA14 Sidiroglou	MOB14 Mlynczak	MOC14 **Townes-Andrews**	MOD14 Parappilly	MOE14 Power	MOF14 Gilmore
1200–1220	MOA15 Warrington	MOB15 **Kozyra**		MOD15 Lasscock	MOE15 Muller	MOF15 Corry
1220–1400	Lunch Break					
1300–1400	**Sutherland Lecture:** Speculating about Atoms in Early 20th-century Melbourne: William Sutherland and the 'Sutherland–Einstein' Diffusion Relation *R.W. Home*					
	AOS/nonlinear photonics	**STSP**	**CMMSP**	**NUPP**	**AMOS**	**ASRP**
	Chair: J. Love	*Chair:* M. Parkinson	*Chair:* M. Das	*Chair:* K. Fifield	*Chair:* J. Taylor	*Chair:* M. Ridgway
1400–1420	MOA21 **Buchler**	MOB21 Maher	MOC21 **Oitmaa**	MOD21 **Maier**	MOE21 **Roderick**	MOF21 Kluth
1420–1440		MOB22 Ables				MOF22 Dhal
1440–1500	MOA23 Weily	MOB23 Morley	MOC23 Jakovidis	MOD23 Lane	MOE23 Baines	MOF23 Kempson
1500–1520	MOA24 Lyytikainen	MOB24 **Horton**	MOC24 Court	MOD24 Gladkis	MOE24 Trewin	MOF24 **Liss**
1520–1540	MOA25 Aruldoss		MOC25 Clarke	MOD25 Wilcken	MOE25 Henderson-Sellers	
1540–1620	Coffee Break					
	AOS/new faces 1	**STSP**	**CMMSP**	**NUPP**	**AMOS**	**BMP**
	Chair: J. Dawes	*Chair:* M. Duldig	*Chair:* G. Collins	*Chair:* D. Leinweber	*Chair:* W. Drosdowsky	*Chair:* P. Robinson
1620–1640	MOA31 de Vine	MOB31 **Cane**	MOC31 **Neumann**	MOD31 **Atkinson**	MOE31 Vincent	MOF31 Chelkowska
1640–1700	MOA32 Mok				MOE32 Pope	MOF32 Gray
1700–1720	MOA33 Harvey	MOB33 Knock	MOC33 Robinson	MOD33 Loan	MOE33 Ballinger	MOF33 Rennie
1720–1740	MOA34 Briedis	MOB34 Mitchell	MOC34 Daniels	MOD34 Dasgupta	MOE34 **May**	MOF34 Steyn-Ross
1740–1800	MOA35 Baker	MOB35 Newell	MOC35 Henderson	MOD35 **Sowerby**		MOF35 Drysdale
1800–1930	Dinner Break					
1930–2130	**Posters:** *Melville Hall*					

Note: *Keynote Speakers in bold. Medal winners underlined.*

Tuesday 1 February

	MC1	MC2	MC3	MC4	MC5	MC6
0830–0915	**Plenary:** (*Chair:* D. McClelland) Gravitational Wave Detectors on the Earth and in Deep Space—*Danzmann*					
0915–1000	**Plenary:** (*Chair:* R. Elliman) "Reaction Microscopes": The "Cloud Chambers" of Atomic and Molecular Physics—*Ullrich*					
1000–1040	Morning Tea					
	AOS/nonlinear photonics 2	**AMOS**	**CMMSP**	**NUPP**	**ASGRG**	**PEG**
	Chair: W. Krolikowski	*Chair:* A. Henderson-Sellers	*Chair:* J. Williams	*Chair:* B. McKellar	*Chair:* P. Veitch	*Chair:* M. Sharma
1040–1100	TUA11 **Eggleton**	TUB11 **Cleugh**	TUC11 Sze	TUD11 Hedditch	TUE11 **Blair**	TUF11 **Swan**
1100–1120			TUC12 Sellar	TUD12 Wilson	TUE12 Brooks	
1120–1140	TUA13 Akhmediev	TUB13 Goergen	TUC13 Goh	TUD13 Stutchbery	TUE13 Gray	TUF13 Logan
1140–1200	TUA14 Petersen	TUB14 Hallal	TUC14 **Hill**	TUD14 **Leinweber**	TUE14 Ashley	TUF14 Merchant
1200–1220	TUA15 Canning	TUB15 M. Box			TUE15 Ware	TUF15 Kruhlak
1220–1400	Lunch Break					
1200–1400	**Pearman National Press Club Lunch** (for further information, please see section Events Programme)					
	AOS/appetizer	**AMOS**	**CMMSP**	**NUPP**	**ASGRG**	**PEG**
	Chair: G. Milburn	*Chair:* S. Power	*Chair:* S. Butcher	*Chair:* D. Hinde	*Chair:* D. McClelland	*Chair:* K. Wilson
1400–1420	TUA21 A. White	TUB21 Hogg	TUC21 **Dzurak**	TUD21 **Dracoulis**	TUE21 Hartnett	TUF21 **Guenther**
1420–1440	TUA22 Longdell	TUB22 Dupre			TUE22 Scott	
1440–1500	TUA23 Savage	TUB23 Kiss	TUC23 Reusch	TUD23 Watanabe	TUE23 Davies	TUF23 Roberts
1500–1520	TUA24 **Kivshar**	TUB24 **Wijfells**	TUC24 Vickers	TUD24 Nieminen	TUE24 Whale	TUF24 Greaves
1520–1540			TUC25 Lay	TUD25 Cole	TUE25 Van Putten	TUF25 Low
1540–1620	Coffee Break					
	AOS/quantum systems	**AMOS**	**CMMSP**	**NUPP**	**BMP**	**PEG**
	Chair: P.K. Lam	*Chair:* A. Hogg	*Chair:* R. Elliman	*Chair:* B. Robson	*Chair:* C. Charles	*Chair:* D. Mills
1620–1640	TUA31 **Drummond**	TUB31 Tomczak	TUC31 **Enderby**	TUD31 Bouriquet	TUE31 Burden	TUF31 **Zadnik**
1640–1700		TUB32 Turner		TUD32 Boinepalli	TUE32 Ramdutt	
1700–1720	TUA33 Pryde	TUB33 Kaempf	TUC33 Stevens-Kalceff	TUD33 Low	TUE33 Rosenfield	TUF33 Muller
1720–1740	TUA34 Lance	TUB34 Bye	TUC34 Singh	TUD34 **Hinde**	TUE34 Vella	TUF33 Wilson
1740–1800	TUA35 Ralph	TUB35 Frederickson	TUC35 Lee		TUE35 Boyd	TUF35 O'Connor
1800–1930	Dinner Break					
1930–2130	**Posters:** *Melville Hall*					

Note: *Keynote Speakers in bold. Medal winners underlined.*

Wednesday 2 February

	MC1	MC2	MC3	MC4	MC5	MC6
0830–0915	**Plenary:** (*Chair:* J. Finnigan) From Physics to Policy: The Science of Climate Change Underpinning Private and Public Policy Decisions—*Pearman*					
0915–1000	**Plenary:** (*Chair:* H. Bachor) What Can Physics Say about Life?—*Chu*					
1000–1040	Morning Tea					
	AOS/AMPQC *Chair:* P. Hannaford	**PP** *Chair:* R. Tarrant	**CMMSP** *Chair:* M. Spencer	**NUPP** *Chair:* R. Delbourgo	**AMOS** *Chair:* B. Trewin	**GP** *Chair:* L. Moresi
1040–1100	WEA11 **Denschlag**	WEB11 **Goldston**	WEC11 Russo	WED11 McCaw	WEE11 Platt	WEF11 **Sandford**
1100–1120			WEC12 Kluth	WED12 Blankleider	WEE12 Borlace	WEF12 **Kennett**
1120–1140	WEA13 Hall	WEB13 Hole	WEC13 Larsson	WED13 Tobar	WEE13 Andersen	WEF13 Miller
1140–1200	WEA14 Vale	WEB14 Hora	WEC14 **Rode**	WED14 **Flambaum**	WEE14 **Alves**	WEF14 Jackson
1200–1220	WEA15 Ostrovskaya	WEB15 Howard				WEF15 Xing
1220–1330	Lunch Break					
1330–1530	**Posters:** *Melville Hall*		*Llewellyn Hall* **Schools Outreach:** 1330–1430 Future of Physics 1430–1530 Entertaining Physics 1530–1630 Physics as a Life Skill 1630–1730 Entertaining Physics 1730–1830 Einstein's Revolution			
1530	**Tour of the Physics Department and Research School of Physical Sciences and Engineering**					
1900 for 2000	Congress Dinner *Great Hall, Parliament House* (for further information, please see section Events Programme)					

Note: *Keynote Speakers in bold. Medal winners underlined.*



Program at a Glance
Wednesday 2 February

Program at a Glance
Thursday 3 February

Thursday 3 February

	MC1	MC2	MC3	MC4	MC5	MC6
0830–0915	**Plenary:** (*Chair:* C. Barton) Airborne Gravity Gradiometry Applied to Mineral and Hydrocarbon Exploration—*van Leeuwen*					
0915–1000	**Plenary:** (*Chair:* B. Schmidt) A Golden Age for Astronomy—*Cesarsky*					
1000–1040	Morning Tea					
	AOS/AMPQC	**PP**	**CMMSP**	**GP**	**PEG**	**ASA**
	Chair: A. Truscott	*Chair:* J. Harris	*Chair:* E. Mitchell	*Chair:* J. Freeman	*Chair:* D. Low	*Chair:* B. Schmidt
1040–1100	THA11 **Shlyapnikov**	THB11 McMillan	THC11 Macfarlane	THD11 Kerr	THE11 **Livett**	THF11 **McClelland**
1100–1120		THB12 Meige	THC12 Deslandes	THD12 Müller		THF12 **Clay**
1120–1140	THA13 Martin	THB13 Ostrikov	THC13 Polonski	THD13 Moresi	THE13 Workshop–Pollard	THF13 **Storey**
1140–1200	THA14 Robins	THB14 Tarrant	THC14 **Schmitt**	THD14 **Lenardic**		THF14 **Couch**
1200–1220	THA15 Davis	THB15 Xia		THD15 **Davies**		THF15 **Boyle**
1220–1400	Lunch Break					
	AOS	**AMPQC**	**CMMSP**	**GP**	**AAS**	**ASA/ASGRG**
	Chair: B. Oreb	*Chair:* R. McEachran	*Chair:* T. Finlayson	*Chair:* K. Dodds	*Chair:* E. LePage	*Chair:* S. Scott
1400–1420	THA21 Gilchrist	THB21 **Bray**	THC21 **Foley**	THD21 **Mason**	THE21 Inta	THF21 **Huber**
1420–1440	THA22 Zvyagin			THD22 **GreenHalgh**	THE22 Poulton	THF22 **Reitze**
1440–1500	THA23 Plakhotnik	THB23 Stevenson	THC23 Ling	THD23 **Gurevich**	THE23 Wolfe	THF23 Searle
1500–1520	THA24 **Kane**	THB24 Ginges	THC24 Crew	THD24 Freeman	THE24 **Parncutt**	THF24 **Manchester**
1520–1540		THB25 Chantler	THC25 Tettamanzi	THD25 Zhao		THF25 **Bailes**
1540–1620	Coffee Break					
	AOS/new faces 2	**AMPQC**	**CMMSP**	**CSCMP**	**AAS**	**WIP/HOP**
	Chair: J. Hope	*Chair:* B. Lohmann	*Chair:* L. Hollenberg	*Chair:* R. Dewar	*Chair:* N. Fletcher	*Chair:* J. Pollard
1620–1640	THA31 McKenzie	THB31 Mueller	THC31 **Das Sarma**	THD31 **Di Matteo**	THE31 **LePage**	THF31 Binnie
1640–1700	THA32 Dodd	THB32 Campbell				THF32 Stevens-Kalceff
1700–1720	THA33 Atkins	THB33 Wang	THC33 Butcher	THD33 Gunner	THE33 Pax	THF33 Feteris
1720–1740	THA34 Doherty	THB34 **Lawrance**	THC34 Wahyu Utami	THD34 Robins	THE34 Hamilton	THF33 **Foley**
1740–1800	THA35 O'Brien		THC35 Dorsett	THD35 O'Kane	THE35 Buick	
1800–1930	Dinner Break					
1930–2130	**Posters:** *Melville Hall*					
2000	**Public Lecture:** *Questacon*					

Note: *Keynote Speakers in bold. Medal winners underlined.*

Friday 4 February

	MC1	MC2	MC3	MC4	MC5	MC6
	AOS/laser & applications	**STSP**	**CMMSP**	**CSCMP**	**AMPQC**	**EP/RE**
	Chair: M. Hamilton	*Chair:* B. Fraser	*Chair:* R. Lewis	*Chair:* M. Batchelor	*Chair:* R. Robson	*Chair:* J. Finnigan
0820–0840	FRA11 Arkwright	FRB11 **Chaston**	FRC11 **Frenken**	FRD11 Moylan	FRE11 Stelbovics	FRF11 Drake
0840–0900	FRA12 Huntington			FRD12 Quenette	FRE12 Ivanov	FRF12 Collings
0900–0920	FRA13 Delaubert	FRB13 Terkildsen	FRC13 King	FRD13 Maruno	FRE13 Sullivan	FRF13 Aberle
0920–0940	FRA14 **McManamon**	FRB14 Foroutan	FRC14 Broekman	FRD14 Kurniawan	FRE14 **Bromley**	FRF14 Richards
0940–1000		FRB15 Li	FRC15 Stampfl	FRD15 Barjaktarevic		FRF15 Plumb
1000–1040	Morning Tea					
	AOS/quantum information	**STSP**	**CMMSP**	**CSCMP**	**AMPQC**	**AOS/Laser Dev**
	Chair: P. Drummond	*Chair:* R. Vincent	*Chair:* G. Stewart	*Chair:* D. Evans	*Chair:* R. Sang	*Chair:* J. Munch
1040–1100	FRA21 **Carmichael**	FRB21 **Conde**	FRC21 Olivero	FRD21 **Sevick**	FRE21 **Bieske**	FRF21 Hosken
1100–1120			FRC22 Khalil			FRF22 Barriga
1120–1140	FRA23 Bartlett	FRB23 Yizengaw	FRC23 Doolan	FRD23 Carberry	FRE23 Orr	FRF23 Pask
1140–1200	FRA24 Wiseman	FRB24 Getley	FRC24 **Marcus**	FRD24 Wang	FRE24 Cavanagh	FRF24 Englich
1200–1220	FRA25 Brooke	FRB25 Green		FRD25 Williams	FRE25 Uhlmann	FRF25 Slagmolen
1220–1400	Lunch Break					
1300–1330	**AIP AGM**					
1330–1400	**AIP PRIZES AND MEDALS**					
1400–1445	**Plenary:** (*Chair:* G. Stewart) Plasma Physics enters the Nano-Age—*Bilek*					
1445–1530	**Plenary:** (*Chair:* A. Byrne) The Asymmetry Between Matter and Antimatter—in the Universe and in the Laws of Physics—*Quinn*					
1530	Close					
1530	Tour of the Department of Physics and Research School of Physical Sciences and Engineering					
1800	ANU BBQ					

Note: *Keynote Speakers in bold. Medal winners underlined.*



Monday 31 January

	MC1	MC2	MC3	MC4	MC5	MC6
0830–0915	**Congress Opening**					
0915–1000	**Plenary:** (*Chair:* K. Baldwin) Cold Dilute Alkali Gases—Bose Condensation Meets Cooper Pairing—*Leggett*					
1000–1040	Morning Tea					
Topic area	AOS/spectroscopy	STSP	ASRP	NUPP	AMOS	BMP
Chair	N. Manson	I. Cairns	R. Garrett	L. Peak	R. Griffiths	Shin-Ho Chung
1040–1100	**MOA11** **Nonlinear Optical Spectroscopy** ***van Stryland***	**MOB11** **Climate and Weather of the Sun-Earth System (CAWSES): SCOSTEP's New Inter-disciplinary Research Program** ***Basu***	**MOC11** **The Australian Synchrotron—A Status Report** ***Boldeman***	**MOD11** **Hints of New Physics from Measurements of CP Violation** ***Urquijo***	**MOE11** **Southern Ocean Circulation and Global Climate** ***England***	**MOF11** Protein Crystallography with Spallation Neutrons *Schoenborn*
1100–1120						**MOF12** The Most Energetic Process in Biology *Krausz*
1120–1140	**MOA13** Cavity Ringdown Spectroscopy with Widely Tunable Swept-Frequency Lasers *He*	**MOB13** The Intensity of 558 nm Airglow at Adelaide, Australia *Reid*	**MOC13** X-ray Lithography—An Australian Perspective *Peele*	**MOD13** Measurement of BR(B->rho l nu) and Vub via Neutrino Reconstruction at Belle *Parslow*	**MOE13** The Role of Buoyancy in the Energetics of the Global Over-turning Circulation of the Oceans *Hughes*	**MOF13** The Melanins: form Experiment to Quantum Chemistry to Many-Body Quantum Theory *Powell*
1140–1200	**MOA14** Micro-characterisation of Erbium Doped Optical Fibers *Sidiroglou*	**MOB14** Expanding Our Understanding of Atmospheric Ozone through CAWSES *Mlynczak*	**MOC14** **4GLS: the UK's Fourth Generation Light Source at Daresbury** ***Townes-Andrews***	**MOD14** Quark Propagator in Full QCD from the Lattice *Parappilly*	**MOE14** The Predictability of Interdecadal Changes in ENSO Activity and ENSO teleconnections *Power*	**MOF14** Quantum Decoherence of Electronic Excitations of Biomolecules *Gilmore*
1200–1220	**MOA15** A Microwave Frequency Standard in the 10^{15} Accuracy Range Using $171Yb^{+}$ Ions *Warrington*	**MOB15** **Geospace System Behavior from Global Observing Campaigns: Science at the Core of the CAWSES Space Weather Focus** ***Kozyra***		**MOD15** Pentaquark Interpolating Fields in Lattice QCD *Lasscock*	**MOE15** Do Massive Corals Reflect Global Change? Coral Reconstructions of Changes in Temperature and Carbonate Saturation State of the Surface Ocean *Muller*	**MOF15** Electrostatic Basis of Valence Selectivity in Biological Ion Channels *Corry*
1220–1400	Lunch Break					
1300–1400	*Chair:* D.Jamieson **Sutherland Lecture:** Speculating about Atoms in Early 20th-century Melbourne: William Sutherland and the 'Sutherland-Einstein' Diffusion Relation *(MC1)* *R.W. Home*					
Topic area	AOS photonics 1	STSP	CMMSP	NUPP	AMOS	ASRP
Chair	J.Love	M.Parkinson	M.Das	K.Fifield	J.Taylor	M.Ridgway
1400–1420	**MOA21** **Near-field Imaging and Manipulation of Photonic Crystals** ***Buchler***	**MOB21** Nowcasting and Forecasting at the Australian Space Forecast Center *Maher*	**MOC21** **Quantum Mechanics Rules** ***Oitmaa***	**MOD21** **Shell Model Interaction around 208Pb Derived from Experimental Data** ***Maier***	**MOE21** **The Causes of Declining Pan Evaporation and Consequences for the Surface Moisture Balance over the Last 50 Years** ***Roderick***	**MOF21** Structural Characterization of Ion Implanted Au Nanocrystals Using Synchrotron-based Analytical Techniques *Kluth*

Note: *Keynote Speakers in bold. Medal winners underlined.*

1420–1440		**MOB22** Observing the Open-closed Boundary Using Pc5 ULF Waves *Ables*				**MOF22** Imaging on Nanocluster Using Coherent X-ray Diffraction and Computational Phase Retrieval Technique *Dhal*
1440–1500	**MOA23** Output Couplers for 3D Photonic Crystal Waveguides *Weily*	**MOB23** The Ionospheric Convection Response to Transient Reconnection *Morley*	**MOC23** The Locus of High Temperature Superconductivity in YBa2Cu3O7 *Jakovidis*	**MOD23** Search for 'Doorway States' Relevant to the Production and Survival of Ta-180 in Stars *Lane*	**MOE23** Long-term Variations in Winter Rainfall of Southwest Australia and Rapid Climate Change in the Late 1960s *Baines*	**MOF23** Applications of Synchrotron X-Ray Sources for Forensic Characterisation of Glass *Kempson*
1500–1520	**MOA24** Fabircation of Advanced Air-Silica Structured Optical Fibres *Lyytikainen*	**MOB24** **Solar Wind Driven Storms and Substorms with High Energy Electron Injections into the Inner Magnetosphere** ***Horton***	**MOC24** Toward Quantum-limited Detection with an Aluminium SQUID Amplifier *Court*	**MOD24** The AMS Technique for 53Mn *Gladkis*	**MOE24** An Extended High-quality Temperature Data Set for Australia *Trewin*	**MOF24** **High Energy Synchrotron X-rays: A Tool for Bulk Investigations in Physics and Materials Science** ***Liss***
1520–1540	**MOA25** Characterisation of Optical Wavefields Propagated through Scattering Media *Aruldoss*		**MOC25** Evolution of the Bilayer nu=1 Quantum Hall State under Charge Imbalance *Clarke*	**MOD25** Characterizing Uranium Ores with 236U and 239Pu *Wilcken*	**MOE25** Atmospheric Isotopes: Evolution of Stable Water Isotopologues as an Applicable Data Source *Henderson-Sellers*	
1540–1620	Coffee Break					
Topic area	**AOS/new faces 1**	**STSP**	**CMMSP**	**NUPP**	**AMOS**	**BMP**
Chair	J. Dawes	M.Duldig	G.Collins	D.Leinweber	W.Drosdowsky	P.Robinson
1620–1640	**MOA31** Cavity-enhanced, Noise-canceling Saturation Laser Spectroscopy *de Vine*	**MOB31** **Diagnosing Solar Particle Acceleration and Propagation Using Radio Emissions** ***Cane***	**MOC31** **Inelastic Neutron Scattering and the Dynamics of Biomolecules** ***Neumann***	**MOD31** **Atlas Status and Physics Program** ***Atkinson***	**MOE31** Constant Pressure Balloon Studies of Gravity Wave Momentum Fluxes in the Tropical and High-latitude Lower Stratosphere *Vincent*	**MOF31** Visualising the Genetic Code *Chelkowska*
1640–1700	**MOA32** Ultra-slow Light in Fibre Gratings *Mok*				**MOE32** Deep Convection in the Australian Tropics *Pope*	**MOF32** Stability and Connectivity of the Brain *Gray*
1700–1720	**MOA33** Holographic Mode Converters: Laser Beams Are not Plane Waves *Harvey*	**MOB33** Type II Radio Bursts: Theoretical Predictions of Dynamic Spectra and Source Regions *Knock*	**MOC33** Opportunities for Scientific Research at Australia's Replacement Research Reactor *Robinson*	**MOD33** Lattice Study of Possible Proton Anti-proton Bound State and H-dibaryon *Loan*	**MOE33** On the Height Distribution of Convection in the Tropics *Ballinger*	**MOF33** A Model-based Approach to EEG Spectral Analysis *Rennie*
1720–1740	**MOA34** Vortex Solitons in Nonlocal Kerr-like Media *Briedis*	**MOB34** Timing of the 2–3 kHz Radio Emission within the Solar Cycle *Mitchell*	**MOC34** Time Resolved Studies of Neutron Diffraction Intensities in Association with Phase Transitions *Daniels*	**MOD34** Fusion Mechanism of Light Weakly Bound Nuclei *Dasgupta*	**MOE34** **Tropical Convective Systems—The Tropical Warm Pool International Cloud Experiment** ***May***	**MOF34** A Phase-transition Model for the Cycles of Natural Sleep *Steyn-Ross*
1740–1800	**MOA35** Nanofabrication Using Standing Wave Optical Masks for Metastable Atom Lithography *Baker*	**MOB35** The Ion Aurora and Its Seasonal Variations *Newell*	**MOC35** Neutron Reflectivity of Titania and Zirconia-based Films Self-assembled at the Solid/Liquid Interface *Henderson*	**MOD35** Scanner for the Detection of Contraband in Air Cargo Containers ***Sowerby***		**MOF35** BOLD Responses to Stimuli: Dependence on Frequency, Stimulus Form, Amplitude and Repetition *Drysdale*
1800–1930	Dinner Break					
1930–2130	**Posters** *Melville Hall*					

Note: *Keynote Speakers in bold. Medal winners underlined.*

Tuesday 1 February

	MC1	MC2	MC3	MC4	MC5	MC6
0830–0915	**Plenary:** (*Chair:* D. McClelland) Wave Detectors on the Earth and in Deep Space—*Danzmann*					
0915–1000	**Plenary:** (*Chair:* R. Elliman) "Reaction Microscopes": The "Cloud Chambers" of Atomic and Molecular Physics—*Ullrich*					
1000–1040	Morning Tea					
Topic area	AOS/photonics 2	AMOS	CMMSP	NUPP	ASGRG	PEG
Chair	W. Krolikowsky	Henderson-Sellers	J. Williams	B. McKellar	P. Veitch	M. Sharma
1040–1100	**TUA11** **Microphotonic Crystal Fibres** ***Eggleton***	**TUB11** **Terrestrial Carbon and Water Cycles in Australian Landscapes: A Multi-scale Approach using Micrometeorology, Remote Sensing and Mesoscale Models** ***Cleugh***	**TUC11** Conducting Ni Nanoparticles in an Ion-modified Polymer *Sze*	**TUD11** A Broad Look at Mesons with Lattice QCD *Hedditch*	**TUE11** **The Australian International Gravitational Observatory** ***Blair***	**TUF11** **Key to Participation** ***Swan***
1100–1120			**TUC12** Investigation of the Growth and Spontaneous Alignment of Lanthanum Gallate Self-Assembled Microdots on SI(111) Surface *Sellar*	**TUD12** Excitation Energy and Spin of the Yrast Superdeformed Band in 196Pb *Wilson*	**TUE12** Off-axis Wavefront Sensors in High Power Gravitational Wave Interferometers *Brooks*	
1120–1140	**TUA13** Multiple Dissipative Soliton Interactions in a Passively Mode-Locked Fiber Laser *Akhmediev*	**TUB13** The Impact of Abrupt Land Cover Changes by Savannah Fire on Northern Australian Climate *Goergen*	**TUC13** Nano-assembly of Conjugated Polymer on Carbon Nanotubes: An STM Study *Goh*	**TUD13** Shell Structures in Exotic Nuclei from Magnetic Moment Measurements on Radioactive Beams *Stutchbery*	**TUE13** Advanced Interferometry for Gravitational Wave Detection *Gray*	**TUF13** The Missing Factor for Students in 1st Year Physics? *Logan*
1140–1200	**TUA14** Dark Soliton Formation and Interaction in Nonlocal Nonlinear Thermal Media *Petersen*	**TUB14** Seasonal Variations in Size-Resolved Properties of Aerosols in the Sydney Region *Hallal*	**TUC14** **Nanoporosity in a Self-Assembled Drug Delivery System Detected by Positron Annihilation Lifetime Spectroscopy** ***Hill***	**TUD14** **Visually Revealing the Secrets of QCD** ***Leinweber***	**TUE14** Tracking the Unity Gain Frequency of the Open Loop Gain Function in LIGO Interferometers *Ashley*	**TUF14** Using Student Authored Questions to Encourage Deeper Learning in Physics *Merchant*
1200–1220	**TUA15** Air-clad Fibres with Diffractive Intra-modal Cross Coupling *Canning*	**TUB15** Satellite Investigations of Aerosol Effect on Cloud *M. Box*			**TUE15** Measuring LISA Phase *Ware*	**TUF15** Online assessment in first year physics courses *Kruhlak*
1220–1400	Lunch Break					
1200–1400	**Pearman National Press Club Lunch** *(for further information, please see section Events Programme)*					
Topic area	AOS/appetizer	AMOS	CMMSP	NUPP	ASGRG	PEG
Chair	G. Milburn	S. Power	S. Butcher	D. Hinde	D. McClelland	K. Wilson
1400–1420	**TUA21** Optical Quantum Computing: Science-fiction, Horror-story or News? *A. White*	**TUB21** Ocean-atmosphere Dynamics in the Southern Ocean *Hogg*	**TUC21** **Silicon-based Quantum Computing using Buried Donor Architectures** ***Dzurak***	**TUD21** **Deformed Nuclear Isomers** ***Dracoulis***	**TUE21** Carmeli's Cosmology Indicates No Dark Matter in the Universe *Hartnett*	**TUF21** **Comprehensive Photonics Education Model—The Albuquerque Ladder** ***Guenther***

Note: *Keynote Speakers in bold. Medal winners underlined.*

1420–1440	**TUA22** Quantum Optics with Solid State Optical Centres *Longdell*	**TUB22** Impacts of Latitude Shifts in the Southern Ocean Westerly Winds on Past and Present Climates *Dupre*			**TUE22** Curvature Singularity Theorems for Space-time *Scott*	
1440–1500	**TUA23** BEC Analogues of Quantum Field Theory in Curved Space-time *Savage*	**TUB23** Non-linear Resonance and Chaos in an Unstable Western Boundary Current under Periodic Forcing *Kiss*	**TUC23** Differentiating Dpoant and Resist in Device Fabrication on the Atomic Scale *Reusch*	**TUD23** Lifetime of a New High-spin Isomer in 150Dy *Watanabe*	**TUE23** Transit Time of a Freely-falling Quantum Particle in a Background Gravitational Field *Davies*	**TUF23** Mathematics Transfer of First Year Science Students *Roberts*
1500–1520	**TUA24** **Nonlinear Light Propagation in Periodic Structures—Experiment vs. Theory** ***Kivshar***	**TUB24** **New Insights into the Indonesian Throughflow: Its Variability and Role in Global Heat Balances** ***Wijffels***	**TUC24** Magnetospectroscopy to 18T of Phosphorous Donor in Silicon *Vickers*	**TUD24** Structure of 188TI *Nieminen*	**TUE24** Causal Geodesics in Space-time and the Existence of Singularities *Whale*	**TUF24** Developing Investigative Skills Through a 'Challenge' Experiment *Greaves*
1520–1540			**TUC25** Kelvin Probe Force Microscopy Study of Ion Implanted Thermal Oxide Thin Films on Silicon *Lay*	**TUD25** Measurement of BR(B–>π / ν) and V_{ub} Using Neutrino Reconstruction at Belle *Cole*	**TUE25** Cosmological Gamma-ray Bursts: Singlets, Doublets? Triplets! *Van Putten*	**TUF25** Back to the Future: Cafeteria Laboratories in First Year Physics *Low*
1540–1620	Coffee Break					
Topic area	**AOS**	**AMOS**	**CMMSP**	**NUPP**	**BMP**	**PEG**
Chair	P.K. Lam	A. Hogg	R. Elliman	B. Robson	C. Charles	D. Mills
1620–1640	**TUA31** **Quantum Phase-space Applied to Ultra-cold Atoms** ***Drummond***	**TUB31** Mixing at the Subtropical Front in the Indian Ocean South of Australia *Tomczak*	**TUC31** **Liquid Semiconductors: Is Mott or Anderson Localisation Relevant?** ***Enderby***	**TUD31** How Can We Discover New Chemical Elements? *Bouriquet*	**TUE31** Oligonucleotide Microarrays and Langmuir Adsorption Theory *Burden*	**TUF31** **Changing Times—Changing Teaching** ***Zadnik***
1640–1700		**TUB32** The Melting of Ice in the Arctic Ocean: Double-Diffusive Transport of Heat from Below *Turner*		**TUD32** Electromagnetic Properties of Octet Baryons *Boinepalli*	**TUE32** Nano-structured Surfaces for Guided Actomyosin Motility to Develop New Toxin-indicating Biosensors *Ramdutt*	
1700–1720	**TUA33** Quantum Nonlocality without Entanglement *Pryde*	**TUB33** Cascading-Induced Upwelling in Submarine Canyons: A New Upwelling Mechanism *Kaempf*	**TUC33** Investigation of Subsurface Specimen Charging Induced in Buried Oxide Layers by Electron Beam Irradiation *Stevens-Kalceff*	**TUD33** Family Symmetries and the Peculiar Neutrino Mixing Matrix *Low*	**TUE33** Research and Development of Semiconductor-based Instrumentation with Application to Medical Physics *Rosenfield*	**TUF33** Video Physics Education: Falling Cats and Terminal Velocity *Muller*
1720–1740	**TUA34** Experimental Demonstration of Coherent State Continuous Variable Quantum Cryptography *Lance*	**TUB34** Control of Mean Sea Level Change by Net Oceanic Evaporation during Greenhouse Warming *Bye*	**TUC34** Photo-excitation Induced Processes in Amorphous Semiconductors *Singh*	**TUD34** **Reaching the Super-heavies** ***Hinde***	**TUE34** The Key Factors which Determine the Cooling Effect of Blood Flow Near Ultrasonically Heated Bone *Vella*	**TUF34** The RTASO Physics Olympiad Program *Wilson*
1740–1800	**TUA35** Quantum Non-Demolition Measurements on Qubits *Ralph*	**TUB35** Seasonal Variability of Atmospheric Teleconnection Patterns *Frederickson*	**TUC35** Electrical Conduction Mechanism of ZnO Thin Films *Lee*		**TUE35** Application of the Lattice Boltzmann Model to Hemodynamics with Arterial Stenosis Growth *Boyd*	**TUF35** The Science and Engineering Challenge *O'Connor*
1800–1930	Dinner Break					
1930–2130	**Posters** *Melville Hall*					

Note: *Keynote Speakers in bold. Medal winners underlined.*

Detailed Program
Tuesday 1 February

Detailed Program
Wednesday 2 February

Wednesday 2 February

	MC1	MC2	MC3	MC4	MC5	MC6
0830–0915	**Plenary:** (*Chair:* J. Finnigan) From Physics to Policy: The Science of Climate Change Underpinning Private and Public Policy Decisions—*Pearman*					
0915–1000	**Plenary:** (*Chair:* H. Bachor) What Can Physics Say about Life?—*Chu*					
1000–1040	Morning Tea					
Topic area	AOS/AMPQC	PP	CMMSP	NUPP	AMOS	GP
Chair	P. Hannaford	R. Tarrant	M. Spencer	R. Delbourgo	B. Trewin	L. Moresi
1040–1100	**WEA11** **BEC of $^6Li_2$ Molecules: Exploring the BEC-BCS Crossover** ***Denschlag***	**WEB11** **Advances in Magnetic Fusion Science and the ITER Project** ***Goldston***	**WEC11** Prediction of Surface Free Energy and Surface Phonon Modes in Nanodiamond Clusters *Russo*	**WED11** An Analysis of the Spectrum for the Time Evolution of a Periodically Rank-N Kicked Hamiltonian *McCaw*	**WEE11** Cloud Properties from the CALIPSO Satellite Lidar and Radiometer *Platt*	**WEF11** **A Most Remarkable Surface** ***Sandiford***
1100–1120			**WEC12** Ion-Irradiation-Induced Porosity in GaSb and InSb *Kluth*	**WED12** In-matter Three-body Problem *Blankleider*	**WEE12** Effects of Air-sea Interactions on the Development of Intrusions at the Subtropical Front South of Australia *Borlace*	**WEF12** **Imaging the Earth—the Nature of Seismic Heterogeneity** ***Kennett***
1120–1140	**WEA13** Bose Einstein Condensation with a Permanent Magnetic Film Atom Chip *Hall*	**WEB13** Equilibrium and Stability of the Mega Ampere Spherical Tokamak *Hole*	**WEC13** On the Structure of Self-assembled Biomimetic Precipitates *Larsson*	**WED13** New Methods of Testing Lorentz Violation in Electrodynamics *Hartnett*	**WEE13** Mapping Australia's Oceans with Over-the-Horizon Radar *Anderson*	**WEF13** Imaging Subducting Slabs along the Western Pacific Margin *Miller*
1140–1200	**WEA14** Bose-Einstein Condensates on an Atom Chips *Vale*	**WEB14** New Type of Laser Produced Ions for Simplified Fusion *Hora*	**WEC14** **Magnetic-Carbon Nanofoam** ***Rode***	**WED14** **Effects of Variation of Fundamental Constants from Big Bang to Atomic Clocks** ***Flambaum***	**WEE14** **Ocean-atmosphere Coupled Forecast Models** ***Alves***	**WEF14** Seismological Applications of Laboratory Measurements of Dispersion and Attenuation of Upper-mantle Materials *Jackson*
1200–1220	**WEA15** Vortices in Bose-Einstein Condensates Confined by Optical Lattices *Ostrovskaya*	**WEB15** Imaging Plasma Spectroscopy Using Novel High-resolution, High-speed Optical Coherence-based Methods *Howard*				**WEF15** Finite Element Modelling of Crustal Dynamics with the Imaging Information of the Earth *Xing*
1220–1330	Lunch Break					

Note: *Keynote Speakers in bold. Medal winners underlined.*

<table>
<tr><td>1330–1530</td><td>Posters:
Melville Hall</td><td>Schools Outreach
Llewellyn Hall
1330–1430 Future of Physics
1430–1530 Entertaining Physics
1530–1630 Physics as a Life Skill</td></tr>
<tr><td>1530</td><td>Tour of the Physics Department and Research School of Physical Sciences and Engineering</td><td>1630–1730 Entertaining Physics
1730–1830 Einstein's Revolution</td></tr>
<tr><td>1900 for 2000</td><td colspan="2">Congress Dinner
Great Hall, Parliament House
(For further details, please see section Events Programme)</td></tr>
</table>



Detailed Program
Wednesday 2 February

Detailed Program
Thursday 3 February

Thursday 3 February

	MC1	MC2	MC3	MC4	MC5	MC6
0830–0915	**Plenary:** (*Chair:* C. Barton) Airborne Gravity Gradiometry Applied to Mineral and Hydrocarbon Exploration—*van Leeuwen*					
0915–1000	**Plenary:** (*Chair:* B. Schmidt) A Golden Age for Astronomy—*Cesarsky*					
1000–1040	Morning Tea					
Topic area	**AOS/AMPQC**	**PP**	**CMMSP**	**GP**	**PEG**	**ASA**
Chair	A. Truscott	J. Harris	E. Mitchell	J. Freeman	D. Low	B. Schmidt
1040–1100	**THA11** **New Physics with Degenerate Ferni Gases** ***Shlyapnikov***	**THB11** Stability for Kinetic Ballooning Modes in Stellarators *McMillan*	**THC11** Helium Vapour Pressure Thermometry by Ultrasound Attenuation *Macfarlane*	**THD11** The Dynamics of Sheared Mantle Plume Tails *Kerr*	**THE11** **Key Findings of the National Physics Project on Learning and Teaching** ***Livett***	**THF11** **Interferometric Gravitational Wave Antenna** ***McClelland***
1100–1120		**THB12** One-dimensional PIC Simulation of a Current-free Double-layer in an Expanding Plasma *Meige*	**THC12** Crystallinity in Lumogen Optical Thin Films *Deslandes*	**THD12** The Effect of Mantle Cconvection on Surface Topography over the Last 120 Million Years: An Evaluation of Model Predictions Based on the Geological Record *Müller*		**THF12** **Future High Energy Cosmic Ray Detection Facilities** ***Clay***
1120–1140	**THA13** Reflection of Dilute Gas Bose Einstein Condensates off a Silicon Surface *Martin*	**THB13** Reactive Plasma-assisted Nanofabrication: Unique Features and Future Challenges *Ostrikov*	**THC13** Application of Optical Near-fields for Dry Etching *Polonski*	**THD13** The Influence of Rheological Structure in the Deformation of the Lithosphere *Moresi*	**THE13** Implications of the National Physics Project for Teaching and Learning *Workshop-Pollard*	**THF13** **Antarctic Astronomy** ***Storey***
1140–1200	**THA14** Limits to the Flux of a Continuous Atom Laser *Robins*	**THB14** High-Density Pulsed Cathodic Arc Plasmas *Tarrant*	**THC14** **Acoustic Reflectivity of Liquid Saturated Porous Materials** ***Schmitt***	**THD14** **Paradoxical Behavior in a Partially Insulated Thermally Convecting System with Application to the Thermal History of the Earth** ***Lenardic***		**THF14** **ELTs: The Next Generation of Extremely Large Optical/ Infrared Telescopes** ***Couch***
1200–1220	**THA15** Dynamical Tunneling with Bose-Einstein Condensates on Atom Chips *Davis*	**THB15** Self-organization in Turbulence as a Route to Order in Plasma and Fluids *Xia*		**THD15** **Tectonic Drivers** ***Davies***		**THF15** **Future Radio Facilities** ***Boyle***
1220–1400	Lunch Break					
1300	**ITER Meeting** *(MC6)*					
Topic area	**AOS**	**AMPQC**	**CMMSP**	**GP**	**AAS**	**ASA/ASGRG**
Chair	B. Oreb	R. McEachran	T. Finlayson	K. Dodds	E. LePage	S. Scott
1400–1420	**THA21** Stable Phase Imaging and Measurement *Gilchrist*	**THB21** **Close Coupling Approach to Electron-hydrogen Ionisation** ***Bray***	**THC21** **Superconducting Quantum Engineering at the CSIRO** ***Foley***	**THD21** **The Physics of Imaging Faults in Precious Mineral Reefs** ***Mason***	**THE21** A Study of Ageing and Playing Effects on Violins: The First Three Years *Inta*	**THF21** **Testing Foundations of Physics in Space — and European Plans in this Matter** ***Huber***

Note: *Keynote Speakers in bold. Medal winners underlined.*

1420–1440	**THA22** Experimental Study of Full-field Fourier-Domain Optical Coherence Tomography *Zvyagin*			**THD22** **Seismic Imaging of Complex Geological Structures** ***Greenhalgh***	**THE22** An Analysis of Undercut Toneholes in Woodwinds *Poulton*	**THF22** **The Current Status of LIGO** ***Reitze***
1440–1500	**THA23** Impurity Centers in Solids: Suppression and Enhancement of Matrix Induced Dephasing in Strong Optical Fields *Plakhotnik*	**THB23** (e,2e) Measurements Using a Magnetic Angle Changer *Stevenson*	**THC23** Competing Types of Long-range 3D Magnetic Order in the Layered Molecular Network Compounds ||M(NCO)2(pyz), M=Mn, Fe or Co *Ling*	**THD23** **Seismic Wave Attenuation and Dispersion in Heterogeneous Porous Rocks** ***Gurevich***	**THE23** Singing Strategies: How Tenors and Sopranos 'Tune' Their Vocal Tracts *Wolfe*	**THF23** Correlated Global Noise in Gravitational Wave Astronomy *Searle*
1500–1520	**THA24** **When is a Transparent Particle not Transparent?** ***Kane***	**THB24** Violations of Parity and Time-reversal in Heavy Atoms: Calculations for Cesium and Radium *Ginges*	**THC24** Studying Antiferromagnets Using an Exchange Bias Bilayer Thin Film *Crew*	**THD24** Thermal Convection with a Water Ice Rheology *Freeman*	**THE25** **An Unnatural Test of a Natural Model of Pitch Perception: The Tritone Paradox and Spectral Dominance** ***Parncutt***	**THF24** **Detection of Gravitational Waves Using a Pulsar Timing Array** ***Manchester***
1520–1540		**THB25** Measurement of Two-electron QED in Helium-like Titanium *Chantler*	**THC25** Surface Studies of Horse-spleen Ferritin *Tettamanzi*	**THD25** Regional Strain Pattern in the Australian Plate Revealed by GPS *Zhao*		**THF25** ***Pulsar Timing and General Relativity*** ***Bailes***
1540–1620	Coffee Break					
Topic area	**AOS/new faces 2**	**AMPQC**	**CMMSP**	**CSCMP**	**AAS**	**WIP/HOP**
Chair	J. Hope	B. Lohmann	L. Hollenberg	R. Dewar	N. Fletcher	J. Pollard
1620–1640	**THA31** Squeezing in the Audio Gravitational Wave Detection Band *Mckenzie*	**THB31** Electrical Conduction of Single Organic Molecules *Mueller*	**THC31** **Tidbits about Qubits: Spin Computation in Nanostructures** ***Das Sarma***	**THD31** **Econophysics: from Statistical Physics to Economics** ***Di Matteo***	**THE31** **The Potency of Otoacoustic Emissions: The Auditory Evaluation Tool for the Twenty-first Century?** ***LePage***	**THF31** A History of the Australian Atomic Energy Commission *Binnie*
1640–1700	**THA32** Universality for Quantum Computation of Many-Body Systems with Fast Local Control *Dodd*	**THB32** Electron Cross Sections in Modelling of Auroral Emissions *Campbell*				**THF32** Maximising Potential in Physics *Stevens-Kalceff*
1700–1720	**THA33** Classical Robustness of Quantum Unravellings *Atkins*	**THB33** On the Changes of Tidal Characteristics due to Sediment-induced Stratification in a Macro-tidal Coastal Sea *Wang*	**THC33** Fabrication of Nano-Devices in Silicon Using Scanning Tunneling Microscopy *Butcher*	**THD33** Asymmetry of Returns in the Australian Stock Exchange *Gunner*	**THE33** Dynamics of SAG/AG Mills as Measured by Non-Contact Acoustic Measurement *Pax*	**THF33** Seating in Laboratory Classes: Achieving Critical Mass *Feteris*
1720–1740	**THA34** Population Inversion in a Strongly Driven Two-level System *Doherty*	**THB34** **Interatomic and Intermolecular Interactions Studied by Imaging Techniques** ***Lawrance***	**THC34** Quantum Electro-Mechanical System (QEMS) *Wahyu Utami*	**THD34** From Hyperbolic Patterns to Euclidean Structures *Robins*	**THE34** Interference Fringes with a Stochastic Origin *Hamilton*	**THF34** **Status of Women in Physics in Australia and Overseas** ***Foley***
1740–1800	**THA35** Quantum Nondemolition Measurement of the Polarisation of a Single Photon *O'Brien*		**THC35** Electron Momentum Spectroscopy of Some Simple Condensed Materials *Dorsett*	**THD35** Renormalization, Regularization and the Statistical Mechanics of Topographic Rossby Wave Turbulence *O'Kane*	**THE35** Investigation of the Radiation Force on Particles in an Ultrasound Field *Buick*	
1800–1930	Dinner Break					
1930–2130	**Posters** *Melville Hall*					
2000	**Public Lecture** *Questacon*					

Note: *Keynote Speakers in bold. Medal winners underlined.*

Detailed Program
Thursday 3 February

Friday 4 February

	MC1	MC2	MC3	MC4	MC5	MC6
Topic area	**AOS/laser & applications**	**STSP**	**CMMSP**	**CSCMP**	**AMPQC**	**EP/RE**
Chair	M. Hamilton	B. Fraser	R. Lewis	M. Batchelor	R. Robson	John Finnigan
0820–0840	**FRA11** Fabrication of Large Aperture Fabry Perot Etalons with Sub-nanometer Thickness Uniformity *Arkwright*	**FRB11** **The Alfvénic Aurora** ***Chaston***	**FRC11** **Scanning Tunneling Microscopy of Real Time Defect Motion on Surfaces** ***Frenken***	**FRD11** Verified Computing in GR Workbench *Moylan*	**FRE11** Calculation of Stokes Parameters for e-H(2P) Excitation *Stelbovics*	**FRF11** Radar Interrogation of High-flying Insects: What Bug Is That? *Drake*
0840–0900	**FRA12** Ultra High Throughput Optical Fiber Probes *Huntington*			**FRD12** Achieving Scalable Computational Modelling through Frameworks of Interchangable Numerical Methods: StGermain-Snark *Quenette*	**FRE12** Lippmann-Schwinger Description of Multiphoton Ionization *Ivanov*	**FRF12** Ultrasonic Destruction of Contaminants in Soil *Collings*
0900–0920	**FRA13** TEM01 Homodyne as an Optimal Small Displacement Measurement Scheme *Delaubert*	**FRB13** Fine-scale Field-aligned Current Structures: Distribution and Relation to Dayside Magneto-spheric Particle Boundaries *Terkildsen*	**FRC13** Analysis of Peptides Desorbed from Silicon by a Free Electron Laser *King*	**FRD13** Soliton Resonance and Web Structure in Discrete Integrable Systems *Maruno*	**FRE13** Positron Studies for Atomic and Molecular Physics and Materials Science *Sullivan*	**FRF13** Crystalline Silicon Thin-film Solar Cells on Glass - Cheap Electricity from the Sun? *Aberle*
0920–0940	**FRA14** **Optical Phased Array Technology Development** ***McManamon***	**FRB14** Gasdynamical Description versus Quasilinear Simulations for a Hot Electron Beam Propagating in a Plasma *Foroutan*	**FRC14** Photoelectron Diffraction from Cu(111) Surfaces *Broekman*	**FRD14** Pathwise Solution of a Class of Quantum Filtering Equations *Kurniawan*	**FRE14** **The Exotic World of Low-energy Positron-atom Interactions** ***Bromley***	**FRF14** Modifying the Solar Spectrum: Bridging the Gap between First and Third Generation Photovoltaics *Richards*
0940–1000		**FRB15** Quasilinear Simulation of Second Harmonic Electromagnetic Emission *Li*	**FRC15** Bio-molecule Adsorption Studied using Micro-beam Photoemission Spectroscopy *Stampfl*	**FRD15** Quantum Teleportation by Measurements on a Large Class of Wavefunctions *Barjaktarevic*		**FRF15** Photoelectrochemical Hydrogen Production *Plumb* *Glasscock*
1000–1040	Morning Tea					

Note: *Keynote Speakers in bold. Medal winners underlined.*

Topic area	AOS/Quantum Inf	STSP	CMMSP	CSCMP	AMPQC	AOS/Laser Development
Chair	P. Drummond	R. Vincent	G. Stewart	D. Evans	R. Sang	J. Munch
1040–1100	**FRA21** **Quantum TRajectort Treatment of the Continuous Variable Telportation of Quantum Fields** ***Carmichael***	**FRB21** **Implications of Height-varying Vertical Winds in Earth's Auroral Thermosphere** ***Conde***	**FRC21** Micromachining of Single Crystal Diamond using a Novel Lift-off Technique *Olivero*	**FRD21** **Experimental Demonstrations of a New Second Law-like Theorem** ***Sevick***	**FRE21** **Trapped Clusters and Nanoparticles** ***Bieske***	**FRF21** 10W, Single Frequency, CW Nd:YAG Laser *Hosken*
1100–1120			**FRC22** Observation of Track Formation and Track Annealing in Swift Heavy Ion Irradiated InP *Khalil*			**FRF22** Design of an Optical Fiter for Suppresion of High Order Modes in High Power Continuous Mode Laser *Barriga*
1120–1140	**FRA23** Relativistically Invariant Quantum Information *Bartlett*	**FRB23** Tomographic Observations of the Plasmasphere using FedSat *Dyson*	**FRC23** Modification of Surface & Barrier Properties of Polyethylene Terephthalate and Polycarbonate Plastics by Ion Implantation *Doolan*	**FRD23** The Optical Tweezers "Capture" Experiment to Demonstrate the Transient Fluctuation Theorem and the Kawasaki Identity *Carberry*	**FRE23** Rovibrational Energy Transfer in the 4nuCH Manifold of Acetylene, Viewed by||IR-UV Double Resonance Spectroscopy *Orr*	**FRF23** Solid-state Raman Lasers: Efficient Multi-wavelength Lasers for the Green-yellow-red Region *Pask*
1140–1200	**FRA24** The Preferred Ensemble Fact with Applications to Quantum Feedback Control *Wiseman*	**FRB24** A Comparison of Observed and Modelled Aircraft Radiation Dose Rates during Cosmic Ray Transient Variations *Getley*	**FRC24** **Nanoelectronics for Quantum Information Processing** ***Marcus***	**FRD24** Demonstration of the Steady-State Fluctuation Theorem Using a Colloidal Particle in a Translating Optical Trap *Wang*	**FRE24** High-resolution Photoelectron Spectroscopy via Velocity-map Imaging of Anion Radicals: A Window into Chemical Reaction Dynamics *Cavanagh*	**FRF24** Stimulated Raman Gain Cavity Ringdown (SRG-CRD) Spectroscopy for High-Resolution Gas Sensing *Englich*
1200–1220	**FRA25** Quantum Logic in a Decoherence-suppressed Subspace with Aatomic Qubits *Brooke*	**FRB25** Comparison of Large-scale Field-aligned Currents Calculated from SuperDARN and Iridium *Green*		**FRD25** Statistical Mechanics Applied to an Undercoooled Metastable Liquid *Williams*	**FRE25** Towards Electron Momentum Spectroscopy Studies of Clusters—A New Apparatus *Nixon*	**FRF25** First Locking of a 80m Baseline Suspended Fabry-Perot Cavity *Slagmolen*
1220–1400	Lunch Break					
1300–1330	**AIP AGM**					
1330–1400	**AIP PRIZES AND MEDALS**					
1400–1445	**Plenary:** (*Chair:* G. Stewart) Plasma Physics Enters the Nano-Age—*Bilek*					
1445–1530	**Plenary:** (*Chair:* A. Byrne) The Asymmetry Between Matter and Antimatter—in the Universe and in the Laws of Physics—*Quinn*					
1530	**Close**					
1530	**Tour of the Physics Department and Research School of Physical Sciences and Engineering**					
1800	**BBQ at the end of the Tour**					

Note: *Keynote Speakers in bold. Medal winners underlined.*

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Plenary Speakers

Professor Tony Leggett

FRS, FAPS, FAIP
Department of Physics, University of Illinois at Urbana-Champaign, USA
www.physics.uiuc.edu/People/Faculty/profiles/Leggett/

2003 Nobel Prize winner in Physics "for pioneering contributions to the theory of superconductors and superfluids"

Anthony J. Leggett was born in London, England in March 1938. He attended Balliol College, Oxford where he majored in Literae Humaniores (classical languages and literature, philosophy and Greco-Roman history),and thereafter Merton College, Oxford where he took a second undergraduate degree in Physics. He completed a D.Phil. (Ph.D.) degree in theoretical physics under the supervision of D. terHaar. After postdoctoral research in Urbana, Kyoto and elsewhere he joined the faculty of the University of Sussex (UK) in 1967, being promoted to Reader in 1971 and to Professor in 1978. In 1983 he became John D. and Catherine T. Macarthur Professor at the University of Illinois at Urbana-Champaign, a position he currently holds. His principal research interests lie in the areas of condensed matter physics, particularly high-temperature superconductivity, glasses and ultracold atomic gases, and the foundations of quantum mechanics.

Ultracold Fermi Alkali Gases: Bose Condensation Meets Cooper Pairing

For many years, condensed-matter theorists have appreciated that Bose-Einstein condensation of diatomic molecules and Cooper pairing of degenerate fermions are in some sense opposite ends of the same continuous spectrum, and the problem of the "crossover" between these two limits has been intensively studied, in particular because of its possible connection with issues in cuprate superconductivity.

Recent experimental work on the ultracold Fermi alkali gases (6-Li and 40-K) has made it extremely plausible that this crossover actually occurs in these systems. However, both the physical conditions and the properties most easily investigated experimentally are rather different from those traditionally assumed in the theoretical literature. I review the salient properties of these new systems, and discuss the experimental results so far obtained and some of the challenges they present to theory.

Professor Karsten Danzmann

Director, Max Planck Institute for Gravitational Physics, Hannover, Germany
www.geo600.uni-hannover.de
Lead scientist for the European space-based LISA gravity wave observatory and Co-Director of the GEO ground based gravity wave detector project

Karsten Danzmann obtained his diploma and PhD from the Universität Hannover in Germany with work on plasma spectroscopy. Next he joined the Physikalische Technische Bundesanstalt (PTB) concentrating on optical precision measurements. From 1986–89 he was an Assistant Professor at Stanford University where he worked on high resolution spectroscopy. He returned to Germany in 1990 as the leader of the project for detecting gravitational waves (GW) at the Max-Planck-Institut for Quantenoptik (MPQ) in Garching. Since 1993 he is full Professor at the Universität Hannover. In 2002 he became the founding Director of the Hannover branch of the Max-Planck-Institut for Gravitationsphysik (Albert-Einstein-Institut) and devotes his time to the detection of gravitational waves with earth-based and outerspace instruments.

Gravitational Wave Detectors on the Earth and in Deep Space

Gravitational waves have been predicted more than 80 years ago by Einstein as a consequence of his Theory of General Relativity. Although gravitational waves have not yet been seen directly, their indirect influence can be observed in the binary pulsar PSR 1913+16. This binary's two neutron stars are spiralling together at just the rate predicted by gravitational radiation reaction.

Gravitational waves, once observed, promise us a radically new view of the universe.

Electromagnetic waves are incoherent superpositions of emission from individual electrons, atoms or molecules in low-density regions. But gravitational waves will tell us about the coherent motion of huge amounts of mass-energy and the vibrating, non-linear spacetime curvature itself.

Several kilometres-sized laser interferometric gravitational wave detectors have been under construction in the US and Europe over the last few years (LIGO, VIRGO, GEO600). LIGO and GEO600 have gone into operation in 2004 and VIRGO will join in the near future, forming a world-wide network of ground-based detectors to perform routine observations of gravitational waves in the high-frequency band between a few Hz and 10 kHz, aiming at sources such as coalescing binaries or supernovae.

The low-frequency band from 1 Hz down to less than a milli-Hertz is populated by waves emitted by sources as diverse as supermassive black holes at large red-shifts to short period binaries in our own galaxy. This band will never be observable on the ground due to the unshieldable background of Newtonian gravity gradients on earth. This is the domain of detectors flown in space. The European Space Agenca (ESA) and NASA in the US have reached agreement on a spaceborne laser interferometric gravitational wave detector (LISA) as a collaborative ESA/NASA mission with a launch date in 2013.The technology demonstrator mission LISA Pathfinder has entered into its final Implementation Phase in October of 2004, aiming at a launch date in 2008.

Professor Joachim Ullrich

Director
Max Planck Institute for Nuclear Physics, Heidelberg, Germany
www.mpi-hd.mpg.de/ullrich/

Leibniz Award winner, 1999

Joachim Ullrich studied physics and geo-physics at the Johann-Wolfgang-Goethe Universität in Frankfurt. His PhD, about novel methods to detect small recoil-momenta in atomic or molecular fragmentation reactions (Recoil-Ion Momentum Spectroscopy), was awarded the Best Thesis Prize in 1988. At the BEVALAC of the LBL, Berkeley and as scientific staff member at the GSI, Darmstadt he explored energetic heavy-ion atom collisions and, later, photon interactions at the ALS, Berkeley or at DESY, Hamburg. For the development of many-particle imaging techniques, so-called "Reaction-Microscopes", he received the German Leibniz-Award in 1999. From 1997 to 2000 he held a Full Professor position at Freiburg University and was appointed Director at the Max-Planck-Institute for Nuclear Physics (MPI-K), Heidelberg in 2001. He is Honorary Professor at the University of Heidelberg since 2001, Managing Director at the MPI-K since 2002, Consultant Professor at the Shanghai Fudan University since 2003 and has published about 250 articles. His main current interest is in atomic and molecular many-particle dynamics in ultra-fast intense lasers, free electron lasers, in collisions with electrons, heavy ions and antiparticles. He is developing storage techniques, like ion-traps and sources (EBIT) as well as novel storage rings for molecular ions, heavy ions and antiprotons.

"Reaction Microscopes": The "Cloud Chambers" of Atomic and Molecular Physics

Reaction-Microscopes, developed 10 years ago in order to investigate ultra-fast electronic dynamics in ion-atom collisions[1], allow one to determine the complete vector momenta of several electrons and ions resulting from the fragmentation of atoms, molecules or clusters. In a unique combination, large solid angles close to 4π and superior momentum resolutions around a few percent of an atomic unit are typically reached in state-of-the art machines corresponding to energy resolutions of a few μeV for ions and sub-meV for electrons. Thus, these "cloud chambers" deliver precise images of the complete final-state many-particle wave function in momentum space essentially for any atomic and molecular fragmentation reaction[2]. Consequently, the technique has been tremendously expanding in recent years beyond the investigation of ion-atom collisions and was successfully used by an increasing number of groups to explore the interaction of photons, electrons, antiprotons and, most recently, of intense ultra-short lasers with atoms, molecules and clusters[3,4]. It turns out, that Reaction-Microscopes enable to follow in unprecedented detail and completeness correlated electronic and nuclear quantum dynamics on ultra-fast time scales from tens of femto- to sub-attoseconds.

In the talk the working principle of newest machines will be highlighted. Benchmark experiments will be presented in the various areas that have been explored where atoms, molecules or clusters interact with individual eV up to 100 keV photons, with singly up to highly-charged $U92^+$ ions at eV to 200 GeV energies, with ultra-fast lasers at 1013 to 1016 W/cm^2 intensities, with electrons from threshold to keV energies or with antiprotons at any velocity.

Finally, the rich future potential of the method will be envisaged ranging from the investigation of correlated electron emission from (super-conducting) solids and surfaces, the possible study of single-particle (molecule) properties of Bose-Einstein-Condensates to proton exchange (chemical) reactions at thermal energies and the possible control of ultra-fast correlated electronic motion in laser assisted reactions using few-cycle phase-controlled laser pulses or future free-electron lasers.

[1] R. Moshammer et al., Phys. Rev. Lett. 73 (1994) 3371
[2] J. Ullrich et al., J. Phys. B 30 (1997) 2917
[3] R. Dörner et al., Phys. Rep. 330 (2000) 95
[4] J. Ullrich et al., Rep. Prog. Phys. 66 (2003) 1463

Professor Graeme Pearman

AM, FAA, Chief of Sustainability Science, Monash University, Australia; formerly Chief, CSIRO Division of Atmospheric Research
www.dar.csiro.au/profile/pearman.html

CSIRO Medal, 1988
UNEP Global 500 Award, 1989

Professor Graeme Pearman obtained his degrees from the University of Western Australia where he was trained as a biologist. He joined CSIRO, in 1971 where he was Chief of the CSIRO Division of Atmospheric Research for ten years 1992–2002. He established an active research team looking at the biogeochemical cycles of climatically active trace gases.

He contributed over 150 scientific journal papers primarily on aspects of the global carbon budget. In 2003 he established the CSIRO CLIMATE program a thirteen-Division CSIRO wide research activity in climate change and variability. In 2004 he joined the Australian Climate Group and left CSIRO to start a consultancy company and to develop Sustainability Science at Monash University.

He was awarded a United Nation's Environment Program Global 500 Award in 1989 for his involvement in a national awareness program on the climate change issue. He was elected to Fellowship of the Australian Academy of Science in 1988 and to Fellowship of the Royal Society of Victoria in 1997 for his contribution to scientific knowledge.

In 1999 he was awarded the Australian Medal of the Order of Australia for his services to atmospheric science and promotion of the science of climate change to the public. In 2002 he was a finalist in Prime Minister's Environmentalist of the Year, and in 2001 he was awarded a Federation Medal in 2003.

Examples of his membership are: Past member of the National Greenhouse Science Advisory Committee; Past President of the Australia Meteorological and Oceanographic Society; Past Co-Chairman of the Science Advisory Group for the Asia Pacific Network for global change (Kobi); Past Chairman of the Joint Australian Academies Committee for Sustainability; Past Chairman of the National Committee for Sustainability (AAS); current Chairman of START International (Washington; System for Analysis, Research and Training of the IGBP, WCRP and IHDP international programs); Acting Chair of the Board of Greenfleet Australia; Deputy Chair of the ICSU Committee for Strategic Planning and Review (Paris). He currently serves on the Advisory Bodies of WWF and Environment Business Australia and Chairs the Antarctic Research Assessment Committee (Physical Sciences) of the Australian Antarctic Division.

From Physics to Policy: The Science of Climate Change Underpinning Private and Public Policy Decisions

Analyses of countries around the world demonstrate a growing need through this century for energy in response to increasing life-style expectations and population. At least for some time, these needs can be met only by a continued utilisation of fossil-fuel energy that in turn results, with current technologies, in the emission of carbon dioxide.

The accumulation of this gas in the earth's atmosphere has already changed the climate of the earth and more change is likely. In 2001, the international science community reported it is now clear that the earth warmed through the last century; most of this warming was likely due to increasing levels of greenhouse gases; the demand for energy will ensure that carbon dioxide continues to accumulate in the atmosphere and thus the climate warm through this century; and there are many observed and anticipated impacts of this warming on natural ecosystems and human activities around the world.

Since that time, the science has progressed further and here in Australia, evidence for warming, other climatic changes and impacts is growing.

So what is the solution to this apparent conflict for the future? Is it in new technologies? Is there a single response that will save the day? Or is there a demand for a new portfolio of energy production and utilisation technologies that meet the demands for the amenity that energy delivers, but does not compromise the future?

Are there economic gains to be made through early engagement in a new vision of energy futures? Can we usefully extrapolate our existing energy systems into the future? Or is the solution in behavioural change, and new expectations for economic growth and social security?

Graeme Pearman will outline some of the more recent evidence for climate change; address the issue of how much change might turn out to be "dangerous"; discuss the dynamic between a still incomplete and developing science and the perceived need for intervention and legislative action to deal with climate change; and the risks that this imposes on the operating environment of the commercial and industrial world, both through the impact of climate change itself and through the need for adaptive and mitigative responses to the issue.

He will discuss also the nature of a new paradigm for the development of policy, both private and public, that maximise delivery of these needs.

Professor Steven Chu

Lawrence Berkeley National Laboratory and Stanford University, USA
www.stanford.edu/group/chugroup

1997 Nobel Prize winner in Physics "for development of methods to cool and trap atoms with laser light"

Steven Chu is the Director of the Lawrence Berkeley National Laboratory and a Professor of Physics and Molecular and Cellular Biology at the University of California, Berkeley.

His thesis and postdoctoral work was the observation of parity non-conservation in atomic transitions. While at Bell Laboratories he and Allen Mills did the first laser spectroscopy of positronium and muonium. Chu led a group that showed how to first cool and then trap atoms with light. The "optical tweezers" trap is also widely used in biology. Other contributions include the demonstration of the magneto-optic trap, the theory of laser cooling (also by Claude Cohen-Tannoudji and Jean Dalibard), the first atomic fountain, and precision atom interferometry based on optical pulses of light. Using the optical tweezers, Chu introduced methods to simultaneously visualize and manipulate single bio-molecules in 1990. His group is also applying methods such as fluorescence energy transfer, optical tweezers and atomic force microscope methods to study the biology at the single molecule level.

Chu has been awarded numerous prizes that include co-winner of the Nobel Prize in Physics with William Phillips and Claude Cohen-Tannoudji (1997). He is a member of the National Academy of Sciences, the American Philosophical Society, the American Academy of Arts and Sciences, the Academia Sinica, and a foreign member of the Chinese Academy of Sciences and the Korean Academy of Science and Engineering.

What Can Physics Say about Life?

An increasing number of physical scientists are beginning to devote considerable attention to biological problems. As more physical/mechanistic understandings of biological systems emerge, we are beginning to develop a deeper, quantitative understanding of how biological systems work. With this understanding, we are beginning to appreciate the extraordinarily clever ways living systems have chosen to solve can be though of as essentially engineering problems. I will present examples of the engineering problems and solutions that life has taken that allow us to hear music and make proteins. Finally, if time permits, I will discuss how nature can give us insights into how we might solve the challenge of realizing a sustainable, CO_2 neutral source of energy before out fossil fuel supply is depleted.

Dr Edwin Hans van Leeuwen

FAA

Manager Exploration Technologies, BHP Billiton, Melbourne, Australia. http://falcon.bhpbilliton.com/

Clunies Ross National Science and Technology Award winner, 2002

Leader, development team for the FALCON airborne gravity gradiometer

Dr Edwin van Leeuwen is the Global Manager of BHP Billiton's Exploration and Mining Technologies Group and is responsible for developing new exploration and mining technologies to ensure BHP Billiton stays at the forefront of its competitive business's.

Dr van Leeuwen has held several senior positions with BHP Billiton managing the Advanced Systems Engineering Group, BHP's External Research and Development Portfolio and Business Development Group. Prior to his career with BHP Billiton he spent five years working in the Australian Defence Department.

He currently serves on the Board of several international consortia involving Australia, Japan, USA, Canada, South Korea and Europe and is the international chairman of a program on Advanced Systems. He also sits on several University Boards and Research Centres in Australia.

In 2000, Dr van Leeuwen was elected a fellow of the Australian Academy of Technology Science and Engineering. In 2002 he was awarded the Centenary Medal for services to Australian Society in Research and Development and the prestigious ATSE Clunies Ross Award for his contributions to exploration geophysics.

He is also responsible for leading the team that developed the world's first airborne gravity gradiometer system for mapping mineral and hydrocarbon structures from a light aircraft. This technology has won the team the CSIRO award for excellence in science and the Graham Sands award from the Australian Society for Exploration Geophysics.

Airborne Gravity Gradiometry Applied to Mineral and Hydrocarbon Exploration

Gravity, the most ubiquitous of all forces, is difficult to measure with the accuracy needed for both fundamental research, and for applications such as geodesy, mineral exploration, and defence. The reason is easy to understand, the variations in gravity from point to point on the earth's surface are of the order of 10^{-6} of the average value of 9.81 ms^{-2}. Even today, that is a major measurement challenge.

The instrumentalists of the late 1800s solved the problem the way all good instrumentalists approach such a problem; they turned it into a differential measurement. Thus the Eotvos gradiometer was developed that measured the difference between the gravitational attractions at two points about a meter apart. While excruciatingly slow to use (8 hours per measurement), and very sensitive to external influences (eg. temperature), this remained the standard technology for five decades.

By the 1950s, gravimeters (that measure the gravitational acceleration directly) had been developed to the point that they replaced the gravity gradiometer for most applications. However, a new need arose in the 1970s, when it was recognised that the accuracy with which a missile would hit it's target was strongly influenced by the gravity gradient at the point of launch. This drove a new wave of research that led to an entirely new generation of gravity gradiometers.

While the gravimeter had satisfied many of the needs of mineral and petroleum explorers since 1950, it had failed almost totally in one important application; namely in airborne geophysics. Once again it is easy to understand why; the gravitational signals of interest are a factor of $<10^{-7}$ of the accelerations of the aircraft and are indistinguishable from them at a point measurement.

Starting in 1991, BHP Billiton surveyed all the known gravity technologies and in particular gravity gradiometer technologies to assess the practicability of developing an operational airborne system with the sensitivity, reliability, and operating costs required by the minerals industry. The goal of the team was to determine whether BHP Billiton could achieve a competitive advantage in mineral and hydrocarbon exploration industry by building the 'worlds first' airborne gravity gradiometer system.

Since 1999, BHP Billiton has successfully built and deployed three airborne gravity gradiometer systems, (Newton, Einstein, and Galileo) based upon the Bell Aerospace (now Lockheed Martin) Gravity Gradient Instruments. A second-generation digital gravity gradiometer (Feynnman) is presently undergoing airborne testing. The GGI technology is based on groups of four (4) accelerometers where the accelerometers are equi-spaced on a circle with the sensing axis tangential to the circle. The configuration successfully rejects both common mode accelerations and rotations about the axis perpendicular to the plane of the complement.

The BHP Billiton AGG technology provides high quality gravity maps with a resolution and sensitivity to map gravity anomalies associated with both minerals and hydrocarbon deposits.

This paper presents an overview of the technology and technical challenges in developing an airborne gravity gradiometer by using a partially declassified military technology and the success BHP Billiton has achieved in deploying technology for the detection of mineral and hydrocarbon targets.

Dr Catherine Cesarsky

Director-General, European Southern Observatory, Garching, Germany
www.europa.eu.int/comm/research/eurab/cvcesarsky.html

COSPAR Space Science Award winner, 1998
President of the International Astronomical Union, 2006

Born in France, **Catherine Cesarsky** graduated in Physics from the University of Buenos Aires in 1965 and obtained a Doctorate in Astronomy in 1971 from Harvard University. She then worked at the California Institute of Technology, before returning to France in 1974. She spent the major part of her career at the "Commissariat à l'Energie Atomique (CEA)". She has been the Head of the Service d'Astrophysique from 1985 to 1993, and the Directeur des Sciences de la Matiére, responsible for all activities in basic research in physics and chemistry at CEA from 1994 to 1999. She was the Principal Investigator of the ISOCAM instrument on board of the ESA ISO satellite.

Since September 1999, Catherine Cesarsky is Director General of the European Southern Observatory (ESO) which has the La Silla Observatory, four 8m telescopes (VLT) at Monte Paranal, and is constructing in a world wide collaboration the ALMA Observatory, all in Chile.

She is a member of many national and international associations and organisations within physics, astrophysics and space sciences, as well as of Academia Europeae and of the National Academy of Sciences (USA, as foreign associate). She is the president elect of the International Astronomical Union.

A Golden Age for Astronomy

We live in a truly exceptional age of discovery in astronomy and cosmology. Revolutionary advances have taken place in our knowledge in these fields, ranging from our local galactic environment to the entire Universe. Thanks to new and powerful observational facilities, on the ground and in space, virtually every stage of evolution of the universe and its components is now within reach.

Following the discovery of the first planets outside our solar system a decade ago, well over a hundred are now known. At the other end of the scale, the large-scale properties of the Universe have been determined with astonishing precision over just the last few years. The existence of pervasive dark matter has been confirmed, and new discoveries have revealed the existence of a mysterious dark energy that dominates the expansion of the Universe. The presence of black holes in the centers of galaxies, including our own, the Milky Way, has been ascertained.

While several of the classic questions of the last century have been answered, a whole host of new and profound questions has arisen. Will we find earth-like planets, capable of sustaining life, as we know it? How do stars and planets form and how do they evolve? What are the dark matter and dark energy that comprise 96% of our Universe? The ultimate question can now begin to be addressed: What is the origin and fate of our Universe?

Professor Marcela Bilek

University of Sydney, Australia
www.physics.usyd.edu.au/~mmmb/

Malcolm McIntosh Prize for Physical Scientist of the Year, 2002
Federation Fellow, 2003

Marcela Bilek was appointed Professor of Applied Physics at the University of Sydney in 2000 and awarded an ARC Federation Fellowship in 2003. She holds a PhD in Engineering from the University of Cambridge, UK, a B.Sc. in Physics from the University of Sydney and an MBA degree from the Rochester Institute of Technology, USA. Prior to her present appointment she held a visiting Professorship at the Technische Universität Hamburg-Harburg, Germany, and a Research Fellowship at Emmanuel College, University of Cambridge, UK. She also worked as a visiting Research Scientist at the Lawrence Berkeley Laboratory, University of California, USA. Aside from her academic experience, Marcela has spent time working in industry as a Research Scientist at Comalco Research Centre, Melbourne, and at the IBM Asia Pacific Group Headquarters in Tokyo, Japan. Her research focus is plasma processing for materials synthesis and surface modification. She has published over 60 referred journal articles and won a number of prizes, including the Malcolm McIntosh Prize for Physical Scientist of the Year in 2002, an MIT TR100 Young Innovator award in 2003, and the Australian Academy of Science's Pawsey Medal in 2004.

Plasma Physics Enters the Nano-Age

Ions, the positively charged species extracted from a plasma, have an established role as the work horse of the microelectronics age. Their use as machining and fabrication tools in the microelectronics and now in the MEMs industries is well established. Ions are commonly used for deposition of thin film layers and the etching of features which make up sub micron scale devices. Because of their charge, their energies are easily controlled by the application of electric fields. With control of ion energy, it is relatively straightforward to tailor the microstructure and properties of thin films deposited from plasma sources and to control the directionality of reactive ion etching processes. Recently, research has been focused on the development of devices with features at the nanoscale. Whether ion based technologies will continue to dominate this new field is uncertain. Scale down of top-down machining methods, such as most ion based methods, is difficult, with control of the process on such a fine scale presenting the biggest problem.

The creation of nanostructures in nature occurs by bottom-up processes, such as self-assembly, where the molecular building blocks organize themselves into the final structures. Self assembly is based on the concept that a system will move under natural forces to the minimum energy state it can reach given the time and energy available to it. Control can be achieved by ensuring that the properties of the system and the nanoscale building blocks in it are such that energy minimization under the applied external constraints leads to the desired structures. An example of such an approach is the self organization, in water, of a dispersion of nanoparticles with hydrophobic and hydrophilic surfaces, produced by polymer grafting or co-polymerisation. These particles self assemble because energy minimization principles dictate that the hydrophobic parts cluster together away from the solution while the hydrophilic surfaces make contact with the solution. Structures such as spheres, rods and planes have been demonstrated depending on the ratios of hydrophobic to hydrophilic surfaces on the self-assembling nanoparticles. Plasma processing has the potential to play an important role in the production of nanoscale devices in treating or grafting the surfaces of particles or in producing substrates and templates with anchoring, control and readout functions for the devices.

This paper will review recent applications of ions extracted from plasma with controlled energy to produce structure at the nanoscale. Strategies, systems and processes to create nanoscale multilayered structures, nanocomposites and patterned surfaces will be presented. The experimental results presented show the range of structures which can be achieved and in particular the power of these methods to produce preferred crystallographic orientations and metastable phases within nanostructured materials. Plasmas can be used to control the hydrophilic/hydrophobic properties of surfaces to prepare them for interaction with molecules and particles in solution. Plasma methods to produce functional groups on surfaces for interaction with self-assembling particles and biomolecules, such as proteins and antibodies, will also be discussed.

Professor Helen Quinn

FAPS, FAAAS
Stanford Linear Accelerator, USA
www.slac.stanford.edu/slac/faculty/hepfaculty/quinn.html

Dirac Prize winner, 2000
President of the American Physical Society, 2004

Helen Rhoda (Arnold) Quinn was born in Melbourne. After matriculating from Tintern CEGGS in 1959, she attended Melbourne University for two years. She emigrated to the United States in 1962 with her family, following a career opportunity for her father. She enrolled at Stanford University where she received a B.Sc. in 1963 and a Ph.D in Physics in 1967. She was a postdoctoral researcher at the Deutches Elektronen Synchrotron in Hamburg in 1968–69. Returning to the United States she had one year with no employment and then took a postdoctoral position at Harvard University, and later became Assistant and then Associate Professor. In 1976 she followed her husband back to California and to Stanford using a Sloan Foundation Fellowship to support her research for the year. She took up a staff position at Stanford Linear Accelerator Center in 1977 and in 2003 was promoted to Professor of Physics.

Her research has been recognized with a Dirac Medal from the International Center for Theoretical Physics in Trieste, Italy in 2000 and by election to both the American Academy of Arts and Sciences (1998) and the (US) National Academy of Science (2003).

Helen married Daniel Quinn in 1966. They have two children and two grandchildren.

The Asymmetry between Matter and Antimatter—in the Universe and in the Laws of Physics

A major outstanding puzzle at the intersection of particle physics and cosmology is the asymmetry between matter and antimatter. The Universe contains significant amounts of matter and an insignificant amount of antimatter. The puzzle is how this can occur when the laws of physics for matter and antimatter are very close to identical. Unless it arises from a very finely tuned initial condition that is maintained by an absolute conservation law, the matter-antimatter asymmetry of the Universe can only occur due to an asymmetry between matter and antimatter in the laws of physics. In technical terms this asymmetry in the laws of physics is known as CP violation, where C is the operation that interchanges all particles and antiparticles and P is the operation that reverses all spatial coordinate directions (mirror reflection plus rotation about an axis perpendicular to the mirror).

I will review how CP violation can arise in particle theories. In the current (extended) Standard Model of particle physics CP violation can appear in only two places, one affecting heavy quark decays and the other, which enters only after the theory is expanded to include neutrino masses, affecting heavy neutrino decays. Extensions of the theory can add additional CP violating effects. I will explain why this is so.

I will also discuss the status of experiments aimed at investigating these features of the theory in further detail. I will then discuss scenarios for the evolution of matter-antimatter asymmetry in the Universe based on each of these possibilities. In either case it seems that the current Standard Model theory must be extended in some way to give the observed Universe.

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Australian Synchrotron

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The Australian Synchrotron will open in 2007 and will offer researchers access to diverse techniques and capabilities beyond those currently available within Australia.

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Nuclear-based science benefiting all Australians

Medals and Awards

Awards for Excellence

The Congress will highlight discipline contributions to *Physics for the Nation* through the awarding of prizes for excellence. The AIP will have a special awards ceremony immediately preceding the closing plenary session on the Friday, and will present the Massey, Education, Boas, Bragg and Walsh medals and the Women in Physics Lecturer Award. The individual discipline societies will be encouraged to present their awards in the discipline sessions. All winners of Australian Medals (including those awarded by the AIP) will have their presentations highlighted at the opening ceremony.

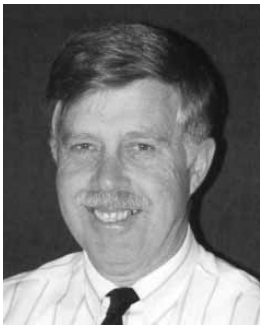
AIP Walsh Medal

This award recognizes significant contributions by a practicing physicist to industry in Australia. It is named for the late Sir Alan Walsh, Kt, FAA, FTS, FRS, one of Australia's most eminent and distinguished scientists, who was the originator and developer of Atomic Absorption Spectrophotometry (AAS) and pioneered its application as a tool in chemical analysis.

Born in Lancashire in 1916 and educated at Darwen Grammar School, Sir Alan studied physics at Manchester University. After a few years in industry in the UK, he was recruited in 1946 to join the newly-created Chemical Physics Section of the CSIR (now CSIRO) Division of Industrial Chemistry in Melbourne. In 1952 he had the idea of using atomic absorption spectra, rather than atomic emission and molecular absorption spectra, in spectrochemical analysis. The subsequent development of AAS as a simple, rapid and inexpensive method for the analysis of minute traces of metals (and some non-metals) is a tribute to Sir Alan's extraordinary creativity, his business acumen and his infectious enthusiasm. He promoted the establishment of an Australian manufacturer of the atomic absorption spectrophotometer, the original company Techtron Pty Ltd eventually growing into Varian Australia, now one of the world's leading spectroscopic instrument companies.

The award consists of a Medal and is open to competition every second year among persons resident in Australia for at least five of the seven years preceding the closing date for applications. The award will be given for physics research and/or development that has led to patents, processes or inventions which, in the opinion of the judging panel, have led to significant industrial and/or commercial outcomes, such as devices that are being manufactured or have influenced a major industrial process.

Winners: Brian Sowerby and James Tickner (NUPP MOD35)



Brian Sowerby

Brian Sowerby is currently Chief Research Scientist, On-Line Analysis and Control in CSIRO Minerals at Lucas Heights. He holds a B.Sc. (Hons. 1) in Physics from the University of NSW and a Ph.D. in Nuclear Physics from the Australian National University.

Following post-doctoral work in Canada he has, since 1969, carried out research and development on the application of nuclear and ultrasonic techniques in the mineral and energy industries in the Australian Atomic Energy Commission and CSIRO. This work has led to the commercialisation of techniques for the bulk analysis of copper and nickel ores, the on-line analysis of coal (two of the Coalscan gauges) and the on-belt determination of coke moisture. His work also led to the development of the UltraPS particle size analysers, the UltraPF coal mass flow measurement system and various on-conveyor belt analysers. His current main research interest is the development and application of techniques to detect contraband in air cargo. He has received ten awards for his work including the inaugural Sir Ian McLennan Achievement for Industry Award (1985) and the 1992 Australia Prize (shared with Watt, Cutmore and Howarth). He was elected a Fellow of the Australian Academy of Technological Sciences and Engineering in 1986.

James Tickner

James read physics at Oxford University, graduating in 1994. He completed his DPhil at the same institution, measuring proton structure functions at the ZEUS experiment based at the DESY laboratory in Hamburg. In 1998 he moved to Australia to join the On-line Analysis and Control group at CSIRO Minerals. Since then he has worked on the development of nuclear instrumentation for the minerals industry and more recently for security applications, specialising in the development of Monte Carlo methods for designing and optimising nuclear analysers. In 1999 he joined the International Atomic Energy Agency's coordinated research project on the application of nuclear technologies for humanitarian demining, developing the concept for a hand-held, 3-dimensional gamma-ray camera capable of one-sided imaging. In 2002 he co-developed the fast-neutron/gamma-ray radiography method for cargo screening which is due to be trialled at Brisbane airport next year. James has authored over 70 publications and patents in the fields of particle physics and nuclear instrumentation.

Malcolm McIntosh Medal

The Malcolm McIntosh Prize for Physical Scientist of the Year is awarded for an outstanding achievement in science that advances, or has the potential to advance, human welfare or benefits society. This Prize is awarded only to an individual. The Malcolm McIntosh Prize is comprised of a silver medallion and a grant of $50,000.

The objectives of the Prize are to recognise and reward outstanding research by younger scientists; and to demonstrate to the public, and to school students and science undergraduates in particular, that early-stage career achievement in science can be of world-class importance.

Winner: Ben Eggleton (AOS TUA11)

Benjamin J. Eggleton is currently an ARC Federation Fellow and Professor of Physics at the University of Sydney and the Director of CUDOS, an ARC Centre of Excellence. In 1996, he joined Bell Laboratories, Lucent Technologies as a Postdoctoral Member of staff then transferred to the Optical Fiber Research Department. In 2000 he was promoted to Research Director within the Specialty Fiber Business Division where he was responsible for forward-looking research supporting Lucent Technologies business in optical fiber devices. Prof. Eggleton has co-authored over 100 journal publications and numerous conference papers and was the recipient of the 2004 Malcolm McIntosh Prize, the 2003 ICO prize from the International Commission on Optics, the 1998 Adolph Lomb Medal from the OSA the distinguished lecturer award from the IEEE/LEOS, is an OSA fellow and recipient of an R&D100 award.

ANZAAS Medal

His Excellency Major General Michael Jeffery AC CVO MC, Governor-General of the Commonwealth of Australia will be presenting the medal at 1330 hrs at Llewellyn Hall at the opening of the Outreach programme.

The ANZAAS medal is awarded for services in the advancement of science or administration and organisation of scientific activities, or the teaching of science throughout Australia and New Zealand and in contributions to science which lie beyond normal professional activities. The ANZAAS Medal is only presented to the recipient at a suitably prestigious scientific gathering or event.

Winner: David Blair (ASRG TUE11)

In recognition of his outstanding contribution to world science through his pioneering research work on gravity waves, the Council of the Australian and New Zealand Association for the Advancement of Science has awarded the ANZAAS Medal to Professor David Blair.

Professor Blair, from the School of Physics at the University of Western Australia, is a high profile scientist who has researched gravity waves for more than 25 years. This research has led to the development of the world's most accurate clock and to the development of a new form of astronomy—gravitational wave astronomy—the spectrum of which is awaiting discovery. When harnessed, gravitational waves will offer a powerful new probe of the universe. This research has received has much media attention and captured the public's imagination.

Professor Blair is Director of the Australian International Gravitational Research Centre at Gingin, approximately 80 km north east of Perth, in Western Australia. The Centre involves collaboration between Australian and international scientists and incorporates one of the largest astronomy centres in the southern hemisphere, the Australian International Gravitation Observatory. The public arm of the Observatory is the Gravity Discovery Centre which features science education and tourist displays designed to stimulate interest in science.

Professor David Blair's commitments to the advancement of science and to the promotion of science for secondary and tertiary students make him an outstanding role model and worthy recipient of the ANZAAS Medal.

Boas Medal

The Medal was established in 1984 to promote excellence in research in Physics and to perpetuate the name of Walter Boas. The award is for physics research carried out in the five years prior to the date of the award, as demonstrated by both published papers and unpublished papers prepared for publication, a list of which should accompany the nomination.

Winner: Professor George Dracoulis (NUPP TUD21)

George Dracoulis is a graduate of Melbourne University and has been on the staff at the Australian National University since 1973. He has been Head of the Department of Nuclear Physics since 1991. That Department operates a major facility based on a Heavy Ion Accelerator, which is used for a broad range of research, from basic studies in nuclear physics and nuclear reactions, to innovative applications.

His main interests, pursued at both the local and various international facilities, are in the structure of unusual nuclear states populated in heavy ion reactions and studied with time-correlated, gamma-ray spectroscopy. The recent focus of this work has been on the identification of metastable states, or Isomers, and in their use as a probe of the underlying nuclear structure, including elucidation of the mechanisms which control the formation of multi-quasiparticle states in deformed nuclei, and the orbital-dependence controlling nuclear shape co-existence.

He was awarded the 2003 Lyle Medal of the Australian Academy of Science

2004 AIP Massey Medal

The Massey Medal was proposed at the AIP Congress in 1988 as a gift from the Institute of Physics, UK, to the AIP, to mark the 25th anniversary of the founding of the AIP as a separate institution in 1963. It was first awarded in 1990.

Sir Harrie Massey, born near Melbourne in 1908, had a distinguished career in the UK and in 1931 with Edward Bullard, published the first experimental evidence for electron diffraction in gases. He saw the potential of using direct rocket probes of the atmosphere layers and eventually, as Chairman of the British National Committee for Space Research, he guided the entire UK space research program. From 1960 to 1964 he was President of the European Preparatory Commission for Space Research. He was knighted in 1960.

The medal is awarded every two years for contributions to physics or its applications made by an Australian physicist working anywhere in the world, or by a non-Australian physicist resident in and for work carried out in Australia.

Winner: Peter Drummond (AOS TUA31)

Peter Drummond is the Professor of Theoretical Physics at the University of Queensland, and UQ Director of the Australian Centre for Quantum-Atom Optics. He has degrees from Auckland, Harvard and Waikato Universities, and is a Fellow of the AIP, APS and AAS.

He has worked on: techniques and tests of quantum theory, theory of quantum and classical solitons, computational physics, physics of communication and information, laser physics, Bose-Einstein condensation and atom lasers.

He has published over 135 research papers in refereed journals, with more than 4100 citations. The calculations are generally closely related to experiments—and have been verified in many laboratories in the USA, Europe, Japan and elsewhere.

The most significant work was the development of novel theoretical phase-space representations of quantum operators. A practical application of this technique was the prediction of the first evidence for quantum solitons in optical fibers.

This was verified in several laboratories, and featured on Nature's front cover.

In addition, he has contributed to the field of computational physics, through the development of new programs and algorithms, which are widely available to the physics community. He is currently working on new techniques for correlated fermions.

AIP Education Medal

The purpose of the prize is to recognize an outstanding contribution to physics education in Australia. It was proposed as an initiative of the Physics Education Group at the 2002 AIP Congress in Adelaide. The prize is awarded to any member of the AIP who is judged to have made a significant contribution to physics education in Australia. In determining the recipient of the award, the quality of the work, the significance to physics education, and the creativity displayed will be taken into account. The inaugural prize will be presented at the 2005 AIP Congress in Canberra.

Winner: Marjan Zadnik (PEG TUF31)

Marjan Zadnik is the inaugural Professor and Dean of Teaching and Learning in the Division of Engineering, Science and Technology at Curtin University of Technology. Prior to this position he taught and carried out research in the Department of Applied Physics at Curtin. Before joining Curtin he carried out research on the isotopic composition of noble gases trapped in meteoritical and terrestrial samples at the Enrico Fermi Institute, University of Chicago, and at the Max-Planck-Institut für Chemie, in Germany. He has a strong commitment to student learning and supporting staff improve their teaching. He has been a co-investigator

on over 40 competitive research and development grants totalling over $1.2 M. These include 5 national Committee for the Advancement of University Teaching and the Committee for University Teaching and Staff Development grants, plus a large ARC research grant. Awards and honours include the Vice-Chancellor's Award for Excellence in 1993, a CAUT National Teaching Fellowship in 1996, the inaugural Curtin Student nominated Guild Award for Excellence in Teaching (1999), the Dean of Science Medal (2000), the Most Valuable Paper published in 2000 in the Aust Science Teachers Journal and was a National Finalist for the Australia Awards for University Teaching, in 2002. He has published over 120 papers and presented at over 100 conferences.

2003 AIP Bragg Medal

The Bragg Medal was established in 1992 as an initiative of the South Australian Branch, to commemorated Sir Laurence Bragg and his father Sir William Bragg. The medal is awarded annually to the student who is judged to have completed the most outstanding PhD thesis in Physics under the auspices of an Australian university.

Nominations from each university are submitted to the State Branch Committee, which selects a state winner. A national selection panel then selects the national winner.

The medal will be presented to the winner at the congress by the President of the AIP.

Winner: Michael Bromley
(AMPQC FRE14)

Michael completed his PhD on "Positron-atom interactions studied using configuration-interaction methods" in 2002 for which he was awarded the 2003 Australian Institute of Physics Bragg Gold Medal for Excellence in Physics. His computer-based research, on anti-matter/matter interactions, was performed under the supervision of Dr. Jim Mitroy at the Northern Territory University in Darwin. The main result of this research was the identification of a number of new positronic atoms (i.e. atoms which could stably bind a positron to them).

Post-PhD, he has been a Research Associate at Kansas State University (U.S.A.) investigating atom optical elements ("atom chips") with Prof. Brett Esry. He recently returned to Australia for a short-term Postdoctoral Fellow position at the (now renamed) Charles Darwin University, while looking for further work. He was a Young Australian of the Year winner in 2001 (Northern Territory, Science and Technology category) and, as of October 2004, has published 23 scientific papers with an emphasis on computational atomic physics; ranging from the electronic structure of atoms through to matter-wave (eg. Bose-Einstein condensate) propagation and manipulation.

Scholarships

A range of Postgraduate Research Scholarships is available and awarded on the basis of academic excellence and research potential from The University of New South Wales at the Australian Defence Force Academy (UNSW@ADFA). Applications must be lodged with the Research Office by 30 April or 31 October. For more details visit our website below or telephone +61 2 6268 8112. All Endeavour International Postgraduate Research Scholarship and Australia Postgraduate Award applicants are automatically considered for these scholarships. Research can be undertaken within the following stimulating and innovative schools: School of Aerospace, Civil and Mechanical Engineering; School of Business; School of Humanities and Social Sciences; School of Information Technology and Electrical Engineering; School of Physical, Environmental and Mathematical Sciences.

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Topic Areas and Highlights

Celebrating Einstein's Miraculous Year 1905: The International Year of Physics 2005

The year 2005 is the 100th anniversary of Albert Einstein's "MiraculousYear" of 1905 when Einstein published four revolutionary ideas that forever changed the way we see the world. To celebrate this anniversary, the year 2005 has been declared the International Year of Physics by the United Nations. This provides Australian physicists with an opportunity to raise the public awareness of physics and Einstein's revolutionary contributions to our society (see *http://www.physics2005.org/*). The four ideas were: (i) The idea of the light quantum, (ii) the idea of molecular motion leading to the very useful diffusion relation, (iii) the theory of special relativity and (iv) the idea that mass and energy are linker by $E=mc^2$.

Throughout the Congress you will find many presentations of current research that have extended these ideas. They include also topics relating to Einstein's later work, such as the use of quantum entanglement and Bose-Einstein Condensation. These themes will be covered by several of the plenary lecture and in the topical areas.

In addition we have a special lecture, lunchtime Monday, which shows the historical link to early work in Australia and we have an outreach program on Wednesday featuring future work in relativity and quanta of light.

The highlights listed by the individual discipline groups include:

Acoustics and Music (AAS)

You're not the only one who is listening to your ears! Once you know that the human ear has a dynamic range of over 120 dB and a frequency range of 10 octaves and a precision of a fraction of a percent, it's no suprise to learn that the cochlea, its acoustical-electrical and analogue-digital converter, has active elements. And active elements mean that, yes, the ear can make sounds too. Come to an invited talk by Eric LePage .

Do violins really get better with age, and how could you tell? Whether it is the passage of time, the exposure to the atmosphere, or the amount of playing, many violinists believe that oldies are goodies, and spurn inexperienced instruments. When the Powerhouse Museum wanted to buy for its collection an instrument from renowned maker Harry Vatiliotis, an opportunity arose to examine these questions. Three years ago, two very similar instruments were made from seasoned wooden plates that had originally been intended to make a cello. They were subjected to acoustical, playing and listening tests. Since then, one has been maintained in museum conditions, unplayed, while the other belongs to busy Sydney musician Romano Crivici. How have they changed? Ra Inta will explain that on Thursday.

Did the pitch rise or fall? And what does that say about the nature of pitch perception? A range of odd psychophysical results are produced by octave-complex tones—tones whose frequency components are spaced one octave apart. When such tones jump by half an octave (a dissonant interval that also corresponds to the maximum harmonic distance between two musical keys), listeners may disagree on whether it rose or fell. Richard Parncutt uses experiments like these to test different theories on the way humans perceive pitch.

Atomic and Molecular Physics and Quantum Chemistry (AMPQC)

Topics to be covered in the Atomic and Molecular Physics and Quantum Chemistry (AMPQC) sessions span the full research spectrum from the fundamental to the applied.

At the fundamental level, Michael Bromley (Bragg Medal Winner 2004) will discuss recent progress made in the theoretical treatment of the interaction of positrons with isolated atoms. This talk is complimented by James Sullivan describing the new experimental positron facility presently under construction. Igor Bray will review the longstanding difficulties in describing the Coulomb few-body breakup problem and describe how resolution of outstanding problems has led to unprecedented agreement between theory and experiment. A subsequent talk by Andris Stelbovics will describe in detail their development of a new formulation of the theory of electron-impact ionization of atoms. Chris Chantler will describe measurements performed on highly charged titanium ions which provide critical tests of QED in a new regime. Results for many-body atomic structure calculations probing violations of parity and time reversal will be presented by Jacinda Ginges. Linda Uhlmann will present results for the scattering of electrons from trapped metastable helium atoms.

The interaction of photons with matter will be addressed by a number of speakers. Evan Bieske will

discuss the dynamics of trapped clusters and nano-particles probed with infrared light and describe and how information regarding molecular bonds and intra-molecular energy transfer can be extracted from experiment.

Brian Orr (OSA William F. Meggers Award 2004) will speak on intramolecular dynamics studied by time-resolved infrared-ultraviolet double resonance spectroscopy. The powerful technique of velocity map imaging will be reviewed by Warren Lawrence. He will describe how it can be applied to determine the binding energies of van der Waals molecules and provide insights into the dissociation process. The velocity map imaging technique is also being pursued in Canberra with first results to be presented by Steve Cavanagh. On the theoretical front, Igor Ivanov will discuss a formalism and computational procedure to treat the process of multiphoton ionization in strong laser fields.

Environmental and technological applications of atomic and molecular physics also form a key theme of our sessions. Recent advances in computational models describing auroral emissions will be presented by Laurie Campbell. The question of whether a detailed comparison between predictions and measurements can be used to discriminate between different cross-section measurements will be discussed. Results of investigations into the electrical conduction properties of single organic molecules will be addressed in the talk of Karl-Heinz Mueller with the development of molecular electronics depending crucially on the understanding of such phenomena. Finally, the results of calculations on different tautometric forms of the biologically important molecule adenine will be presented by Feng Wang.

Meteorology, Climate Change and Oceanography (AMOS)

The AMOS program includes contributions from the fields of meteorology, climate and oceanography and, by extension, ocean-atmosphere interactions.

The oceanography part of the program begins in session 1 with keynote speaker Matthew England exploring the role of the Southern Ocean in climate change using climate models. Susan Wijffels, also a keynote speaker (in session 5), will present measurements of the Indonesian Throughflow, the ocean current system which transports heat between the Pacific and Indian oceans. Other oceanography talks will cover the dynamics of the global thermohaline circulation, nonlinearity and chaos in the wind-driven ocean circulation and methods for the reconstruction of palaeo-climate changes from coral reefs.

Keynote speakers in meteorology and climate include Michael Roderick (session 2), who will offer a physical explanation for the measured global trend of decreasing pan evaporation rate despite climate warming, and Peter May (session 3), who will discuss observations of tropical convection and clouds. In session 4, Helen Cleugh will talk about interactions between climate and land processes, including the terrestrial carbon cycle and its relationship to the water cycle. There are additional contributions on the role of aerosols in climate and weather, evidence for a long-term trend of decreasing rainfall over southern Australia and the nonlinear relationship between Australian climate and the El Niño-Southern Oscillation phenomenon.

Oscar Alves, will unite the two AMOS threads of oceanography and meteorology. Specifically, he will highlight current efforts to use ocean data assimilation models to help with seasonal climate predictions. A number of other talks on coupled ocean-atmosphere interactions, covering a range of temporal and spatial scales (from small-scale wind-driven mixing to ocean basin climate variability), are included in the AMOS sessions.

Australian Optical Society and Quantum Physics (AOS)

The special feature of the Australian Optical Society meeting is its breadth and depth. It starts on the Monday with a session on aspects of spectroscopy, including a keynote address by Eric van Stryland (USA) and followed by sessions on the Monday and Tuesday with talks showing new developments in non-linear optics and photonic crystals. You can find out what's happening in the field of optics and lasers, laser development and laser applications from the sessions on Thursday and Friday mornings.

Quantum physics, quantum information, quantum control and quantum logic are fields of considerable interest which flourish in Australia and New Zealand. This topic has two sessions on Tuesday and Friday. Similarly quantum & atom optics, with an emphasis on Bose Einstein Condensation and Fermi gases, has two full sessions, jointly organised with atomic physics, on Wednesday and Thursday. These topics feature several keynote speakers from Australia, New Zealand, plus Gora Schlapnikov (France) and Johannes Denschlag (Austria).

On the Tuesday and Thursday we hold a session which is restricted to 'new faces': early career and student speakers. Another session on Tuesday afternoon has a less conventional format in that the audience will be given an introduction to four interesting and separate topics.

Within the AOS program there are Keynote talks from winners of significant scientific awards: Ben Eggleton, winner of the Australian Government Malcolm McIntosh Prize, and Peter Drummond, winner of the AIP Massey Medal. Keynote and contributed papers also feature Presidents-elect of our sister societies OSA (Eric van Stryland) and SPIE (Paul McManamon) and three Federation Fellows.

All the presentations could be highlights but you have to be there to find out!

General Relativity and Gravitation (ASRG)

General Relativity and Gravitation features in three sessions during the Congress, two on Tuesday and a joint session with Astronomy on Thursday. David Blair (ANZAAS medal winner) will lead off with the bigger picture of research and public outreach in Western Australia. Optical techniques the US LIGO project and the international LISA project are all featured. Look out for other presentations on gravitational wave interferometry in the AOS sessions on Monday, Thursday and Friday and Tuesday's poster session.

The afternoon session on Tuesday is devoted to general relativity theory. John Hartnett kicks off with a novel application of 5D cosmology to the issue of dark matter in the Universe. The long-standing question of whether the famous cosmological singularity theorem by Hawking actually predicts a curvature singularity will be resolved by S. Scott. The well-known author and science communicator Paul Davies will present interesting consequences of the study of the transit time of a freely-falling particle in a background gravitational field.

Thursday's joint session with Astronomy continues the theme of the earlier Astronomy session by featuring large projects. Martin Huber, Switzerland, provides an overview of the ESA program in fundamental physics. David Reitze's update on the US LIGO Project will report that LIGO is close to its design sensitivity. The gravitational wave theme will then move to the ultra low frequency regime with talks by Robert Manchester from CSIRO and Matthew Bailes from Swinburne University on pulsar timing and the detection of gravitational waves using a pulsar timing array.

Australian Synchrotron Science (ASRP)

The Australian Synchrotron is now under construction in Melbourne with a scheduled opening date of March 2007. Despite the historical lack of a domestic facility, Synchrotron science is well established in Australia with researchers utilizing numerous synchrotrons world-wide. The AIP Congress will feature two sessions dedicated to synchrotron science. The first will focus on the future and includes an update on the design and construction of both the Australian Synchrotron and the Fourth Generation Light Source planned for the UK. The second will highlight the present and includes Australian examples of the application of synchrotron-radiation-based techniques to materials-science/condensed-matter research. Two years time will see the opening of a new national and regional facility that will transform the agenda for Australian science. Our two sessions of synchrotron science at the AIP Congress are but one step in preparing the physics community for March 2007 and beyond.

Astrophysics (AAS)

The coming decade will see a range of new astronomical instrumentation covering the whole electromagnetic spectrum from gamma rays to the metre-wave radio, and including other areas such as gravitational wave and high-energy cosmic ray detection. In the sessions on Thursday, we have five eminent leaders of the Australian Astronomical community describing ongoing and proposed work in the key areas of new instrumentation. John Storey of UNSW will discuss Australian plans for building telescopes in Antarctica. The Director of the Australian Telescope National Facility, Brian Boyle will describe the new generation of Australian radio telescope facilities. Roger Clay of Adelaide will describe High-energy cosmic ray Facilities. David McClelland of ANU will describe Australian involvement in Gravitational Wave Facilities. Warrick Couch UNSW will talk about the next generation of Extremely Large Telescopes.

Biophysics and Medical Physics (BMP)

The collection of material to be presented paints a vivid picture of the crucial role of physics plays in modern biology. The first session looks chiefly at how proteins provide a rich opportunity for physicists to bridge-build towards biology. From the very structure of these complex biopolymers (Benno Schoenborn) to the cooperative higher functions such as signal transduction (Ben Corry). The influence of quantum mechanics is also discussed in light of electronic and photonic properties in a number of systems ranging from photosynthesis, to the role of melanin, and to act of vision .

The second session draws upon the physics of signal processing and visualisation of fundamental patterns in biology. The scene is set with an analysis of genetic patterns. The brain is the next source of complex signals and presents a dynamic network which begs

visualisation. The electrical activity of the brain is one of the key experimental quantities that lends itself to physical interpretation. MRI allows the brain to be monitored for a response to a given stimulus, blood oxygen levels for example.

An important role for physics is to develop novel devices, techniques and algorithms to extend the possibilities for biologists. In the final session, it is shown that silicon-based biosensors and microarrays are greatly increasing throughput and scope of testing regimes for protein and gene-based screening. The safe operation of medical devices relies on a practical physical understanding, not in the least the ultrasonic heating of bone or the hydrodynamics of blood around a stent. The Biophysics and Medical Physics sessions span the spectrum of physics and should be both of general and specific interest.

Condensed Matter and Materials and Surface Physics (CMMSP)

The program in Condensed Matter, Materials and Surface Physics highlights many of the contemporary frontiers in condensed matter physics and its applications including nanomaterials, quantum computing, superconductivity and novel magnetic systems, along with scientific opportunities arising from the development of the Replacement Research Reactor, a major new facility for Australian research.

Over two hundred individual contributions will be presented in eleven oral sessions and two comprehensive poster sessions. The program has a strong international character with contributions from Europe and North America—too numerous to list here in detail. At the same time the full cross section of Australian research is included, including many early career and student presenters.

Excellence in presentation is encouraged, and prizes will be awarded for best poster, best oral presentations and best student oral presentation.

Complex Systems, Computational and Mathematical Physics (CSCMP)

This topic covers related themes not supported by a single society. The study of complex systems science in Australia has been invigorated by recent funding initiatives in CSIRO and the University sector.

The Thursday session highlights include overviews of the new field of econo-physics and recent experimental demonstrations of the Fluctuation Theorem, with further contributions in computational and mathematical physics.

The topic of econo-physics is a new and rapidly developing field of activity in which principles of statistical physics and nonlinear dynamics, dealing with correlations and complexity, are being used to uncover universal laws in economic phenomena. Details can be found at www.econophysics.org

The Friday sessions are mainly devoted to the Fluctuation Theorem, including the recent experimental demonstrations using a colloidal particle in an optical trap. This is groundbreaking work which has generated great interest in the international press, with reports appearing in The New York Times and The Wall Street Journal among others.

Environmental Physics/ Renewable Energy (EP/RE)

Nearly all solar modules use crystalline silicon solar cells. The cost of the silicon wafer is half of the cost of the module, with solar cell fabrication and encapsulating comprising the other half of the cost. Large reductions in cost of PV electricity require that the cost of the solar cell substrate be reduced.

Armin Aberle and Andrew Blakers will present a paper on the use of thin crystalline silicon solar cells to reduce the amount of expensive pure silicon by 90% or more. Bryce Richards will talk about alternative materials that might be capable of very high efficiencies. And Ian Plumb's paper deals with the production of hydrogen directly from water.

Special Insect Monitoring Radars have been used to track swarming or migrating insects for quite a few years. A key problem is to decide what insects are being observed. Alistair Drake will describe advances in beam modulation and retrieval techniques that allow us to tell what bug is in the beam.

Soil decontamination can be an intractable problem when reclaiming industrial sites for reuse. Recent research by Tony Collings and colleagues has shown the potential of a novel technique that uses ultrasound to generate regions of high temperature within soil pores, thereby denaturing the contaminants.

Education (PEG)

The Australian Universities Teaching Committee (AUTC) and The Carrick Institute for Learning and Teaching in Higher Education are funding a review of "Learning Outcomes and Curriculum Development in Physics" through 2004–2005. As part of the Stage One review, Michelle Livett will present "Key Findings from the National Physics Project on Learning and

Teaching", which will be followed by a one-hour Workshop/Panel Session (led by Judith Pollard, with the AUTC Project Team) .

The inaugural AIP Education Medallist, Marjan (Mario) Zadnik, will present a keynote entitled "Changing Time-Changing Teaching", where he will discuss his personal teaching philosophy and present some practical strategies that individuals and groups may wish to consider. Mario promises to challenge the audience to critically review their own attitudes and beliefs regarding teaching and learning, in light of the changes he identifies have occurred in recent times.

Arthur Guenther, Past President for the International Commission for Optics, will present a "Comprehensive Photonics Education Model" established in Albuquerque in direct response to the needs of the local optics and photonics sector (both industry and government). This model enables individuals to enter and return to the workforce routinely as they ascend the educational chain, starting from high school and progressing through the degree stream to the doctoral level.

Secondary teachers will find much to interest them throughout the programme. There are contributions on the Rio Tinto Australian Science Olympiads (Kate Wilson), the Science and Engineering Challenge (John O'Connor), the transfer of mathematics knowledge and understanding from high school to university (Andrew Roberts).

GeoPhysics (GP)

The first session focuses on understanding the Earth of today. The agonizingly slow dynamics of the Earth's interior records easily discernible patterns in the changing modern landscape. We examine how geoscientists image the inaccessible deep interior of the planet with seismic tomography as a key to understanding the long geological history of plate motions, and explore into the Earth's mantle to see what happens when the tectonic plates are swallowed up.

The second session probes the planetary engines that power geology on the billion year timescale. Just how does heat escaping from the Earth organize plate motion and continental drift? Are the continents just pushed around by convection in the deep Earth or do they control what goes on down below? What would the Earth have looked like 2 billion years ago—a place where we could feel at home or an alien world with a surface like Venus?

Nuclear and Particle Physics (NUPP)

The meeting has presentations from the full spectrum activities of Australia's active Nuclear and Particle Physics community. These range from the theory of fundamental interactions and reports from large international collaborations to advances in the understanding of nuclear reaction dynamics and nuclear structure and the applications of nuclear techniques to other areas. The keynote speakers below have been selected to reflect this diversity.

The presentation by Victor Flambaum will explore the nature of the fundamental constants and Derek Leinweber will provide a rare visual presentation of the basic strong interaction physics of quark confinement, which is notoriously difficult to analyze, using advanced computer graphics to represent results from lattice gauge theory calculations.

The talks by Tom Atkinson and Phill Urquijo will look at large the international facilities at CERN and KEK, with Tom discussing the Large Hadron Collider, the largest particle accelerator ever constructed, which will begin taking data in late 2007. It hopes to discover the Higgs boson and hence begin to solve the problem of the origin of mass. An overview of the LHC and the ATLAS detector will be provided, including the substantial contribution being made by Australian physicists. Phill will review some of the many exciting results in this area emerging from the Belle experiment which has over the last several years has collected some 300 million decays of pairs of particles known as B mesons. Using these, subtle differences between the behaviour of matter and antimatter have been established, through a process known as CP violation.

David Hinde will be discussing the present understanding of the mechanisms controlling nuclear fusion reaction, in particular the implication that the results that recent measurements on light systems have for the formation super-heavy elements. George Dracoulis will be showing how nuclear metastable states (isomers) can be used as powerful probes in the understanding of fundamental nuclear properties and Hugo Maier will show how the nuclear shell model can be used to explain the behaviour of nuclei near the heaviest doubly magic system.

The meeting will also celebrate the recent AIP awards to G. Dracoulis (Boas Medal) and B. Sowerby/J. Tickner (Walsh Medal).

Plasma Physics (PP)

Laboratory plasma physics encompasses studies of ionised gases from a few thousand degrees C for plasma materials processing to hundreds of millions of degrees for fusion energy development. On Friday afternoon, Prof. Marcela Bilek, a Federation Fellow from the University of Sydney, will give a plenary lecture on "Plasma Physics Enters the Nano-Age" describing the many uses of plasmas in producing nano-structured materials. At the opposite end of the temperature scale, Prof. Robert Goldston, the Director of Princeton Plasma Physics Laboratory in the United States will give a keynote lecture on “Advances in Magnetic Fusion Science” on Wednesday morning which describes advances in understanding of the complex behaviour of high energy confined plasmas, its relationship to astrophysical phenomena, and its role in developing the basis for the large International Thermonuclear Experimental Reactor (ITER) project, for which final site selection is imminent.

Other oral (Wednesday and Thursday mornings) and poster presentations will cover the plasma confinement in stellarator, spherical torus and compact torus devices, the physics of laser-compressed fusion plasmas, plasma thrusters for space propulsion, innovative diagnostic techniques for high and low temperature laboratory plasmas, and the use of plasmas for efficient production of high-value thin films and other material. Plasmas being highly non-equilibrium complex physical systems, the theory, modelling, and experimental study of plasma stability and turbulence is represented and forms a cross-disciplinary link with space and astrophysical plasma physics, fluid dynamics and complex systems theory.

Solar-Terrestrial and Space Physics (STSP)

These sessions address the physics of phenomena ranging from Earth’s neutral atmosphere and magnetosphere to the Sun and the outer boundaries of our solar system, where the Sun’s solar wind meets the local interstellar medium. A major focus for these sessions is the international program CAWSES (Climate and Weather of the Sun Earth System), which combines research on solar and interplanetary physics with magnetospheric, ionospheric, and atmospheric physics, and with cosmic rays and the solar system’s interstellar environment. Observational data are obtained from spacecraft, including Australia’s FedSat, and ground-based sources, while the interpretative and theoretical work primarily involves plasma physics. Invited Keynote presentations and contributed talks will be given in five sessions on Monday and Friday. The bulk of the Australian STSP community will be present at the poster session on Thursday. In addition a lunchtime meeting for the STSP Group will be held.

The CAWSES program will be summarised and Janet Kozyra (USA) discusses magnetospheric physics. The theme of space weather in Earth’s ionosphere and magnetosphere continues into the second session, including predictions of transient events and a presentation by Wendell Horton (USA) on a new integrated theory for electron acceleration and magnetic substorms. The third session focuses on the physics of the Sun and interplanetary medium and their links with auroral activity. Hilary Cane (Australia) will discuss solar flares, coronal mass ejections, radio emissions, and particle acceleration.

The first Friday session addresses the plasma physics of Earth’s auroral region and the generation and propagation of energetic particles, starting with a Keynote talk by Christopher Chaston (Australia). The final session links the neutral atmosphere with the ionosphere and magnetosphere. It includes a review by Mark Conde (Australia) and presentations on tomographic reconstruction and the radiation dose on airplanes due to energetic particles.

Women in Physics (WIP)

The level of involvement of women in this year’s Congress is quite remarkable, with high profile female physicists making a mark in many of the discipline groups. The Women in Physics Group of the AIP particularly welcomes the large proportion of women plenary and keynote speakers, illustrating the high quality contribution that women make to physics research in Australia and overseas.

This year’s Women in Physics Group program has been specially designed to mesh with the Physics Education Group, as there are many topics of interest to both streams. Our parallel session (Thursday afternoon) includes contributions on ways to improve retention rates for female undergraduate students and also equity issues facing women later in an academic/ research career. All those interested in these and related issues are encouraged to attend the keynote talk by Cathy Foley which will close the WiP session.

This session includes the History of Physics presentations.

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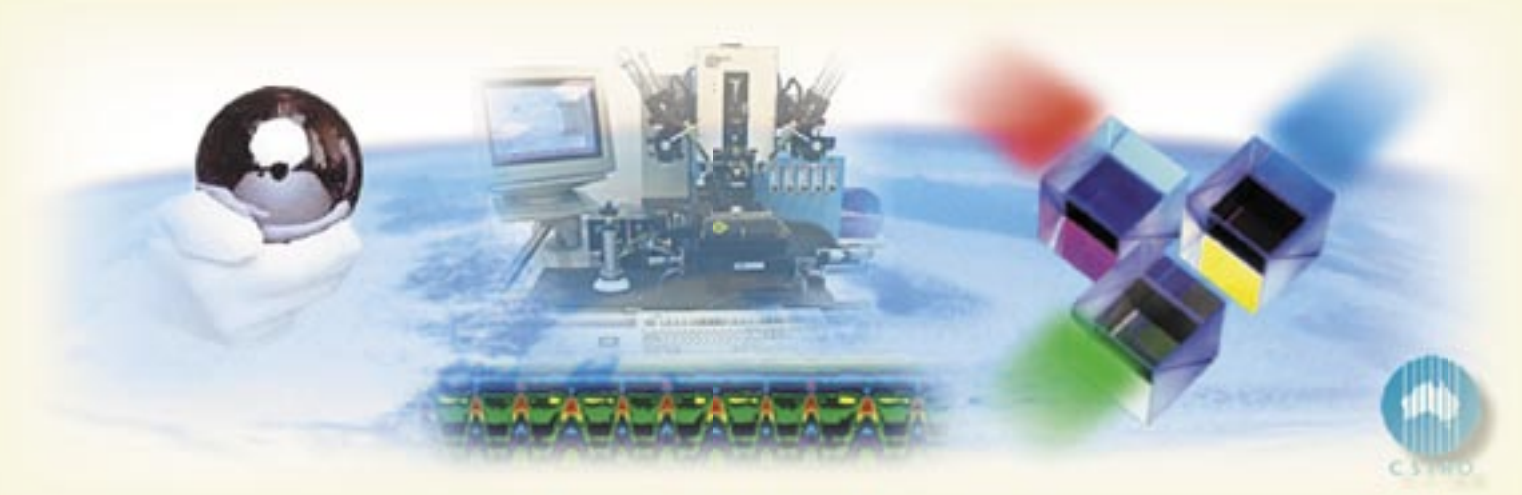

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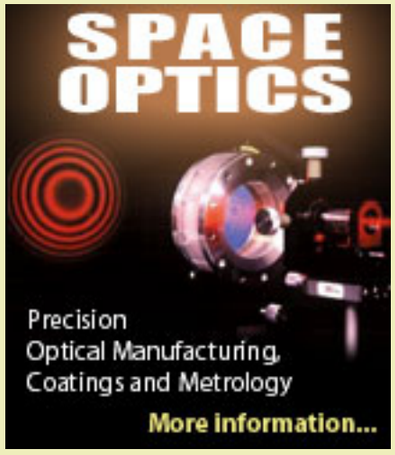

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Book of Abstracts

Abstracts have been organised by **topic area acronym in alphabetical order**. Within the topic area, **oral presentations are in program order**. Keynotes and medalists are highlighted in blue background.

Posters follow the oral presentations on the day of presentation. Presenting authors are underlined.

Proceedings are available on a CD Rom provided to each delegate as a satchel insert. Submission of papers was optional.

Acoustics and Music (AAS)

AAS THE21
Thursday 1400–1420 hrs

A Study of Ageing and Playing Effects on Violins: The First Three Years

R. Inta, J. Smith and J. Wolf

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We have begun a long-term experiment designed to measure the changes over time in two very similar violins. One is stored under controlled conditions and not played, while the other is played regularly by a professional musician. Vibro-acoustic measurements were performed on the instruments and parts thereof during and after construction. Playing and listening tests by a panel of experienced violinists were conducted at completion, after three years with no adjustment, and then after sound-post and other adjustments were made on the played violin only. The results in all cases were consistent with the hypothesis that the violins were identical.

AAS THE22
Thursday 1420–1440 hrs

An Analysis of Undercut Toneholes in Woodwinds

Geoffrey T. Poulton

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An analysis is presented for undercut toneholes in woodwind musical instruments of circular cross-section, extending previous results for cylindrical toneholes perpendicular to the axis of the instrument[1]. The undercut region takes the form of a sloped elliptical cone, representing the most common types of undercutting.

A hybrid analysis technique combining moment and finite difference methods is used to generate three-port scattering matrices for single tonehole/bore junctions. A simple equivalent circuit is derived which approximates the scattering matrices quite well over a range of tonehole parameters, and this model is used to comment on the effects of undercutting on the fine tuning of woodwinds.

[1] V. Dubos et al, Acustica, 85, 153–169 (1999).

AAS THE23
Thursday 1440–1500 hrs

Singing Strategies: How Tenors and Sopranos 'Tune' Their Vocal Tracts

N. Henrich[1,2], E. Joliveau[1], J. Smith[1] and J.Wolfe[1]

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2. Laboratoire d'Acoustique Musicale, Paris

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The vocal tract is a horn transmitting periodic, harmonic-rich signals from the vocal folds to the radiation field[1]. The tract resonances transmit some frequency bands (formants) more effectively than others. What happens when the pitch frequencies (and therefore the spacing of harmonics) approaches or exceeds that of the resonances? It has been suggested[2] that sopranos might sometimes 'tune' tract resonances to the fundamental. Using technology we developed for speech[3], we show that this is the case[4,5], and we compare this with the less obvious strategies used by tenors.

[1] G. Fant. Speech Sounds and Features. MIT, Cambridge, Mass (1973)

[2] J. Sundberg, The Science of the Singing Voice, Northern Illinois Univ. Press. (1987)

[3] J. Epps, J. Smith and J. Wolfe, Measurement Science and Technology, 8, 1112 (1997)

[4] Joliveau, E., Smith, J. and Wolfe, J. Nature, 427, 116. (2004)

[5] www.phys.unsw.edu.au/~jw/soprane.html

AAS THE25
Thursday 1500–1540 hrs

An Unnatural Test of a Natural Model of Pitch Perception: The Tritone Paradox and Spectral Dominance

Richard Parncutt and Amos Tan

University of Graz

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Octave-complex tones (OCTs, cf.[1]) elicit paradoxical pitch effects, e.g. C-F# may rise or fall[2]. Speech-based explanations are problematic[3]. Terhardt[4] assumed sensitivity to naturally occurring sounds; e.g. partials around 700 Hz strongly influence virtual pitch because they also determine speech vowels. Variations in this "dominance region" may explain the "tritone paradox". Our listeners (i) indicated whether tritones of OCTs rose or fell, (ii) rated the absolute pitch height of individual OCTs, and (iii) compared the pitch of OCTs and pure tones. Results of (ii) and (iii) mostly predicted results of (i), supporting[4].

[1] Shepard, R.N. (1964). Circularity in judgments of relative pitch. Journal of the Acoustical Society of America, 36, 2346–2353.

[2] Deutsch, D. (1986). A musical paradox. Music Perception, 3, 275–280.

[3] Repp, B. H. (1994). The tritone paradox and the pitch range of the speaking voice: A dubious connection. Music Perception, 12, 227–255.

[4] Terhardt, E., Stoll, G., & Seewann, M. (1982). Algorithm for extraction of pitch and pitch salience from complex tonal signals. Journal of the Acoustical Society of America, 71, 679–688.

AAS THE31
Thursday 1620–1700 hrs

The Potency of Otoacoustic Emissions: The Auditory Evaluation Tool for the Twenty-first Century?

E.L. LePage, N.M. Murray, J.D. Seymour

National Acoustic Laboratories, Chatswood, NSW

e-mail of corresponding author: Eric.LePage@nal.gov.au; ericlepage@optusnet.com.au

Otoacoustic emissions (sounds produced by the ear itself, due to outer hair cell activity) have emerged from curiosity status, to a powerful tool for evaluating the performance of any ear and its response to noise trauma. It also quantifies binaural interactions involved in stereo perception. This talk will review recent history and present hot topics in audiological evaluation, using data from musicians to coal miners. It will show how the technique, now part of an Australian Standard[1], may be used to estimate how much normal hearing any person has left.

[1] AS/NZS 1269.4:2004 Occupational noise management. APPENDIX H — OTOACOUSTIC EMISSIONS (Informative) Using Early Warning Properties Of Click-Evoked Otoacoustic Emissions For Application To Hearing Loss Prevention. (2004)

AAS THE33
Thursday 1700–1720 hrs

Dynamics of SAG/AG Mills as Measured by Non-Contact Acoustic Measurement

R. A. Pax

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e-mail of corresponding author: r.pax@mailbox.uq.edu.au

Mineral processing operations use semi autogenous (SAG) and fully autogenous (AG) grinding mills to provide liberated valuable minerals for subsequent separation from waste. These unit operations are hostile to conventional instrumentation. Significant acoustic emissions occur to allow a non-contact measurement approach that allows the determination the mechanisms of the internal operation of these mills. By understanding the information that is available from the acoustic emissions emanating from mills, the physical processes that occur inside the mills can be determined. The information thus obtained can then be used for optimisation and control of this unit operation. Key processes that can be identified are the impact breakage, abrasion as well as some of the details of charge composition. In this paper an implementation for non-contact acoustic measurement as well as some results of studies conducted using a variety of acoustic arrays on a number of industrial mills will be presented.

AAS THE34
Thursday 1720–1740 hrs

Interference Fringes with a Stochastic Origin

M.W. Hamilton and B-L Nguyen

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An acoustic experiment is described in which interference fringes are observed that have maximum visibility for partial field coherence[1]. These fringes arise from measurements of fourth order field correlations; this is of higher order than the usual second order correlation measured in ordinary interference experiments. The origin of the fringes is stochastic, rather than due to the oscillation of the sign or direction of the field with changing phase, as will be explained in this presentation.

These fringes may also be observed with a wave to which pseudorandom modulation has been applied, rather than a truly random modulation, in order to produce partial coherence. Such modulation is used by GPS satellites, for example.

In this presentation, we will focus on the limitations to measurement of distances with this high order interference that are imposed by the use of pseudorandom modulation.

[1] M.W. Hamilton, Physical Review Letters, vol89, 173901, (2002)

AAS THE35
Thursday 1740–1800 hrs

Investigation of the Radiation Force on Particles in an Ultrasound Field using the Lattice Boltzmann Model

J.M. Buick

Physics and Electronics, School of Biological, Biomedical and Molecular Sciences, The University of New England, Armidale, NSW, Australia

e-mail of corresponding author: jbuick@une

The lattice Boltzmann model (LBM) is a relatively recent development in computational fluid dynamics which is increasingly being recognized as an alternative to more traditional numerical techniques. The application of the LBM to acoustical studies can benefit from the features of the method which have been utalised in fluid dynamics; however, it has only been utalised in a limited number of studies. In this paper the background to the LBM and its application to acoustics is reviewed. The LBM is then applied to study the radiation force on particles in an ultrasound field. Finally future applications are briefly considered.

POSTERS

AAS PTH 1

"Virtual" Flutes and Clarinets: Acoustic Modelling at the Service of Performing Musicians

A. Botros, J. Smith and J. Wolfe

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To be useful to musicians, acoustic applications must exhibit a high degree of accuracy. The virtual woodwind project at UNSW provides technical advice to hundreds of musicians per day. It applies a waveguide model of the woodwind acoustic response to every fingering of the instrument (tens of thousands), guided by an extensive database of measurements. An expert system searches the resultant spectra for notes and multiphonics, to which it ascribes pitch and playability predictions. These are accessed via a musician-friendly web interface[1]. This paper reports the success of the original flute project[2], its extensions and work on a Virtual Clarinet.

[1] "The Virtual Flute"— http://www.phys.unsw.edu.au/music/flute/virtual

[2] A. Botros, J. Smith and J. Wolfe, Acoustics Australia, 30 (2002).

AAS PTH 2

Modeling the Acoustics of Woodwind Instruments: A New Tool for Makers.

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The study of acoustics is as old as physics itself, and the acoustics of woodwind instruments is in general well understood. Only recently, however, have measurement and modeling techniques become precise enough to be of benefit to makers. This work combines precise measurements of acoustic impedance with a one-dimensional model of woodwind instruments to produce an interactive tool for instrument makers to use in designing new instruments. In collaboration with Australian flute maker Terry McGee and the Powerhouse Museum, the work will bring many insights in both contemporary and historical instrument making, and may influence the continuing development of musical instruments.

AAS PTH 3

Spectral Content of Pianoforte Tones

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An experimental study has been undertaken to record and compare spectral content of musical tones produced by a variety of grand and upright pianos. Certain tones produced by a piano have a distinctly different timbre and audio spectrum from most of the other tones played on that piano. The difference in timbre, which is detectable by the human ear, is clearly evident when the spectral content of the tones produced by the piano is examined.

A microphone with flat frequency response from 100Hz to 12 kHz was placed at a distance of 0.5m from each piano string while it was being struck repetitively several times. Microphone output was fed to an audio spectrum analyser which detected a time averaged spectrum of each tone. All pianos tested, including Steinway, Boesendorfer, Yamaha, Kawai, Stuart & Steinbach grand pianos, possessed 8–12 notes in the third & fourth octaves where the fundamental had much lower intensity than one or more overtones. The Boesendorfer piano produced the largest number of these tones. Of all pianos examined the Stuart pianos produced "tones" in the first octave with simplest detected spectral content.

AAS PTH 4

Designing Musical Plates Using Numerical Optimisation

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Numerical techniques have often been used to analyse the vibrational patterns of musical structures, less often for the actual design of a structure. The authors have previously applied numerical optimisation techniques to a percussive bar modelled as a one-dimensional beam. In this paper we extend the technique to a two-dimensional model through the design of plates with specified characteristic frequencies. The technique is illustrated using a circular plate, which is tuned through variations in its thickness.

AAS PTH 5

A New Independent Component Analysis Algorithm: Joint Approximate Diagonalization of Simplified Cumulant Matrices

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This paper proposes a new algorithm to improve robustness, reliability and efficiency for blind signal separation[1–8] with a different diagonal cumulant maximization criterion. It calculates a fraction of the fourth order cumulant set and avoids the eigenmatrix decomposition to considerably reduce the separation cost for large-scale problems. Experimental separation shows that the new algorithm is robust, reliable and efficient for both large and small-scale separation problems, thus has combined merits of the well-known JADE and FastICA algorithms. Mixed music and speech signal separation is presented in this paper.

[1] P. Comon, C. Jutten, and J. Herault, "Blind separation of sources, part II: problems statement", Signal Processing, **24**, pp. 11–21 (1991)

[2] P. Comon, 'Independent component analysis: A new concept?' Signal Processing, **36**, pp. 287–314 (1994)

[3] X. Liu, R. B. Randall and J. Antoni, "Blind source separation of internal combustion engine vibration signals," The 4th Australian Congress on Applied Mechanics, ACAM, Melbourne, Australia (2005)

[4] J. F. Cardoso and Antoine Souloumiac, "Blind beamforming for non Gaussian signals", Journal of IEE Proceedings-F, **140**(6), pp. 362–370 (1993)

[5] A. Hyvärinen, J. Karhunen and E. Oja, Independent Component Analysis, New York, Chichester, John Wiley & Sons (2001)

[6] J. F. Cardoso and P. Comon, "Tensor base independent component analysis," in Pro. EUSIPCO (1990)

[7] G. H. Golub and C. F. Van Loan, Matrix Computations, The Johns Hopkins University Press, Baltimore, 3rd ed. (1996)

[8] X. Liu and R. B. Randall, "Redundant data elimination: A new way of simplifying blind source separation from a different information point of view," International Journal of Acoustics and Vibration, submitted October (2004).

AAS PTH 6

Effects of the Player's Vocal Tract on Sound Production in Wind Instruments

A.Z. Tarnopolsky[1], J. Wolfe[1], N.H. Fletcher[2], L.C.L. Hollenberg[3], J. Smith[1]

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In brass instruments and the didjeridu, the lips are a control oscillator, which interacts with the strong resonances of the instrument and the weaker resonances of the player's vocal tract. Vocal tract changes (especially tongue position) clearly change timbre in the didjeridu, and brass players claim that they affect timbre and pitch. It is difficult to control parameters independently in live players, so we report measurements using artificial lips and vocal tracts whose geometrical and mechanical properties are well controlled and defined. We demonstrate changes in pitch, register and timbre, which we relate to the impedance spectra of the tract.

Meteorology and Climate Change, and Oceanography (AMOS)

AMOS MOE11
Monday 1040–1120 hrs

Southern Ocean Circulation and Global Climate

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The role of the Southern Ocean in the Earth's climate system is assessed. This first involves exploring a series of climate model simulations employing different geometries in the Drake Passage gap[1]. A profound and surprising global climate response is obtained[2]. Apart from this paleo-perspective, the Southern Ocean's role in climate and climate change is explored on time scales of years to centuries. Of particular interest is: (i) the response of the climate system and the ocean carbon cycle to latitude shifts in the subpolar westerly winds[3,4], (ii) Antarctic water-mass variability and its role in regional climate[5] and (iii) the response of the Southern Ocean to Antarctic meltwater changes[6].

[1] Sijp, W.P., and M.H. England, *J. Phys. Oceanogr.*, **34**, 1254–1266 (2004)

[2] Sijp, W.P., and M.H. England, *J. Climate*, accepted (2004)

[3] Oke, P.R., and M.H. England, *J. Climate*, **17**, 1040–1054 (2004)

[4] England, M.H. *et al., Geophys. Res. Lett.*, submitted (2004)

[5] Santoso, A., and M.H. England, *J. Phys. Oceanogr.*, in press (2004)

[6] Bates, M., W.P. Sijp, and M.H. England, *Met. Atmos. Phys.*, submitted (2004)

AMOS MOE13
Monday 1120–1140 hrs

The Role of Buoyancy in the Energetics of the Global Overturning Circulation of the Oceans

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Laboratory observations show that convection driven by a gradient of temperature or heat flux along one horizontal boundary produces a localized turbulent plume and an otherwise stably stratified circulation. We develop a model describing the energetics of this convection and examine the implications for the zonally-averaged meridional overturning (thermohaline circulation) of the oceans. Given the meridional heat flux at the ocean surface, we predict the rate of production of available potential energy (0.5 x 1012 W), the average vertical turbulent diffusivity (k = O(10–5) m2/s) and a thermocline depth (300–530 m), in agreement with measurements.

AMOS MOE14
Monday 1140–1200 hrs

The Predictability of Interdecadal Changes in ENSO Activity and ENSO Teleconnections

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Bureau of Meteorology

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The character of year-to-year changes in the El Niño-Southern Oscillation (ENSO) and ENSO's impact on Australian climate both vary on interdecadal time-scales in the observational record and in the BMRC global coupled atmosphere-ocean climate model. Sensitivity experiments with this model indicate that these interdecadal changes have low levels of predictability. The apparent modulation of ENSO and ENSO's impact on Australia can be at least partially attributed to a surprising but robust nonlinear relationship between ENSO and Australian climate. Implications for climate prediction and climate prediction services are discussed.

AMOS MOE15
Monday 1200–1220 hrs

Do Massive Corals Reflect Global Change?—Coral Reconstructions of Changes in Temperature and Carbonate Saturation State of the Surface Ocean

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Anticipated future effects of the global warming scenario include an increase of ocean surface temperature as well as changes in surface ocean chemistry resulting in reduced coral calcification. In massive corals from Western Australia, early marine diagenesis results in an apparent ~25% decrease in skeletal density towards the present, which misleadingly matches the nonlinear twentieth century decrease in coral calcification predicted by recent modelling and experimental studies. A nonlinear decrease in coral _13C towards the present mimics the decrease expected from the oceanic Suess effect because diagenetic aragonite is enriched in 13C relative to coral aragonite. From Sr/Ca and _18O values, we also see an apparent temperature decrease. Based on our results we suggest that a number of global climate change studies relying on observational data from massive corals may need revision.

AMOS MOE21
Monday 1400–1440 hrs

The Causes of Declining Pan Evaporation and Consequences for the Surface Moisture Balance over the Last 50 Years

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It has long been assumed that surface warming as a consequence of the enhanced greenhouse effect would result in increasing evaporative demand over terrestrial surfaces. However, while the surface has steadily warmed over the last 50 years, the evaporative demand has steadily declined. We know this because the evaporation of water from meteorological pans has been decreasing almost everywhere over the past 50 years[1]. Why has this happened while it has been warming—is there something wrong with the pan evaporation measurements? A simple physical analysis shows that there is nothing wrong with the pan evaporation measurements. The analysis shows that pan evaporation, and hence evaporative demand, is not very sensitive to changes in average temperature. Instead, pan evaporation is mostly sensitive to variations in sunlight, vapour pressure deficit and wind speed. When viewed from a physics-based perspective, the trend for decreasing pan evaporation is consistent with observations from around the world showing decreasing sunlight[2] and possibly wind speed. In this talk, we summarise the observations and present a physical basis for understanding them. When combined with rainfall measurements, the same physical arguments show that the terrestrial surface has become less arid. One analogy is that the terrestrial surface is more like a gardener's greenhouse[3].

[1] T.C. Peterson, V.S. Golubev, P.Y. Groisman, Nature, 377, 687 (1995)

[2] M.L. Roderick, G.D. Farquhar, Science, 298, 1410 (2002)

[3] M.L. Roderick, G.D. Farquhar. International Journal of Climatology, 24, 1077 (2004)

AMOS MOE23
Monday 1440–1500 hrs

The Long-term Rainfall Decrease in Southwest WA and the Rapid Global Climate Change of the Late 1960s

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The rainfall of southwest Western Australia (SWWA) suffered a 20% long-term decrease in the late 1960s, which continues to the present day. This change approximately coincides with the well-known long-term decrease of rainfall in the African Sahel. It is demonstrated here by a combination of statistical and dynamical relationships that these two substantial changes are connected, the latter change being the consequence of the former. These changes in Sahel and SWWA rainfall are part of a coordinated rapid global change in the late 1960s that seems to be largely independent of global warming and ENSO, and has only recently been recognised.

AMOS MOE24
Monday 1500–1520 hrs

An Extended High-quality Temperature Data Set for Australia

Blair C. Trewin

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A long-term daily temperature data set has been produced for Australia. This includes daily maximum and minimum temperatures for 103 locations, with 50 locations having data from 1910 to the present. These data have been homogenised to make them suitable for use in climate change research. The new set extends the previous version[1], which covered the period from 1957 to 1996, by including recent data and pre-1957 daily data which have recently been digitised, and complements the existing 1910–2003 data set of homogenised annual mean temperatures[2]. Results will be presented using the new data set to determine trends in the frequency of temperature extremes in Australia.

[1] B.Trewin, 11th Symposium on Meteorological Observations and Instrumentation, Albuquerque, New Mexico, 14–18 January 2001, 279–284 (2001)

[2] P. Della-Marta, D. Collins and K. Braganza, Aust. Meteor. Mag., 53, 73–94 (2004)

AMOS MOE25
Monday 1520–1540 hrs

Atmospheric Isotopes: Evolution of Stable Water Isotopologues as an Applicable Data Source

A. Henderson-Sellers[1], K. McGuffie[2]

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Stable water isotopes have been employed as a means of challenging, validating and improving numerical models of basin-scale water processes since the 1980s. Two rare but naturally occurring isotopologues of water, $^{1}H_{2}^{18}O$ and $^{1}H_{2}H^{16}O$, are coming to be of practical use in diagnosis of water cycle system changes. Recent developments have served to illustrate how detection and attribution of both human impacts and natural variations in surface-atmosphere water exchanges can beneficially exploit stable water isotope observations and simulations. The promise for isotopic finger-printing of near-surface water cycle changes is illustrated here for three important basins.

AMOS MOE31
Monday 1620–1640 hrs

Constant Pressure Balloon Studies of Gravity Wave Momentum Fluxes in the Tropical and High-latitude Lower Stratosphere

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Constant pressure balloons provide a unique method of studying the properties of gravity waves in the lower stratosphere. We describe observations made on long-duration flights launched from sites in South America and in the Arctic. Measurements of pressure, temperature and position using GPS techniques allow important wave parameters, including momentum fluxes, to be measured as a function of intrinsic frequency. Using wavelet techniques we show that it is also possible to obtain intrinsic phase speeds, which provides a complete picture of the wave field. Considerable spatial and temporal intermittency in wave activity are found and the results are related to possible wave sources. The results will be discussed with relevance to the VORCORE campaign using constant pressure balloons to study the Antarctic stratosphere in spring 2005.

AMOS MOE32
Monday 1640–1700 hrs

Deep Convection in the Australian Tropics

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This paper reports on the early stages of a study that seeks to understand how tropical convection contributes to the large-scale radiation and precipitation budget. This involves the study of cloud systems using a dataset of hourly observations of GMS5 IR1 (10.5–11.5 μm) from September to April (seasons 1995–96 to 2000–01). Over Northern Australia, this entails a “build up” period, active and break monsoon conditions and following transition season. Cloud regimes are identified with a view to finding objective classifications and their representativeness for the study area. Preliminary results on the identification and classification of cloud systems will be presented.

AMOS MOE33
Monday 1700–1720 hrs

On the Height Distribution of Convection in the Tropics

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This report gives a brief analysis of a storm dataset covering the 2003/2004 wet season. An extensive database of storm characteristics measured with the Berrimah (Darwin) and Marburg (Brisbane) radars, covering the period from November 2003 until February 2004 was assembled.

The report investigates the distribution of the maximum height of convective clouds over Darwin and Brisbane. It seeks to give some insight into the diurnal evolution of cloud-top heights, and the variation between the modes of convection seen in monsoonal flow regimes, compared with that in ‘break’ periods. It will also briefly discuss the impact of these observations on the concept of a ‘Trimodal distribution’[1] of convection in the tropics.

[1] Johnson et al. 1999: Trimodal Characteristics of Tropical Convection. Journal of Climate: Vol. 12, No. 8, pp. 2397–2418.

AMOS MOE34
Monday 1720–1800 hrs

Tropical Convective Systems—The Tropical Warm Pool International Cloud Experiment

Peter May

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A major international field experiment to study the evolution, structure and impact of tropical convective clouds is being undertaken around Darwin in early 2006. The scientific issues behind this experiment will be discussed followed by the science objectives and then the experimental design will be described. The aim will be to follow the cloud evolution and impact from the initial convective clouds through to the remnant cirrus and their impact on the chemical, water and radiative budgets of the troposphere and lower stratosphere.

POSTERS

AMOS PMO 1

Seasonal Cycles in Aerosol Optical Thickness in Sydney and Darwin

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Aerosol optical thickness measurements provide a way of monitoring the temporal variation of aerosol column loading. Analysis of radiometer measurements of aerosol optical thickness from Sydney and the Atmospheric Radiation Measurement site in Darwin show clear annual cycles for both cities. In Sydney the highest aerosol loading occurs during the summer months, while the annual cycle for the Angstrom coefficient indicates larger particles in the autumn. The Darwin data shows a strong seasonal cycle in aerosol optical thickness, with marked periods of low optical depth during March–August, while periods of high optical depth coincide with the biomass-burning season (September–November).

AMOS PMO 2

CSIRO Mk3 Climate System Model Integrations for IPCC AR4: Status and Results

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CSIRO Atmospheric Research

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CSIRO is in the process of finalising a minimum of 10 experiments with the Mk3 Climate System Model (CSM) for contribution to the Intergovernmental Panel on Climate Change Data Distribution Centre. This data archive has a key role in the writing of the influential IPCC 4th Assessment Report on Climate Change.

We will provide most of the requested high priority fields. The most important deficiency in our submission is the lack of ensembles, overcoming this would help reduce uncertainty in estimates of model trends and variability.

This paper will describe basic features of the Mk3 CSM, our data processing methodology and some key results describing model sensitivity and performance.

AMOS PMO 3

Retrieval of Higher Order Ocean Spectra from Sunglint

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We employ Monte Carlo methods to generate multiple realisations of the nonlinear ocean surface, from which sunglint realisations, and the correponding bicoherence, can be simulated. A forward model is developed, based on a linear model[1], which relates the sunglint bicoherence and cumulants with the corresponding slope bicoherence and cumulants. This model is then inverted and applied to the simulated sunglint bicoherence to retrieve the slope bicoherence and cumulants. The retrieved slope bicoherence is then Fourier transformed to obtain the slope bispectrum. We examine the retrieved slope bispectrum to infer such quantities as the ratio of primary to quadratically coupled wave power at particular wavenumbers, and the sign of the slope skewness, which provides an indication of the direction of wave travel.

[1] J. Alvarez-Borrego, Wave height spectrum from sunglint patterns: an inverse problem, J. Geophys. Res., **98**, C6 (1993)

AMOS PMO 4

Classification of the Australian Summer Monsoon using SOM Analysis

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Self Organising Maps (SOMs) are used to classify synoptic scale circulation patterns associated with the summer monsoon over Indonesia and northern Australia. SOMs are a class of artificial neural networks which produce similar groupings to, but have some advantages over, those obtained by traditional statistical clustering techniques. Experimentation with different sized arrays produced generally similar results, with the final solution being a 5 by 3 SOM array. While all nodes show strong persistence, the transition matrix depicts the preferred evolution between relatively inactive heat low and more convectively active monsoon situations.

AMOS PMO 5

Enhancement of a Seabreeze Circulation Due to Upwelling

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Coastal upwelling causes cooler sea surface temperatures (SST) in a limited region offshore by as much as 5˚C compared to the surrounding ocean. The increase in land-sea contrast thus enhances the sea breeze circulation[1]. To evaluate the change in strength and initial development of the seabreeze due to upwelling, model simulations are carried out with a limited area model[2]. Atmospheric conditions favourable for upwelling off southern Eyre Peninsula[3] are simplified to extract the change due to the upwelling signal. A characteristic sea breeze during these conditions exhibits a weak front and propagates fast inland. In comparison, a case with no-upwelling shows a significant change in the ocean surface fluxes in the proposed region. During upwelling an earlier development of the seabreeze and an enhanced propagation over land as well as a stronger front are evident.

[1] S.H. Franchito, Rao, V.B., Stech, J.L., Lorenzzetti, J.A., The effect of coastal upwelling on the sea-breeze circulation at Cabo Frio, Brazil: a numerical experiment. Ann. Geophysicae, **16**, 866–881 (1998)

[2] Y. Shao, Sogalla, M., Kerschgens, M.J., Brücher, W., Effects of land surface heterogeneity upon surface fluxes and turbulent conditions. Meteorology and Atmospheric Physics, **78**, 157–181 (2001)

[3] J. Kämpf, Doubell, M., Griffin, D., Matthews, R.L., and Ward, T., Evidence of a large seasonal coastal upwelling system along the southern shelf of Australia. Geophys. Res. Lett., **31**, L09310, doi:10.1029/2003GL019221 (2004)

AMOS PMO 6

Application of Artificial Neural Network Forecasts to Predict Fog at Canberra Airport

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The occurrence of fog and low level stratus clouds impinge upon aviation safety. The prediction of fog occurrence remains difficult despite improvement in numerical guidance and models. This research aims to explore the ability of a relatively new approach, namely Artificial Neural Networks, to provide accurate forecasts of such events. Canberra International Airport experiences an average of 46 fog days per year. Extensive consultation with representatives from the Bureau of Meteorology has established a requirement for increased fog forecast skill. A forward feeding Multi Layer Perceptron, utilising the back propagation of errors during batch training on a 40year dataset (obtained from the Bureau of Meteorology) was employed in the development of several fog forecasting aids. At present, preliminary modelling has shown this methodology capable of analogous forecast skill, versus traditional methods, and further development should offer increased forecasting ability.

AMOS PMO 7

A "Recycling Box" Model of the Global Overturning Circulation of the Oceans: Replacing the Missing Mixing with a Missing Process

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Warm equatorial surface waters are cooled as they are carried polewards by the global overturning circulation in the oceans. These waters sink in turbulent plumes against high-latitude continental margins, replenishing abyssal waters of the oceans. In order to examine the roles of buoyancy, entrainment (into the descending plumes) and interior mixing, we develop an analytical model describing the steady circulation in an ocean driven by a surface heat flux. Given realistic surface fluxes and the measured ocean mixing rate this model successfully predicts an overturning circulation that is consistent with a wide range of observations from the global oceans.

AMOS PMO 8

TROMP: Detecting Water Property Changes from a Time Series of Oceanographic Data

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A constrained minimisation technique is used to identify variations in the properties of source water types (SWT) present in a time series of oceanographic data. Two simulated data sets are analysed with small variations in temperature and salinity being successfully identified. It is found that by targeting which water properties are allowed to vary within the minimisation small changes in individual source water properties can be identified. Analysis of a time series collected in the Sargasso Sea in the North Atlantic Ocean is ongoing.

AMOS PMO 9

A Historical Monthly Pan-evaporation Dataset for Australia

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It is known that discontinuities in climatological time-series can be caused by a range of factors. Station moves, changes in the type of instrument or exposure, and calibration of instruments all feature prominently in the literature. For monitoring long-term climate fluctuations and trends, it is thus important to develop homogenous series that are adjusted for such factors.

In this paper we will present a newly developed high-quality monthly pan-evaporation dataset produced in order to monitor long-term pan-evaporation trends in Australia. Necessary adjustments of time-series were determined using station metadata and an objective analysis method based on Barnes successive correction technique.

AMOS PMO 10

Numerical Study of Seasonal Variations of the Circulation in the Persian Gulf

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A three-dimensional hydrodynamic model is employed to study the seasonal cycle of water mass properties and circulation in the Persian Gulf. Findings are in general agreement with previous hydrographic data but give additional information of processes during autumn and early winter where field data are sparse. In particular, we find that a gulf-wide cyclonic circulation establishes during summer, but this becomes dynamically unstable and develops into mesoscale eddies during autumn and

winter. The exchange circulation through the Strait of Hormuz, however, appears to be largely unaffected by this seasonal collapse of the circulation.

AMOS PMO 11

Mesoscale Variations in Neargound Impurities

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Local wave structure of variations in concentrations of aerosol and minor gaseous impurities as well as meteoparameters is investigated. Simultaneous measurements at five stations placed one from another within 1–6 km allow us to calculate parameters of mesoscale wave variations in concentration such as: wavelengths (1–150 km), periods (1–16 hours), azimuths and phase speeds. Wavelet analysis is used for revealing the characteristics of time variations for each station simultaneously. It is shown that internal gravity waves caused by orography are the reason of meteopameters and impurities variations. This work is supported by RFBR (04-05-64194, 03-05-96211)

AMOS PMO 12

Nuclear Geophysiology: Stable Water Isotopes as Evaluators of Hydroclimate Predictions in the Murray-Darling Basin

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Isotopic data from two end-range and one central aquifer in the Murray Darling Basin are used to determine precipitation intensity thresholds for evaluation of GCM predictions. Applying these to ‘good’ and ‘poor’ Atmospheric Model Intercomparison Project (AMIP) simulations of the Murray Darling gives rise to large differences in rainfall amount (30% to 62%). Selecting only ‘good’ models shows a >150mm annual groundwater recharge loss in El Niño cf. La Niña climates. These isotopic techniques are applicable to future model scenarios of basin-scale hydrology, especially in difficult to simulate semi-arid basins.

AMOS PMO 13

The Effect of Coastal Diabatic Heating Gradients on the Dynamics of Cold Fronts

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The present paper examines how the cold fronts that form in a confluent deformation model are affected by sharp heating gradients associated with coastlines. For example, cold fronts commonly develop over the ocean and sweep onshore in the southern part of the continent.

The numerical model is two-dimensional mesoscale model formulated in sigma coordinates on an f-plane. For simplicity moist processes are neglected.

The results from 4 numerical experiments will be discussed.

1. The first numerical experiment investigates frontogenesis due to confluent deformation above a homogeneous land surface.
2. The second numerical experiment adds sea to the calculation, but without a synoptic cold front.
3. The third numerical experiment examines the interaction of a cold front with a heated land mass and sea breeze. In this experiment the cold front is offshore initially.
4. The fourth numerical experiment examines the interaction of a continental front as it approaches a coastline and interacts with the sea breeze and the maritime boundary layer.

AMOS PMO 14

Coherence and Shock in Sea Waves

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Only 40% of coastal seawater is hydrogen bonded. Some of the remainder is hydrophobic about abundant tiny bits, hydrophilic clustering around hydration shells, or have high polymers in patchy weak gels. This structure-making can cause coherence with some slab-like lips in plunging waves.

Oblique wave trains give nodes where accelerating single jets emanate from concave wave faces. Negative pressure causes cavities and cavitation in the jet with shock and spray in mid-air. Near parallel wave trains reinforce at times giving initial throw upwards.

Prior to breaking the noses of cuspate horns may emit a series of visible shock waves into the atmosphere. There is a venturi shape in plan and a log spiral shape in section. The nose ends in a coil of spume.

AMOS PMO 15

Towards an Understanding of the Flushing of Bass Strait

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This study investigates winter-spring flushing of Bass Strait with a two-dimensional non-linear depth-averaged shallow-water model. An advection-diffusion scheme for several tracers is used to reveal the flushing pattern/timescale of the region. The study considers how external water masses flush strait waters. Results show that the central area of the strait is a stagnation-area of weak currents and relatively long flushing times (>160 days). The influence of external water masses on the stagnation-area is estimated. The findings have implications for marine ecosystems, residence times, air-sea modifications of water mass properties and dense water formation in the region.

AMOS PMO 16

Observations of New Particle Formation in Response to a Frontal Passage

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Airborne measurements of condensation nuclei with radius greater than 1.3 nm were measured in the vicinity of a cold front passing over southern Japan during the ACE-Asia experiment. Measurements were made in both the boundary layer and free troposphere, before and after the cold front. The observations suggest that existing particle surface area is not a determinant in the production of new particles, but rather mixing processes appear to be the main process accompanying new particle production. The general effect of the front was found to decrease the aerosol concentration in both the free troposphere and the boundary layer.

AMOS PMO 17

Verification of a Mesoscale Model using Boundary Layer Wind Profiler Data

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We present an evaluation of the mesoscale model TAPM by comparing simulations with sodar and electromagnetic wind profiler observations. The remote sensing instruments themselves were verified against standard balloon data. Averaged over one month, the model displays good skill, giving confidence that is it well suited to simulating longer-term effects such as the average impact of emissions on air quality. However, a case study approach shows that the model has shortcomings in reproducing the details of boundary layer evolution accompanying mesoscale events such as a frontal passage. This may make TAPM less useful as a forecasting tool for specific episodes.

AMOS PMO 18

On the Changes of Tidal Characteristics due to Sediment-induced Stratification in a Macro-tidal Coastal Sea

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A numerical modelling study on the effects of sediment induced stratification on tidal currents is conducted for the region of the western tip of the southwest muddy coast of Korea. The numerical model is a three dimensional oceanic sediment transport model capable of predicting dynamics of Newtonian fluid mud layers due to coupling of the sea water density and suspended sediment concentration. The model uses a re-parameterized bottom drag coefficient that incorporates a linear stability function of flux Richardson number. The study has shown that the sediment induced stratification in the bottom boundary layer (BBL) reduces the vertical eddy viscosity and bottom shear stress. In response to these apparent reductions, the tidal current shear is increased in the water column.

AMOS PMO 19

Multiple Equilibria in Barotropic Flows over Topography

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Several investigations using severely truncated models, as well as high resolution ones, have shown that more than one equilibrium state is possible for atmospheric flows over topography, for certain ranges of parameters. One equilibrium state is typically dominated by transient eddy activity while the other is dominated by large scale zonal flow. We attempt to reproduce these results using a model similar to that used in[1]. Preliminary findings confirm the existence of multiple equilibria for realistic values of parameters. We aim to investigate this issue further using both an ensemble of flows and Inhomogeneous Closure Theory.

[1] G. Holloway and J. Eert, 1987: Intransitive multiple equilibria in eddy-active barotropic flows, J.Atmos.Sci., 44, 2001–2005.

AMOS TUB11
Tuesday 1040–1120 hrs

Terrestrial Carbon and Water Cycles in Australian Landscapes: A Multi-scale Approach Using Micrometeorology, Remote Sensing and Mesoscale Models

Helen A Cleugh

CSIRO Atmospheric Research, Pye Laboratory

The coupled cycles of carbon and water in the terrestrial biosphere are a critical element of our climate system. For example the future trajectory of atmospheric CO_2 concentrations depends on the longevity and vulnerability of the terrestrial sink, while climate change will almost certainly modify the terrestrial water balance—especially losses via land surface evaporation. Local and regional climates can be altered by changes in land cover, as demonstrated for SW Australia by Pitman et al (2004). This interest in the terrestrial biosphere—especially its role in the global carbon cycle—has led to an enhanced effort to quantify the cycling of carbon and water in terrestrial ecosystems, at scales that range from individual plants to extensive canopies; and from regions to continents.

Atmospheric techniques, where land-air exchanges of carbon and water are inferred from measurements of atmospheric concentrations, have contributed much to this effort at both global and local scales (1–10 km^2). In particular, micrometeorological methods have been implemented to obtain long-term and continuous measurements of evaporation and net carbon exchanges in a global network (Fluxnet) of over 200 flux stations across a diverse range of ecosystems and climates.

This presentation will describe, and present key results from, the multi-scale approach that has been used over the last 5 years to quantify the terrestrial carbon and water cycles in Australian landscapes at multiple space and time scales—combining atmospheric measurements, modelling and remote sensing. Particular focus will be on the methodological challenges and strengths of using micrometeorology to determine fluxes of water, CO_2 and non-CO_2 greenhouse gases in real landscapes; and the approaches being developed to extrapolate from local to regional scales.

AMOS TUB13
Tuesday 1120–1140 hrs

The Impact of Abrupt Land Cover Changes by Savannah Fire on Northern Australian Climate

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Dry season fires in northern Australia annually cause abrupt changes in vegetation properties, influencing local boundary layer processes. Some evidence also suggests impacts on the monsoon development. In the last 50 years, a tendency to more destructive late dry season fires is evident. Vegetation succession after fire is analyzed using a GCM. In addition, preliminary results of parallel experiments with varying fire properties using NIMROD/G are presented. Integrative output metrics are combined with the forcing to express the response as a multi-dimensional reduced-form non-linear model; an efficient way to explore the physical relationships between fires and the Australian Monsoon.

AMOS TUB14
Tuesday 1140–1200 hrs

Seasonal Variations in Size-Resolved Properties of Aerosols in the Sydney Region

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Size resolved chemical composition of atmospheric aerosols is important in determining their optical properties, which in turn affect the way radiation is scattered and absorbed as it passes through the atmosphere. Aerosol samples (PM2.5 and PM10) were collected at four sites around Sydney during 2003 and have been analysed using Ion Beam Analysis (IBA) and Scanning Electron Microscopy (SEM). IBA analyses indicate seasonal differences within sites, and between sites, as well as differences between PM2.5 and PM10–PM2.5 composition at particular sites. SEM results are currently being analysed to obtain information about particle size and shape.

AMOS TUB15
Tuesday 1200–1220 hrs

Satellite Investigations of Aerosol Effect on Clouds

Michael A. Box[1], Anju Thiruna Vukarasu[1], Janet Yu[1], and Sundar A. Christopher[1,2]

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Atmospheric aerosols are among the most heterogeneous of the Earth's atmospheric components and influence the Earth's climate, at both global and regional scales. Aerosols scatter sunlight back to space, leading to a planetary cooling and act as cloud condensation nuclei thereby altering the reflective properties of clouds. Using multiple sensors on the Terra satellite we examine the relationship between aerosol optical thickness and cloud particle size, and the top of atmosphere radiative fluxes, quantified for polluted and unpolluted cases. Preliminary results indicate that in high aerosol loading cases the cloud droplet sizes decrease.

AMOS TUB21
Tuesday 1400–1420 hrs

Ocean-atmosphere Dynamics in the Southern Ocean

A. McC. Hogg[1] and J. R. Blundell[2]

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In this study we present results from QGCM[1], an idealised coupled ocean-atmosphere model which emphasises the role of nonlinear ocean dynamics and turbulence in the climate system. We concentrate on the role of ocean eddies in governing both the mean flow and the variability of the Antarctic Circumpolar Current (ACC) in the Southern Ocean. It is demonstrated that the mean flow pattern of the ACC is strongly dependent upon parameters which govern turbulence. In strongly turbulent parameter regimes, ocean and climate variability at all time scales is enhanced by the explicit simulation of ocean eddies.

[1] A. McC. Hogg, W. K. Dewar, P. D. Killworth & J. R. Blundell, Mon. Weather Rev., 131, 2261 (2003)

AMOS TUB22
Tuesday 1420–1440 hrs

Impacts of Latitude Shifts in the Southern Ocean Subpolar Westerly Winds on Past and Present Climates

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The climate response to an equatorward and poleward shift in the latitude of the mid-latitude westerlies in the Southern Hemisphere is analysed in a coupled climate model of intermediate complexity. This has relevance to the interpretation of past and future climates, as wind shifts are projected under enhanced greenhouse forcing, and the wind axis appears to oscillate in paleoclimate records. The long term response of the ocean's thermohaline circulation and CO^2 uptake are examined. We find an increase (decrease) in the formation of Antarctic Intermediate Water and a lower (higher) oceanic uptake of CO^2 for a poleward (equatorward) shift, respectively. Other important adjustments are noted in regional ocean and climate patterns, confirming that subtle latitude shifts in the mid-latitude westerlies can significantly alter our climate system.

AMOS TUB23
Tuesday 1440–1500 hrs

Nonlinear Resonance and Chaos in an Unstable Western Boundary Current under Periodic Forcing

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Heat transported by western boundary currents (WBCs) is important in the global climate system, and WBC variability is implicated in climate fluctuations. Results are presented from a numerical study of WBC variability under periodic wind forcing. The model WBC has a periodic oscillation under steady forcing, but under periodic forcing it may lock onto a rational multiple of the forcing period (nonlinear resonance), or be quasiperiodic (unlocked), or chaotic (partially locked, with variability on longer timescales than either the natural or forcing periods). The locking mechanism is discussed in terms of Rossby waves and the theory of forced nonlinear oscillators.

AMOS TUB24
Tuesday 1500–1540 hrs

New Insights into the Indonesian Throughflow: Its Variability and Role in Global Heat Balances

Susan Wijffels

CSIRO Marine Reseach, Hobart TAS Australia

In the early 1980's a network of frequently repeated eXendable BathyThermograph (XBT) sections were established in the eastern South Indian Ocean as part of the Tropical Ocean Global Atmosphere experiment. Nearly twenty years later these lines are still operating and are shedding light on the mean structure of the Indonesian Throughflow and its interannual variability. In particular, seasonal anomalies of subsurface temperature variability in the Throughflow region can be seen as largely due to the interaction of remotely wind driven waves originating along the Indian and Pacific Ocean equators. Transport variability is less easily understood. The barotropic Island Rule cannot account for the observed baroclinic transport changes. Mean transports relative to 800m are near 9Sv (geostrophic plus Ekman), with the Throughflow characterized by a subsurface velocity maximum near 100m. Comparisons with moored transport estimates guide estimates of the deep portion of the Throughflow, and thus allow exploration of implications for global heat balances. Unprecedented observations of the Throughflow are being collected by the five-nation INSTANT program. Some early results of its field phase will be shown.

AMOS TUB31
Tuesday 1620–1640 hrs

Mixing at the Subtropical Front in the Indian Ocean South of Australia

M. Tomczak[1], L. Pender[2] and S. Liefrink[1]

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A detailed high resolution survey of a small region (68 by 68 km) of the Subtropical Front south of Australia is used to study the interaction between the mixed layer and the permanent frontal structure underneath. Intrusions and water mass parcels are found just below the mixed layer, produced as a result of the relative movement of the front in and below the mixed layer. The results suggest that any study aimed at understanding the interaction between the mixed layer and the layers below in oceanic fronts will have to address wind-driven dynamics and frontal dynamics together.

AMOS TUB32
Tuesday 1640–1700 hrs

The Melting of Ice in the Arctic Ocean: Double-Diffusive Transport of Heat from Below

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Observations have shown that over several decades a layer of warm water has been advancing across the Arctic Ocean below the halocline, and that currently the sea ice is melting at an increased rate. Recent laboratory experiments[1] suggest that these two phenomena could be linked, and that the expected heat flux due to double-diffusive convection will be larger when the salinity gradient is smaller. Ocean data, laboratory results and various theories are used to quantify this transport, and compare it with the heat flux from the atmosphere to the surface layer.

[1] J.S. Turner & G. Veronis, J. Marine Systems, 45, 21–37 (2004).

AMOS TUB33
Tuesday 1700–1720 hrs

Cascading-Induced Upwelling in Submarine Canyons: A New Upwelling Mechanism

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Findings of process-oriented modelling confirm my initial research hypothesis stating that dense water cascading down a submarine canyon induces localised upwelling of deeper water onto the shelf. This process, not described before, is associated with internal deformation radii inherent with the cascading process being less the canyon width and geostrophic adjustment of a density front that establishes along the canyon axis. Since submarine canyons are common to continental margins, this paper has identified a key process triggering the renewal of shelf waters at high latitudes.

AMOS TUB34
Tuesday 1720–1740 hrs

Control of Mean Sea Level Change by Net Oceanic Evaporation during Greenhouse Warming

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A study of the dynamics of the coupled atmosphere-ocean-ice global system, using an analytical model, will be presented which takes account of the embedding of

the greenhouse warming event in the glacial-interglacial environment. In a short period warming, occurring on a time scale much less than the geological time scales set by the dynamics of the ice fields, it is found that the net oceanic evaporation anomaly is the main control on sea level, and that the likely impact of anthropogenic warming will be to increase evaporation sufficiently to cause sea level to fall after the maximum heat flux has occurred.

AMOS TUB35
Tuesday 1740–1800 hrs

Seasonal Variability of Atmospheric Teleconnection Patterns

J.S. Frederiksen[1] and G. Branstator[2]

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The seasonal variability of 300-hPa global streamfunction fields taken from a 40-year observational data set is analysed in terms of empirical orthogonal functions, principal oscillation patterns and finite-time principal oscillation patterns (FTPOPs). The leading FTPOPs are large-scale teleconnections patterns that have similar seasonal cycles of relative growth rates and amplitudes to the leading finite-time normal modes of the barotropic vorticity equation with basic states that change with the annual cycle. We find a close relationship between the boreal spring predictability barrier for climate prediction and the amplitudes of large-scale instabilities and teleconnection patterns of the atmospheric circulation.

AMOS WEE11
Wednesday 1040–1100 hrs

Cloud Properties from the Calipso Satellite Lidar

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The NASA 'Cloud and Aerosol Lidar and Infrared Pathfinder Satellite Observations' (CALIPSO) satellite instrument, to be launched in mid 2005, will be used to retrieve cloud and aerosol optical properties globally. Values of cirrus ice cloud extinction-to-backscatter ratio, and their variation with temperature, have been obtained by CSIRO in Australia using ground-based observations of mid-latitude and tropical cirrus clouds with lidar and filter radiometers. These will be used to retrieve cirrus cloud extinction from CALIPSO data. Extinction to backscatter values obtained from the scattering phase functions of various ice crystal habits are compared with those obtained theoretically.

AMOS WEE12
Wednesday 1100–1120 hrs

Effects of Air-sea Interactions on the Development of Intrusions at the Subtropical Front South of Australia

M. Tomczak and S.J. Borlace

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High resolution observational data collected at the Subtropical Front south of Australia by the RV Franklin, between the 16th February and 6th March 2001, clearly display evidence of intrusive water parcels, characteristic of the mixed layer water, at depths below the mixed layer. These intrusions are believed to be the result of relative frontal movement both in and below the mixed layer. A high resolution (kilometre scale) atmospherically forced upper ocean model has been used in this investigation to gain a further understanding of how intrusions develop in the region, with particular emphasis placed on the effects of wind and heat flux on both frontal dynamics and convective frontal mixing.

AMOS WEE13
Wednesday 1120–1140 hrs

Mapping Australia's Oceans with over-the-Horizon Radar

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The scattering of HF radar signals from the sea surface can be described in terms of a highly selective resonance mechanism which links the resulting radar Doppler spectrum directly to the autocorrelation structure of the sea surface and hence with the directional wave spectrum. Of the various HF radar configurations which exploit this effect, two have been developed to the point where they can claim some degree of operational status—HF surface wave radar and HF skywave radar. The former can measure the directional wave spectrum at ranges of typically 100–200 kilometres, while the latter may provide estimates at ranges up to several thousand kilometres. But, whereas signals processed by the former configuration have been modulated almost exclusively by the sea surface dynamics of interest, signals from skywave radars are inevitably subjected to a wide variety of additional modulations imposed in the course of their propagation via the ionosphere. The key to practical HF radio oceanography is the combination of ionospheric distortion correction, sophisticated mathematical inversion techniques, detailed electromagnetic scattering models and rigorous consideration of the physics of the ocean surface.

This paper will survey the distinctive remote sensing capabilities of HF radar, illustrated with results from several of Australia's current menagerie of over-the-horizon radars.

AMOS WEE14
Wednesday 1140–1220 hrs

Ocean-atmosphere Coupled Forecast Models

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Most major climate modelling centres now have dynamical seasonal prediction systems. The POAMA (Predictive Ocean Atmosphere Model for Australia) system was developed jointly by BMRC and CSIRO Marine Research. A review of dynamical seasonal prediction systems will be presented.

A description of the POAMA system will also be presented. The first version, POAMA-1, went operational during October 2002. The model is based on the latest version of BMRC's unified climate/NWP atmosphere model (BAM) and the Australian Community Ocean Model (ACOM2). The POAMA-1 system uses a sophisticated ocean data assimilation system that incorporates the latest oceanic observations into the initialisation procedure for the model forecasts. It is also one of the few models that uses real atmospheric data, taken from the Bureau's operational weather forecast system.

The initial focus of POAMA is the prediction of El Nino. The operational system and latest results will be described. Results show that the skill of POAMA forecasts is at least as good as the best international models. Also discussed is the model's unique ability to simulate and predict intra-seasonal variability, such as, the Madden-Julian Oscillation (MJO).

A new version, POAMA-2, is being developed for operational implementation in 2005. For POAMA-2 a large comprehensive set of ensemble hind-casts will be performed to assess the model skill and to develop new products. POAMA-2 will be used to forecast Australian rainfall and temperature anomalies in addition to El Nino conditions.

Atomic and Molecular Physics and Quantum Chemistry (AMPQC)

AMPQC THA11
Thursday 1040–1120 hrs

See AOS THA11

New Physics with Degenerate Fermi Gases

G.V. Shlyapnikov

AMPQC THA13
Thursday 1120–1140 hrs

Reflection of Dilute Gas Bose-Einstein Condensates off a Silicon Surface

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As a Bose-Einstein condensate approaches a Silicon surface it experiences an abrupt (attractive) change in the potential (Casimir-Polder). We show through numerical investigation of the Gross-Pitaevskii equation that this abrupt change can cause a condensate to partially reflect at low incident velocities. We compare our results to recent experiments[1] and find good qualitative agreement. We also show that for low velocities and high condensate densities, it is possible for the condensate to form solitons and vortex rings, which disrupt the reflected cloud significantly. This is analogous to the production of excitations within a condensate as it Bragg reflects in an optical lattice[2].

[1] T.A. Pasquini, Yong-Il Shin, C. Sanner, M. Saba, A. Schirotzek, D. Pritchard and W. Ketterle, cond-mat/0405530.

[2] R.G. Scott, A.M. Martin, T.M. Fromhold, S. Bujkiewicz, F.W. Sheard and M. Leadbeater, Phys. Rev. Lett. 90, 110404 (2003).

AMPQC THA14
Thursday 1140–1200 hrs

See AOS THA14

Limits to the Flux of a Continuous Atom Laser

N.P. Robins, A. Morrison and J.D. Close

AMPQC THA15
Thursday 1200–1220 hrs

See AOS THA15

Dynamical Tunneling with Bose-Einstein Condensates on Atom Chips

M. Lenz, M. J. Davis, G. J. Milburn, and C. A. Holmes

AMPQC THB21
Thursday 1400–1440 hrs

Close Coupling Approach to Electron-hydrogen Ionisation

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Accurate calculation of electron-impact ionisation of atoms has been an intractable problem for many decades. The fundamental problem is due to the long-ranged Coulomb interaction between three charged particles continuing out to infinite distances. Though the formal treatment of this problem has been recently given[1], it followed only after two computational approaches were developed[2,3].
Here we will present the most general approach to atomic collisions, the convergent close-coupling (CCC) method, and apply it to fully differential measurements of electron-hydrogen ionisation, yielding unprecedented agreement with experiment.

[1] A. S. Kadyrov, A. M. Mukhamedzhanov, A. T. Stelbovics, and I. Bray, Phys. Rev. Lett. 91, 253202 (2003).

[2] T. N. Rescigno, M. Baertschy, W. A. Isaacs, and C. W. McCurdy, Science 286, 2474 (1999).

[3] I. Bray, K. Bartschat, and A. T. Stelbovics, Phys. Rev. A 67, 060704(R) (2003).

AMPQC THB23
Thursday 1440–1500 hrs

(e,2e) Measurements Using a Magnetic Angle Changer

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(e,2e) triple differential cross section measurements have been performed on the inner 3s orbital of argon for an incident energy of 113.5 eV and several low ejected electron energies. Large structures are predicted by theory in regions which have been previously inaccessible experimentally due to angular constraints of the apparatus. A magnetic angle changer was used to deflect these regions to angles which were accessible to with our apparatus. This represents the first (e,2e) measurements using this technique.

AMPQC THB24
Thursday 1500–1520 hrs

Violations of Parity and Time-reversal in Heavy Atoms: Calculations for Cesium and Radium

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High-precision measurements of violations of fundamental symmetries (e.g., parity and time-reversal) in heavy atoms

provide an effective and relatively inexpensive means of testing the standard model of elementary particles and searching for new physics. Atomic structure calculations are required for interpretation of these measurements. We present our atomic many-body calculations for two systems of current interest: parity violation in cesium, for which the most precise measurements and calculations exist; and the (parity and time-reversal violating) electric dipole moment in radium, under experimental investigation at two major laboratories.

AMPQC THB25
Thursday 1520–1540 hrs

Measurement of Two-electron QED in Helium-like Titanium

C. T. Chantler, M. Kinnane, J. Kimpton, G. Christodoulou, C-H. Su

School of Physics, University of Melbourne, Parkville, VIC Australia

We have measured the resonance lines for the two-electron titanium ion at the NIST Electron-Beam Ion Trap. Results show a statistical precision of 6 ppm, well in advance of earlier work. This allows a critical test of QED in a new regime.

AMPQC THB31
Thursday 1620–1640 hrs

Electrical Conduction of Single Organic Molecules

K.-H. Müller, J. Herrmann, T. Böhme, B. Raguse, M. Roberts, G. Wei and L. Wieczorek

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An essential initial requirement for developing molecular electronics is a detailed understanding of the electrical conduction properties of molecules placed between two metal electrodes. We have used first-principle quantum mechanical calculations based on the density functional theory and non-equilibrium Green's function techniques to calculate the conduction of single organic molecules. Our results are compared with experiments where molecules in solution bridge the gap between gold electrodes of a break-junction. Our calculations reveal a strong dependence of the conduction on the atomic configuration of the electrodes.

AMPQC THB32
Thursday 1640–1700 hrs

Electron Cross Sections in Modelling of Auroral Emissions

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Accurate cross sections are vital for predictions of auroral emissions produced by electron impact excitation of molecules. Verification of the role of the cross sections is difficult due to other interacting processes (such as collisional quenching, predissociation and chemical reactions) and the variability of auroral and atmospheric parameters. Here predictions of auroral ultraviolet emissions from molecular nitrogen are compared with measurements, in order to evaluate the accuracy and significance of different electron impact cross sections. It is found that using more recent electron impact cross sections gives better agreement with measurements than using a previous set.

AMPQC THB33
Thursday 1700–1720 hrs

Proton Transfer of Adenine Tautomers Studied in Configuration and Momentum Spaces

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The existence of "rare" tautomeric forms of DNA bases increases the possibility of mispairing of purine and pyrimidines that may lead to spontaneous point mutations[3]. The information of adenine tautomers provided by even high level quantum mechanical calculations in configuration space is not so sensitive with respect to the proton transfer[2]. When the orbital are mapped into momentum space using a Fourier transform, which is also known as the dual space analysis (DSA) approach[1], the orbital momentum distributions of the tautomers are sensitive to orbitals related to the proton transfer. In this work, we present our most recent results for a detailed understanding of adenine tautomerism.

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[2] F. Wang, M. Downton and N. Kidwani, J. Theor. & Comput. Chem., (accepted, 2004).

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AMPQC THB34
Thursday 1720–1740 hrs

Interatomic and Intermolecular Interactions Studied by Imaging Techniques

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Non-covalent interatomic and intermolecular interactions govern behaviour in a wide variety of environments. For example, they determine the aggregation of atoms and molecules, govern the structure of polymers and biological molecules, determine solvation properties, and modify chemical reactions in solution. The fundamental understanding of these interactions can be approached particularly well via spectroscopic probing of van der Waals molecules, with small model systems providing insights into the essential interaction mechanisms. Van der Waals molecules are dimers, or larger aggregates, of two

or more species held together by non-covalent interactions.

A crucial experimental value is the binding energy of the van der Waals molecules, which measures the strength of the intermolecular bond. This is difficult to measure. For example, the benzene-Ar complex has been studied for over 20 years because it is one of the simplest examples of dispersion interactions involving an aromatic, and such interactions are important in a biological context, yet its binding energy has remained elusive.

Our group has used the technique of velocity map imaging to investigate the translational energy released in the dissociation of van der Waals molecules. The cut-off in the translational energy release distribution allows the binding energy of the complex to be determined. This approach has been applied to a number of van der Waals species. The translational energy released, in combination with spectroscopic probes, allows the distribution of rotational energy in the fragments to be determined, which provides insights into the dissociation process. The presentation will review the method and give a number of examples from the systems studied to date.

Recently, we have begun velocity map imaging studies of NO-Ar dissociation as a precursor to studies of the dissociation of NO-diatomic species. The aim of this work is to determine the correlated product distributions, thereby providing detailed data for comparison with theoretical calculations. A summary of progress in this project to date will be presented.

POSTERS

AMPQC PTH 7

Atomic Clocks and the Search for Variation of the Fine Structure Constant

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Analyses of quasar absorption spectra suggest that the fine structure constant, α, may be varying[1]. In the presence of α variation relativistic effects cause spectral lines to shift relative to each other. No observation of α variation has yet been obtained from a laboratory experiment, possibly because of the small size of the spectral line shifts. However, the shift of the spectral lines can be larger in heavier atoms. Our results indicate useful atomic transitions to use in atomic-clock-type experiments designed to test whether α varies in time. We perform calculations using the relativistic Hartree-Fock method with many-body perturbation theory and configuration interaction methods to calculate how a varying α would shift different spectral lines.

[1] J. K Webb, M. T. Murphy, V. V. Flambaum, V. A. Dzuba, J. D. Barrow, C. W. Churchill, J. X. Prochaska, and A. M. Wolfe, Phys. Rev. Lett. **87**, 091301 (2001).

AMPQC PTH 8

Evolution of the UWA Solid Nitrogen Dual Mode Sapphire Oscillator, JULIA

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Operating at the quantum limit of an atomic fountain clock requires an extremely stable fly-wheel oscillator with fractional frequency instability (FFI) on the order of 10^{-14} over 1s integration time. Helium cooled sapphire oscillators are the current standard, with FFI on the order of 10^{-15} at 1s, but are expensive to run. A new dual-mode temperature compensation technique has been used in constructing a 50K solid nitrogen cooled sapphire oscillator, nicknamed JULIA. This method, along with a novel temperature control technique, has given FFI of 4.3×10^{-14} at 1s dropping to 3.5×10^{-14} at 30 s integration time.

AMPQC PTH 9

Isotope Shift and the Search for Variation of the Fine Structure Constant

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Recent studies of quasar absorption spectra suggest that the fine structure constant, α, was different in an earlier epoch. A dangerous systematic effect in these studies is that the isotope abundances in the gas clouds sampled may differ from terrestrial abundances, introducing frequency shifts that could mimic α variation. To help resolve these systematic effects, we have calculated the isotope shift in a variety of astronomically important atoms, using relativistic Hartree-Fock as a zero-approximation and adding core-correlation and configuration-interaction effects. Our calculations can also be used to study variation of isotope abundances in the Universe and test cosmic evolution theories.

AMPQC PTH 10

Close Coupling Approach to Electron-hydrogen Ionisation

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Accurate calculation of electron-impact ionisation of atoms has been an intractable problem for many decades. The fundamental problem is due to the long-ranged Coulomb interaction between three charged particles continuing out

to infinite distances. Though the formal treatment of this problem has been recently given[1], it followed only after two computational approaches were developed[2,3]. Here we will present the most general approach to atomic collisions, the convergent close-coupling (CCC) method, and apply it to fully differential measurements of electron-hydrogen ionisation, yielding unprecedented agreement with experiment.

[1] A. S. Kadyrov, A. M. Mukhamedzhanov, A. T. Stelbovics, and I. Bray, Phys. Rev. Lett. **91**, 253202 (2003).

[2] T. N. Rescigno, M. Baertschy, W. A. Isaacs, and C. W. McCurdy, Science **286**, 2474 (1999).

[3] I. Bray, K. Bartschat, and A. T. Stelbovics, Phys. Rev. A **67**, 060704(R) (2003).

AMPQC PTH 11

X-Ray Extended-Range Technique for Precision Measurement of the X-Ray Mass Attenuation Coefficient and Im(F) for Molybdenum Using Synchrotron Radiation

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The accuracy of atomic form factors has long been a concern of the International Union of Crystallography. We present our latest results for Molybdenum featuring an absolutely calibrated energy scale, harmonic component determination to 1 photon in 10^4 and sample thickness calibration. The range of the attenuation measurement far exceeds the Nordfors range of $2 < \ln(I_o/I) < 4$, resulting in a precision and accuracy below 0.1% in the range from 13.5 keV to 41.5 keV. The new result challenges available theoretical calculations and challenges us to develop a theory of XAFS capable of understanding the absolute magnitude of fine structure oscillations.

AMPQC PTH 12

X-Ray Absorption Near-Edge Structure Calculations for Silver

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New calculations of atomic-cluster x-ray absorption spectra are compared to high precision measurements of the x-ray mass attenuation coefficient for silver. The near-edge region is considered in order to examine the applicability of the finite difference method. Discrepancies between the theory and experimental results are discussed. The results indicate that the method proposed by Joly is relevant and useful in the near-edge region. Additionally, the periodicity of the peaks and the variation of the widths are not predicted by the theory, inviting further research.

AMPQC PTH 13

Electron Impact Excitation of Zinc Atoms Studied by the Electron—Photon Polarization Correlation Method

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A high resolution electron impact spectrometer incorporating both the unpolarised and polarized electron beams is developed to study excitation of multi-electron metal atoms, initially zinc. Choice of electron polarization (zero, 28 or 75%) will highlight the spin-dependent effects. Detection of the scattered electron and polarized decay photon will be used to measure differential Stokes parameters and spin up-down asymmetries. Symmetry- and spin-forbidden excitation of the 4^1D and 4^3D states of zinc is expected to show a full range of many-electron effects which need to be adequately modelled. Details of experiment and preliminary results will be presented at the Congress.

AMPQC PTH 14

Quantum State Tomography of BECs and Atom Lasers

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We investigate the possibilities of reconstructing the quantum state of ultracold atomic sources. In optics the quantum state of a single mode can be reconstructed using a series of homodyne detection experiments, but this process depends on the existence of a strong local oscillator, which does not exist for atomic fields. We aim to show how to construct a quasi-probability distribution, such as the Wigner function, by adapting methods used in quantum optics where no local oscillator field is available. Using a full non-relativistic field theory description of the system, we have found that there are limitations on what is measurable depending on the available resources.

AMPQC PTH 15

The Polarisation of Radiation Emitted from Molecular States Excited by Polarised Electrons and Polarised Synchrotron Radiation

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Recent experiments[1–3] have investigated the transfer of spin angular momentum into molecular systems, using spin-polarised electrons and observing the circular

polarisation of the emitted radiation. The results have been interesting since circular polarization has been observed in fluorescence from molecular hydrogen[1] and from atomic fragments created in the photo-dissociation of molecular hydrogen[1,3] but not in the fluorescence from molecular nitrogen[2]. This paper discusses the way in which angular momentum is shared in molecular systems and compares the results obtained in electron scattering experiments with measurements of the circular polarization obtained from various molecular states in H_2 and N_2 excited with circularly-polarised synchrotron radiation.

[1] A. S. Green, G. A. Gallup, M. A. Rosenberry, and T. J. Gay, Physical Review Letters **92**, 093201 (2004).

[2] G. F. Hanne, in *Novel Aspects of Electron Molecule Collisions* edited by K. Becker (World Scientific, Singapore, 1998).

[3] J. F. Williams and D. H. Yu, Physical Review Letters **93**, 073201 (2004).

AMPQC PTH 16

Predissociation in the $B^3\Sigma_u^-$ – $X^3\Sigma_g$ -Spectrum of S_2

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As well as being observed in planetary atmospheres, the $B^3\Sigma_u^-$ – $X^3\Sigma_g^-$ transition in $\mathbf{S_2}$ plays a key role in the white light emission produced by high-efficiency sulfur discharge lamps. However, its spectrum has yet to be fully explained.

We have applied a coupled-channel Schrödinger equation model to examine the mechanisms for dissociation. The calculations clearly identify the role of each of the electronic states responsible for predissociation, and illustrate that, contrary to another study, the $^3\pi_u$ state plays a key role in the dissociation process. A diverse variation of resonance widths and line-shapes arises from the complex interplay between the electronic states of $\mathbf{S_2}$.

AMPQC PTH 17

Spin-Polarised Electron Scattering from Rubidium Atoms: A Search for Relativistic Effects

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A search for relativistic effects in electron-alkali scattering is currently underway. The A_2 spin asymmetry is a direct measure of relativistic effects in the collision process, as it is entirely dependent on the spin-orbit effect. We present measurements of the A_2 spin asymmetry for inelastic and elastic scattering of spin-polarised electrons from rubidium, at intermediate energies. Our results indicate that under these collision conditions, relativistic effects are measurable, in qualitative agreement with the available theory.

AMPQC PTH 18

The Squeezed Atom Laser

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We theoretically investigate how to produce an atom laser with a nonclassical output by using squeezed light. We show that by outcoupling atoms using a Raman transition with squeezed light, under appropriate conditions, that the quantum statistics of the light are almost entirely mapped to the atoms, and that entangled atom laser beams could be produced by using two-mode squeezed light. We investigate the possibility of measuring quantum correlations in the atomic beam with a realistic experimental set up.

AMPQC PTH 19

Advances in the Spectroscopy of Molecular Radicals

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We report a novel technique for measurement of low-energy elastic differential cross sections for electron scattering from molecular radicals. A pulsed target beam is photolysed, forming a mixed radical beam. The differential scattering cross sections of the mixed beam, σ_{mixed}, are determined by the Relative Flow Technique using a fixed multi-analyser array. Time-of-flight mass spectroscopy then provides the fractional composition, l_i, of species i in the mixed beam. The cross sections of individual radicals, σ_i, are then given by:

$$\sigma_{mixed} = \sum_i l_i \sigma_i \qquad [1]$$

AMPQC PTH 20

Electron Collisions with Molecules of Environmental and Technological Interest

Milica Jelisavcic

Australian National University

Electron-driven processes are known to be important across a vast range of everyday processes, from those effecting our living environment to applications in technologies that are based around discharge and plasma devices. This paper will discuss recent experimental measurements of electron scattering in molecules such

as NO, C_2F_4, C_4F_8, and H_2O, all of which have applications in our contemporary lives. We shall also discuss plans for measurements in the near future on biologically relevant molecules.

AMPQC PTH 21

Stabilisation of an Atom Laser Using Feedback

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To obtain an atom laser exhibiting temporal coherence and high spectral density requires that it is continuously pumped and comes to a steady state. It has been shown that increasing the nonlinear coupling between atoms in a condensate encourages stability[1], as does choosing a spatially dependent pumping method[2]. We present detailed numerical simulations of an pumped, outcoupled atom laser using Gross-Pitaevski equations, including spatially dependent pumping and a feedback stabilisation scheme.

[1] S. A. Haine, J. J. Hope, N. P. Robbins, C. M. Savage, Phys. Rev. Lett. **88**, 170403 (2002)

[2] S. A. Haine and J. J. Hope, Phys. Rev. A, **68**, 023607 (2003)

AMPQC PTH 22

An Electron Momentum Spectroscopy, Density Functional and Greens Function Theories Study of the Outer Valence Electronic Structure of Bicyclo[2.2.1]heptane-2,5-dione

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We report our preliminary results for an electron momentum spectroscopy (EMS) study of the outer valence electronic region of bicyclo[2.2.1]heptane-2,5-dione. The measured binding energy spectra are presented for the azimuthal angles 0˚, 10˚ and 0˚ + 10˚ and are compared to new He(Iα) photoelectron spectroscopy results. These data are then compared with results from theoretical computations, using Greens Function theories. Derived momentum distributions are compared against those obtained by calculations which employ the plane-wave impulse approximation. These calculations use basis sets obtained from Density Functional Theory calculations at the triple zeta valence polarization level with a collection of different exchange correlation functionals.

AMPQC PTH 23

Theory of Ionization of Atoms by Electron Impact and the Coulomb Three-Body Breakup Problem

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The Peterkop-Rudge formalism for electron-impact ionization of atoms was given almost four decades ago. Despite the knowledge that this formulation suffers from a number of serious formal problems little progress has been made in their resolution. At the congress we report a development of a new formulation of the theory of electron-impact ionization of atoms[1,2] that addresses these issues. In particular, we show that the ionization amplitude has four alternative, but equivalent, surface-integral forms ideally suited for practical calculations. We then extend the formulation to amplitudes of all possible scattering processes taking place in an arbitrary three-body system. A well-defined *post* form of the breakup amplitude valid for arbitrary potentials including the long-range Coulomb interaction is also presented.

[1] A. S. Kadyrov, A. M. Mukhamedzhanov, A. T. Stelbovics and I. Bray, Phys. Rev. Lett. **91**, 253202 (2003).

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AMPQC PTH 24

Isotopic Vacuum-Ultraviolet Laser Spectroscopy of O_2

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Molecular oxygen plays an important role in the photochemistry of the terrestrial atmosphere, and its spectroscopy is complicated by perturbations near the second dissociation limit. Analysis of isotopic spectra can improve the state of knowledge of these perturbations. We present the results of a high-resolution (~0.1 cm^{-1}) photoabsorption study of the $B^3\Sigma_u^- \leftarrow X^3\Sigma_g^-$ transition of $^{18}O_2$, applying a laser-based two-photon-resonant difference-frequency four-wave mixing technique. The results are analyzed to provide new spectroscopic parameters for the *B* state of $^{18}O_2$ which help to investigate the perturbations between the *B* and other electronic states.

AMPQC PTH 25

Measurements of Differential, Near-Threshold Electron Excitation Cross Sections Using Time-of-Flight Techniques

Michael Lange

Australian National University

We have developed a new, pulsed-electron, time-of-flight scattering technique for the measurement of near-threshold, absolute electron excitation cross sections for atoms and molecules. A crossed beam geometry is used, together with a large area position sensitive detector, which enables the simultaneous detection of scattered electrons over a wide angular range in order to greatly enhance the sensitivity and efficiency of the measurements. Design considerations and preliminary measurements will be presented.

AMPQC PTH 26

High Resolution XUV Laser Spectroscopy and Coupled-Channel Studies of Isotopic Molecular Nitrogen

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Molecular nitrogen is a major absorber of extreme ultraviolet (XUV) solar radiation in the Earth's atmosphere, and is associated with $^1\Sigma_u^+$ and $^1\pi_u$ states[1] which undergo strong predissociation via $^3\pi_u$ states. Knowledge of the spectroscopy and dissociation dynamics of N_2 are also vital to analyse data from, e.g., the current encounter of Cassini with Titan.

We have determined new N_2 isotopic lifetimes via ultrahigh resolution XUV + UV laser ionization (resolving power 10^7). The lifetimes depend strongly on the vibrational level and the isotope. A coupled Schrodinger equation model for the linewidths reveals new information about the predissocation processes that determine these lifetimes.

[1] J.P Sprengers, W. Ubachs, K.G.H. Baldwin, B.R. Lewis and W.-U. L. Tchang-Brillet, J. Chem. Phys. **119** (6), 3160–3173 (2003).

AMPQC PTH 27

Signatures of Mott-Insulator Transition of Ultracold Fermions in One-Dimensional Optical Lattices

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Using the Luttinger Liquid theory and local density approximation, we show that the measurement of collective oscillations of the atomic mass density provides a useful diagnosis for the phase boundary between the metallic and the Mott-insulator phases.

AMPQC PTH 28

Quantum-State Resolved Electron Atom/Molecule Collision Experiments

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Electron collisions with atoms and molecules yield information on bound state electron motion and probe the many-body behaviour of many-electron systems. By employing beams of spin-polarized electrons and/or spin polarized laser-excited atoms and coincidence measurement techniques, contributions from electron exchange, relativity and angular momentum transfer can be untangled from the measurement. We will present recent experimental and theoretical results for the electron-xenon system which show the sensitivity of calculation to the treatment of exchange and electron correlation. Planned experiments probing the spin dependence of molecular cross sections will also be discussed.

AMPQC PTH 29

Characterisation of a Ne* MOT

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We will present the results from the characterisation of our metastable neon magneto optical trap with a comparison of different methods used. Fluorescence imaging is currently used to obtain volume and atom number information in the trap. This will be combined with the implementation of a photodiode to measure the fluorescence from the atomic cloud as well as the use of multi-channel plates to determine the density distribution across the trap. The combination of these techniques will give a measure of the excited state fraction across the trap.

AMPQC PTH 30

Uncertainties in CO_2 VUV Extinction Cross Sections: Impact on Venus and Mars Atmospheric Modelling

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A key question in studies of the Venusian and Martian atmospheres is what chemical mechanism(s) stabilize their primary constituent (CO_2) against ultraviolet (UV) radiation. The efficiency of the chemistry required to balance CO_2 photolysis depends on the photolysis rate, so accurate laboratory measurements of the VUV cross sections for CO_2 are required. Based on numerical sensitivity analyses, existing uncertainties in these cross sections, particularly near 200 nm, lead to atmospheric model uncertainties ~100% in the CO_2 photolysis rate near its maximum. The overall impact of these uncertainties and comparisons among the most recent laboratory measurements will be presented.

AMPQC PTH 31

Electron Impact Ionization of H_2 at Intermediate Energies

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Theoretical studies of the Triple Differential Cross Section (TDCS) for the ionization of H_2 by photon impact have predicted an oscillatory structure due to interference effects[1]. More recently, studies have shown that interference effects are also predicted for ionization by electron impact at incident energies of around 4 keV[2]. We will present experimental results for the electron impact ionization of H_2 for a range of intermediate incident electron energies. The scattering angle and ejected electron energies are varied to reveal whether observation of interference effects in the TDCS for the intermediate electron energy range is possible.

[1] M. Walter and J. Briggs, J. Phys. B, **32**, 2487 (1999)

[2] C.R. Stia, O.A. Foj(n, P.F. Weck, J. Hannssen and R.D. Rivarola, J. Phys. B, **36**, L257 (2003)

AMPQC PTH 32

Progress Towards the Creation of Iron Nanodots Using Atom Lithography

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Iron structures with dimensions below the minimum domain size of 5nm may provide us with a new, high-density data storage medium[1]. Several limitations have been observed in existing depositional atom lithography schemes for producing these structures[2].

We will present an alternative scheme to circumvent these problems, whereby a metastable neon beam damages a self-assembled monolayer (SAM) resist on a gold and iron covered silicon substrate through a grid-patterned mask with pitch of 40μm[3]. We have developed an etching process that is then implemented to produce 40μm iron dots on the substrate. This proof-in-principle experiment holds promise for reduction in feature dimensions by way of standing wave atom lithography methods

[1] J. I. Martín, J. Nogués, K. Liu, J. L. Vicent, and I. K. Schuller, *J. Magn. Magn. Mater.* **256** 449 (2003)

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[3] M. Baker, A.J. Palmer, W.R. MacGillivray and R.T. *Sang Nanotechnology* **15** (2004) 1356.

AMPQC PTH 33

The Dissipative Dicke Model: Cavity Fluorescence and the Quantum Phase Transition

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The Dicke Model of an ensemble of two-state atoms interacting with a single quantised cavity mode exhibits a zero-temperature quantum phase transition to a super-radiant state at a critical atom-cavity coupling strength. We propose and analyse a scheme based on multilevel atoms and cavity-mediated Raman transitions to realise an effective Dicke system operating in the phase transition regime. Cavity fluorescence provides a measurable output channel from the system and displays clear signatures of critical behaviour in the transition regime. The scheme should be realisable with existing experimental parameters and also offers possibilities for investigations of quantum chaos and atom-field entanglement.

AMPQC PTH 34

Polarised Electron Inner-Shell and Outer-Shell Excitation and Ionisation of Zinc Atoms

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The excitation with ionisation collision process for the inner-shell $3d^9\ 4s^2\ ^2D_{3/2}$ and outer-shell $3d^{10}\ 4d^2D_{3/2}$ states of zinc atom have been investigated using incident polarised electrons with near-threshold energies. The observed Stokes parameters of the emitted photons (589.4 nm and 602.2 nm) show that the electron exchange is the dominant collision mechanism, even for the inner-shell ionisation. Furthermore, the residual ions are not only aligned but also oriented through electron exchange and fine-structure coupling. The contributions from various partial waves to the ionisation with excitation process are discussed.

AMPQC PTH 36

Reaction-Induced Duality in Transport Coefficients: The Tagashira-Sakai-Sakamoto Effect

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Using simplified kinetic theory it is shown that the reaction-induced duality in transport properties, first noted by Tagashira *et al*[1] for electron-impact ionisation and attachment in gases, and spectacularly evident in the recently observed phenomenon of negative absolute mobility[2], should be observable for a range of physical problems.

[1] H. Tagashira, Y. Sakai and S. Sakamoto, J. Phys. D **10**, 1051 (1977)

[2] R.E. Robson *et al*, J. Chem. Phys. **119**, 11249 (2003)

AMPQC PTH 37

Photoionisation Cross Section of the $((2P^5(3P))^3D_3$ State of Cold Neon

B.J. Claessens[1], J.P. Ashmore[2], H.C.W. Beijerinck[1], W.R. MacGillivray[2], R.T. Sang[2] and E.J.D. Vredenbregt[1]

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We report on a new measurement of the photoionisation cross section from the $((2P^5(3P))^3D_3$ state of neon at photoionisation wavelengths of 351nm and 363nm. The measurement is accomplished utilising a modified version of the technique pioneered by Dinnen et. al.[1]. This technique measures the absolute photoionisation cross sections of optically trapped atoms via observation of the modification of the loss rate of atoms in an optical trap due to interaction with a photoionising laser beam. We will report on the results of this measurement.

[1] T.P. Dinneen, C.D. Wallace, K.Y.N. Tan and P.L. Gould, *Opt. Lett.* **17**, 1706 (1992).

AMPQC PTH 38

Electronic State Excitations in H_2O

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We are measuring absolute differential cross sections for electronic state excitation in water vapour by electron impact. After consideration of the results from previous studies on the spectroscopy of water, it has been decided to focus on excitation of electronic states with energy-loss thresholds less than 12eV. The energy loss spectra are measured with a crossed beam spectrometer of angular resolution 1° and energy resolution about 60meV. The angular range of the results will be 10° to 95° and the impact energy range will be 20 to 50eV. Progress of our measurements will be presented at the meeting.

AMPQC PTH 39

Towards Electron Momentum Spectroscopy Studies of Clusters—A New Apparatus

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Electron momentum spectroscopy (EMS) has been successfully applied to atoms, molecules and solid targets[1]. The targets, applications and apparatus of (e,2e) experiments are constantly being expanded and improved. EMS studies of the intramolecular bonding of large molecules[2] demonstrate the success in applying EMS to increasingly complex targets. Therefore, investigation of the intermolecular bonding in van der Waals molecules and small clusters should also be feasible.

A new apparatus under construction at Flinders University has been designed to study van der Waals molecules and clusters with EMS. This triple coincidence experiment captures the residual ion as well as the two outgoing electrons from the electron impact ionisation event, ie, it is an (e,2e+ion) experiment. Here we present the details and performance of this new spectrometer along with some preliminary results.

[1] E Weigold and IE McCarthy, *Electron Momentum Spectroscopy*, Kluwer Academic/Plenum Press, New York (1999)

[2] H Mackenzie-Ross, MJ Brunger, F Wang, W Adcock, N Trout, IE McCarthy and DA Winkler, *J. Electron. Spectroc. and Relat. Phenom.*, **123**, (2002), 389.

AMPQC PTH 40

Ultracold Atomic Collisions in Tight Anisotropic Traps with Application to Spin-Polarized Metastable Helium

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An understanding of ultracold collisions between neutral atoms is crucial to the design and operation of atom traps, and to the development of novel quantum processes using trapped atoms. Tight trapping environments, in which the external trapping field cannot be treated as uniform during collisions, are expected to significantly modify these collisions.

We recently developed several techniques to study metastable helium under tight isotropic harmonic confinement and report here an extension of these techniques to anisotropic traps. Results obtained by using a spherical harmonic expansion will be compared with those in which the asymmetry is treated as a second order perturbation.

AMPQC FRE11
Friday 0820–0840 hrs

Calculation of Stokes Parameters for e-H(2P) Excitation

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Recent measurements[1] of the reduced Stokes parameters and excitation coherence parameter for the 1S-2P excitation of hydrogen using 54.4eV incident electrons are in disagreement with accepted convergent close-coupling (CCC) calculations[2]. The authors[1] suggest that spin exchange plays a more significant role than current theoretical methods predict. We have accurately calculated these parameters by solving the full Schrödinger equation for this collision system using the method of propagating exterior complex scaling[3] and obtained good agreement with the CCC calculations. The discrepancy between this experiment and theoretical calculations cannot be accounted for, and suggest that independent measurements are required.

[1] M.L. Gradziel and R.W. O'Neill, J. Phys. B: At. Mol. Opt. Phys., 37, 1893 (2004)
[2] I. Bray and A.T. Stelbovics, Phys. Rev. A, 46, 6995 (1992)
[3] P.L. Bartlett, A.T. Stelbovics and I. Bray, J. Phys. B: At. Mol. Opt. Phys., 37, L69 (2004)

AMPQC FRE12
Friday 0840–0900 hrs

Lippmann-Schwinger Description of Multiphoton Ionization

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We develop a formalism and a computational procedure to treat the process of multiphoton ionization (MPI) of atomic targets in strong laser fields. We treat the MPI process nonperturbatively as a decay phenomenon by solving a coupled set of the integral Lippmann-Schwinger equations. As the basic building blocks of the theory we use a complete set of field-free atomic states, discrete and continuous. This approach enables us to provide both the total and differential cross-sections of MPI of atoms with one or two electrons. As a test of the approach we apply it to study the multiphoton ionization of atomic hydrogen.

AMPQC FRE13
Friday 0900–0920 hrs

Positron Studies in Atomic and Molecular Physics and Materials Science

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A new experimental positron facility is under construction for use in experimental studies. Experiments are planned in both atomic and molecular physics and materials science. The Australian Positron Beamline Facility uses buffer gas trap technology developed by Prof. Cliff Surko at UCSD[1] to make a magnetised positron beam of high resolution (<25 meV). This beam can then be used to study positron scattering from gaseous targets and annihilation of the positrons within materials will give information about material structure and properties. The design of the experiment and an overview of the analysis techniques to be used will be presented.

[1] Murphy and Surko, Phys. Rev. A 46, 5696 (1992)

AMPQC FRE14
Friday 0920–1000 hrs

The Exotic World of Low-energy Positron-atom Interactions

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The interactions of low-energy positrons with atoms provides a host of problems for both experimentalists and theorists alike. For example, even one of the most fundamental questions in positron physics, whether a positron can form an electronically stable bound state with a neutral atom, was only in 1997 theoretically resolved as a 'yes'[1].

I will discuss the application of the configuration-interaction (CI) method to the study of various positronic atoms and ions, demonstrating the stability and structure of the bound states of PsH, e^+Li, e^+Be, e^+Mg, e^+Ca, e^+Cu, CuPs, e^+Zn, e^+Sr and e^+Cd. The CI method has also been used in conjunction with the Kohn variational method to examine low-energy positron scattering and annihilation from H, He^+ and Cu. The presence of localised electron-positron pairing means that these CI calculations are extremely demanding. I will also mention the prospects for using positron scattering from metal vapours as a signature to detect their bound states.

[1] "Positron binding to atoms and ions", J.Mitroy, M.W.J.Bromley and G.G.Ryzhikh J.Phys.B 35 (2002) R81.

AMPQC FRE21
Friday 1040–1120 hrs

Trapped Clusters and Nanoparticles

Evan Bieske

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Advances in the spectroscopic interrogation of charged molecular clusters and nanoparticles will be discussed. A common aspect of the experiments is the use of electrodynamic ion traps and guides to confine the target species so that they can be probed in vacuum, free from environmental influences. The first part of the talk will focus on studies of simple anion complexes and clusters where spectra are obtained by exposing mass-selected ion complexes to tuneable infrared light in an octopole ion guide, with photo-absorption inferred through production of charged photofragments. The focus will be on the Cl–-H2, Br–-H2, and I–-H2 dimers where spectra in the 2.5 μm H-H stretch region provide information on the length and force constant of the intermolecular bonds, and on the rate at which the vibrational energy, originally localised in the H-H stretch mode, is transferred into the weak intermolecular bond. The second part of the talk will describe spectroscopic studies of single charged fluorescent nanoparticles confined in a quadrupole trap. The particle's mass to charge ratio is measured by determining its oscillation frequency within the trap, while its radius and refractive is found by observing morphological dependent resonances in the fluorescence.

AMPQC FRE23
Friday 1120–1140 hrs

Rovibrational Energy Transfer in the $4\nu_{CH}$ Manifold of Acetylene, Viewed by IR-UV Double Resonance Spectroscopy

M.A. Payne[1], A.P. Milce[1], M.J. Frost[1,2] and B.J. Orr[1]

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Rovibrational states of the linear polyatomic acetylene molecule (C_2H_2) are not as simple as might be supposed. For example, the $4\nu_{CH}$ manifold at ~12 700-cm^{-1} in the electronic ground-state of C_2H_2 is congested and affected by anharmonic, l-resonance and Coriolis couplings. This complicates intramolecular dynamics and yields unusual forms collision-induced state-to-state molecular energy transfer. Rotational *J*-states of the $(\nu_1 + 3\nu_3)$ or $(1\ 0\ 3\ 0\ 0)^0$ vibrational combination level are monitored by time-resolved infrared-ultraviolet double resonance (IR-UV DR) spectroscopy, addressing the influence of intramolecular perturbations on *J*-resolved collision-induced energy transfer with both even and odd ΔJ[1-3].

[1] M.A. Payne, A.P. Milce, M.J. Frost and B.J. Orr, Chem. Phys. Lett., 324, 48 (2000)

[2] M.A. Payne, A.P. Milce, M.J. Frost and B.J. Orr, J. Phys. Chem. A, 107, 10759 (2004)

[3] M.A. Payne, A.P. Milce, M.J. Frost and B.J. Orr, submitted to J. Phys. Chem. A (August 2004)

AMPQC FRE24
Friday 1140–1200 hrs

High-resolution Photoelectron Spectroscopy via Velocity-map Imaging of Anion Radicals: A Window into Chemical Reaction Dynamics

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Photoelectron spectroscopy, in all its forms, is a powerful tool for gleaning structural and dynamical information from atomic and molecular targets and chemical processes. However, many targets and processes have been out of reach due to the inefficiencies, or poor resolution, of the techniques used. To reliably study difficult systems high resolution, efficiency, signal-to-noise and robustness is essential. We have recently developed a co-axial velocity-map imaging spectrometer, which address all of these issues. The performance and operation of this spectrometer will be outlined, together with recent photoelectron spectra from anion radicals.

AMPQC FRE25
Friday 1200–1220 hrs

Electron Scattering from Cold Metastable Helium

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Electron scattering experiments involving atoms or molecules in excited states are challenging as targets of this type are difficult to prepare in appreciable quantities. However, with the advent of laser cooling and trapping techniques, the possibility to do electron collision studies on such target species now exists. In our laboratory, two related, yet distinct, experiments for electron scattering from metastable helium are being undertaken. The first utilizes a magneto-optical trap (MOT) of 2^3S Helium atoms as the target for a grand total cross-section measurement. Results of scattering from the 2^3S and 2^3P levels of Helium will be presented in the energy range from 5-75eV. The second set of experiments is designed to determine the differential electron scattering cross-section by using the bright beam line as the source of target atoms1 and employing a technique referred to as Metastable Atom Recoil Spectroscopy (MARS). Progress towards the collection of this data will be discussed.

[1] M.D. Hoogerland, D. Milic, W. Lu, H.A. Bachor, K.G.H. Baldwin and S.J. Buckman, Aust. J. Phys., **49**, 567 (1996).

Optics, Photonics, Laser Physics (AOS)

AOS MOA11
Monday 1040–1120 hrs

Nonlinear Optical Spectroscopy

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With the advent of tunable short-pulsed high-irradiance optical-parametric devices and the ability to create short white-light continua (WLC), nonlinear optical (NLO) spectroscopy is greatly facilitated. We have developed a variety of techniques for measuring two-photon absorption (2PA) and excited-state absorption spectra of semiconductors, dielectrics and organic materials. Using a WLC pump-probe method gives the nondegenerate NLO spectrum which for 2PA gives the dispersion of the nonlinear refraction from Kramers-Kronig relations. This is not possible with techniques such as Z-scan that give degenerate nonlinearities. These complementary techniques on various time scales allow a fairly complete characterization and understanding of the nonlinear processes occurring in these materials.

AOS MOA13
Monday 1120–1140 hrs

Cavity Ringdown Spectroscopy with Widely Tunable Swept-frequency Lasers

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A novel approach to cavity ringdown (CRD) spectroscopy based on swept-frequency (SF) lasers enables rapid measurement of CRD absorption spectra. Our new SF CRD spectrometer incorporates a miniature widely-tunable continuous-wave SF laser[1] and requires less than 1 s to record wide-ranging absorption spectra with high sensitivity in a single rapid sweep of the laser frequency. The spectrometer has a single-ended transmitter-receiver configuration based on retro-reflected optical-heterodyne detection[2], and yields a simple, compact, versatile instrument for efficient sensing of gases. The performance of the spectrometer is demonstrated by measuring weak absorption spectra of carbon dioxide gas at 1.5–1.6 μm.

[1] J.D. Berger and D. Anthon, Optics and Photonics News, 14 (3), 42, 62 (2003)

[2] Y. He and B.J. Orr, Chem. Phys. Lett., 335, 215 (2001); Appl. Phys. B, 75, 267 (2002)

AOS MOA14
Monday 1140–1200 hrs

Micro-Characterisation of Erbium Doped Optical Fibres

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Rare-earth-doped optical fibres continue to play a central role in optical telecommunications and are finding increasing application as optical fibre sensors and high-power lasers. Optimising the performance of devices based on these fibres requires high-spatial resolution information about the distribution of active ions within the fibre. Here we present experimental results demonstrating the application of two microscopic imaging techniques, Raman Fluorescence Intensity Confocal Optical Microscopy and Nano-Secondary Ion Mass Spectroscopy, to the determination of the relative erbium ion distribution in fibres. The extension of these techniques to the study of other rare-earth doped fibres will also be discussed.

AOS MOA15
Monday 1200–1220 hrs

A Microwave Frequency Standard in the 10^{-15} Accuracy Range Using $^{171}Yb^{+}$ Ions

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Microwave frequency standards of the highest stability and accuracy have been under development at CSIRO's National Measurement Laboratory for many years, based on the ground-state hyperfine interval of trapped $^{171}Yb^{+}$ ions (the analogous interval for ^{133}Cs defines the SI second). Laser cooling reduces or eliminates systematic shifts. Recent work includes designing a non-magnetic UHV chamber in novel materials, and loading the trap by photoionization. We are working towards a frequency accuracy of $4x10^{-15}$ or better, comparable to the best Cs fountain standards. Though our interest is metrology, the standard also opens up various possibilities for tests of fundamental physics.

AOS MOA21
Monday 1400–1440 hrs

Near-field Imaging and Manipulation of Photonic Crystals

Ben Buchler

Photonic crystals have applications ranging from miniaturised photonic devices to cavity quantum electrodynamics. The aim of our work is to use scanning

probe techniques to characterise and manipulate the behaviour of photonic crystals and explore the possibility of controlled coupling between single emitters and photonic crystals. We present optical near-field images of 2D microcavities and comparison to numerical models. Further numerical modelling also shows how scanning probes can be used to modify a high-Q cavity. Recent experiments demonstrate the use of scanning probes to affect the spontaneous emission of single emitters. Application of these techniques to photonic crystals will be discussed.

AOS MOA23
Monday 1440–1500 hrs

Output Couplers for 3D Photonic Crystal Waveguides

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One crucial practical problem facing 3D photonic crystal applications is finding a way to couple electromagnetic energy efficiently into and out of a 3D photonic crystal waveguide. We investigate two approaches for solving this problem: the photonic crystal horn antenna[1],[2]; and the conventional waveguide to 3D photonic crystal waveguide mode coupler[3]. We demonstrate both approaches theoretically using numerical simulations, and experimentally using prototypes operating at microwave frequencies. Both methods succeed in providing highly efficient coupling into and out of the 3D photonic crystal waveguide over a wide bandwidth, thereby demonstrating two solutions to the output coupling problem.

[1] A.R. Weily, K.P. Esselle, and B.C. Sanders, Phys. Rev. E, 68, 16609 (2003)

[2] A.R. Weily, K.P. Esselle, and B.C. Sanders, Phys. Rev. E, 70, 37602 (2004)

[3] A.R. Weily, K.P. Esselle, B.C. Sanders, and T.S. Bird (unpublished)

AOS MOA24
Monday 1500–1520 hrs

Fabrication of Advanced Air-Structured Silica Optical Fibres

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Structuring of optical fibres using air-holes offers an alternative method of tailoring the properties of optical fibres. These fibres include photonic crystal fibres, Fresnel fibres, and air-clad fibres for high NA fibres and high power fibre lasers. The control of the geometry is critical to fibre performance. Drawn into lengths over hundreds of meters, retaining such micro- and nano-structures is challenging. This work describes techniques for producing air-structured fibres and parameters that can be used to control fibre geometry. Examples include fibres with <2dB/km losses at 1mm, hi-birefringence photonic crystal fibres and high NA air-clad fibres with bridge thickness <350nm.

AOS MOA25
Monday 1520–1540 hrs

Characterisation of Optical Wavefields Propagated through Scattering Media

C.K. Aruldoss, N. M. Dragomir, R.E. Scholten, K.A. Nugent and A. Roberts

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Knowledge of changes in a wavefield as it propagates through a turbid medium is critical to a complete understanding of optical imaging in biological tissue. As an optical wavefield propagates through such a medium, its Mutual Optical Intensity (MOI), which fully describes a quasi-monochromatic spatially partially coherent field, is changed. The aim of this work is to determine the MOI of optical fields that have propagated through a variety of controlled scattering media applying phase-space tomography. Experimental results will be presented and discussed.

AOS MOA31
Monday 1620–1640 hrs

Pump-probe Differencing Technique for Cavity-enhanced, Noise-cancelling Saturation Laser Spectroscopy

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We present an experimental technique enabling mechanical-noise free, cavity-enhanced frequency measurements of an atomic transition and its hyperfine structure. We employ the 532nm frequency doubled output from a Nd:YAG laser and an iodine vapour cell. The cell is placed in a traveling-wave Fabry-Perot interferometer (FPI) with counter-propagating pump and probe beams. The FPI is locked using the Pound-Drever-Hall (PDH)[1] technique. Mechanical noise is rejected by differencing pump and probe signals. In addition, this differenced error signal gives a sensitive measure of differential non-linearity within the FPI.

[1] R. W. P. Drever, J. L. Hall, F. V. Kowalski, J. Hough, G. M. Ford, A. J. Munley and H. Ward, Laser phase and frequency stabilization using an optical resonator, Appl. Phys. B, 31, 97, (1983).

AOS MOA32
Monday 1640–1700 hrs

Ultra-slow Light in Fibre Gratings

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We present the design and characterisation of fibre gratings for ultra-slow light application using Bragg grating solitons[1]. We simulate pulse propagation through a uniform grating and a Moiré grating[2] fabricated for this application. Effects of grating imperfections on slow light pulse propagation are evaluated.

[1] B. J. Eggleton, C. M. de Sterke and R. E. Slusher, J. Opt. Soc. Am. B, 16, 4 (1999).

[2] J. B Khurgin, Phys. Rev. A, 62, 013821 (2002).

AOS MOA33
Monday 1700–1720 hrs

Holographic Mode Converters: Laser Beams Are not Plane Waves

Michael Harvey[1], Nathan Langford[1,2], Rohan Dalton[1,2], Agatha Branczyk[1], Paul Cochrane[1] and Andrew G. White[1,2]

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Holographic mode converters are widely used to transform laser beams into more useful beam profiles[1,2]. In many instances these devices are realised as thin computer-generated holograms. Typically, these are calculated assuming that one (or more) of the interfering fields are plane wave. And, typically the resulting output does not map at all well onto the desired mode. We present theoretical and experimental studies of the discrepancies between these plane-wave holograms and the modes they are intended to produce. We demonstrate that these discrepancies are reduced substantially by Gaussian (as opposed to plane wave) fields.

[1] N K Langford, et al, Physical Review Letters 93, 053601 (2004)

[2] N R Heckenberg, et al, Optics Letters 17, 221 (1992)

AOS MOA34
Monday 1720–1740 hrs

Vortex Solitons in Nonlocal Kerr-like Media

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Spatial optical solitons are optical beams that propagate in nonlinear materials without changing their shape. The so-called bright vortex soliton is a localized optical beam with a singular phase structure existing in bulk crystals, which has attracted a considerable attention recently. It is known that this particular type of spatial soliton is unstable in spatially local nonlinear materials and will break up into fragments during propagation, while conserving angular momentum. Here we discuss the propagation of cortex beams and solitons in nonlocal focussing materials. We show that spatial nonlocality stabilizes the propagation of vortex beams and allows for the formation of stable solitons.

AOS MOA35
Monday 1740–1800 hrs

Nanofabrication Using Standing Wave Optical Masks for Metastable Atom Lithography

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We present here details of optical masking techniques applied to a Ne* metastable atomic beam source for atom lithography[1,2]. In this scheme, metastable noble gas atoms, focused in an optical standing wave, are used to modify the chemical properties of various resist covered substrates to form nanoscale structures. In previous work, physical masks were used to create patterns in thiolate SAM and oil contaminated resist surfaces[3,4].

Recent improvements to our system include an optical collimation section to improve beam brightness and reduce transverse velocities. We have undertaken Monte-Carlo simulations to model the dipole force on Ne* atoms in an optical standing wave[5]. Results will be presented showing our initial attempts with Ne* using an optical standing wave to create periodic structures.

POSTERS

AOS PMO 20

Modulational Instability and Generation of Pulses in Cubic-Quintic Complex Ginzburg-Landau Models

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We investigate modulational instability (MI) for several discrete cubic-quintic complex Ginzburg-Landau (CQCGL) models and compare with MI for the continuous CQCGL equation. The MI of a discrete cubic-quintic complex Ginzburg-Landau model, which was recently proposed by us, depends on the wave number of a plane wave. We also study, analytically and numerically, bright solitons of the discrete CQCGL model which may be generated by MI.

AOS PMO 21

'Fast-light' Atomic Media with Giant Kerr Nonlinearity

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Light-induced ground-state atomic coherences significantly enhance dispersion dn/d_ and nonlinear susceptibility $\chi^{(3)}$ of an atomic gas. Such 'coherent' control of the optical properties of atomic media makes them potentially suitable for storage of quantum information through 'storage of light'[1].

We discuss a link between nonlinearity at the few-photon intensity level and light propagation with negative group velocities in a 'fast-light' atomic medium, which is characterized by a steep negative dispersion. Also an experimental study of the noise properties of new optical fields generated by nonlinear wave mixing assisted by greatly enhanced Kerr nonlinearity is presented.

[1] C.H. van der Wal et al., Science **301** (5630), 196 (2003); A. Kuzmich et al., Nature **423**, 731 (2003).

AOS PMO 22

Optical Rephasing Using The Stark Effect

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There is great interest in developing a quantum memory capable of storing non-classical light fields. In this paper it has been demonstrated that it is possible to rephase optical coherence through switching the polarity of an applied DC electric field. This experiment uses a narrow inhomogeneous optical transition in a solid-state host doped with rare-earth ions. The applied DC field causes a broadening of the narrow inhomogeneous transition. A weak pulse is input to the crystal and the sample is allowed to evolve before the electric field is switched in polarity. We have seen we are able to rephase optical coherence without the use of intense driving pusles.

AOS PMO 23

Progress Towards Bose-Einstein Condensation of He*

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We report on our progress towards Bose condensing metastable helium (He*). To date, we have demonstrated a magneto-optic trap (MOT) of He*, which contains up to 3 x 10^9 atoms. Due to the high background pressure in our main MOT vacuum chamber, the atoms are transported out of the main chamber into a second high vacuum chamber, at a rate ~ 1x10^9/s using a combination of light pressure and magnetic guiding. These atoms will be captured in a novel magnetic trap and subsequent evaporation should lead to Bose-Einstein condensation of He*.

AOS PMO 24

Quantum Control of a Single Photonic Qubit

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Quantum control involves repeated measurement of a quantum system, altering the dynamics of the system based on the measurement results. The crucial distinction between classical and quantum control is the back-action noise due to measurement. In quantum feedback control it is possible to know too much. We present the design of a prototype single-photon optics experiment demonstrating quantum control. The experiment consists of a sequence of weak measurements[1] of the photon's polarisation followed by correction. The performance of the quantum control system in protecting the quantum state from noise is characterised theoretically, and we investigate the optimal measurement sensitivity.

[1] G J Pryde, J L O'Brien, A G White, S D Bartlett and T C Ralph, Phys. Rev. Lett. **92**, 190402 (2004)

AOS PMO 25

Matter Wave Propagation through Microstructured Waveguides*

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Significant experimental progress in recent years has been seen in the field of “atom chips”, ie. integrated atom optics, where trapping, propagation and manipulation of ultracold atoms have all been done above a single microchip surface. Our theoretical efforts have been focussed on exploring the nature of wave propagation through such microstructured waveguides. We present here a smorgasbord of fundamental physics, ranging from wave excitations and quantum/classical correspondence, through to interference-based vortex production and dispersion management.

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AOS PMO 26

Customised Three-flat Calibration Method for a Large-aperture Fizeau Interferometer with Vertical Optical Axis

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We describe a modified version of the traditional three-flat calibration method, which we have used to calibrate the 320 mm diameter reference flat of the Large Aperture Digital Interferometer (LADI) at the CSIRO’s Australian Centre for Precision Optics. The salient feature of the new method is a combination of rotational averaging and utilisation of symmetry properties to infer absolute surface relief data. We present the data acquisition and processing schemes and show the results of the first experimental calibration run. The results validate the method, establish an accuracy better than 1 nanometre rms and highlight additional practical issues.

AOS PMO 27

Efficient Method for Modelling out of Plane Transmission Loss in Photonic Crystal Slab Waveguides

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Photonic crystal (PC) slab waveguides confine light using a photonic bandgap in one lateral direction, and effective index guidance in the other. These waveguides have applications in guiding light, dispersion compensation, and optical delay lines in integrated photonic devices. A critical issue associated with these waveguides is the loss due to out-of-plane leakage. We have developed a method that can accurately and efficiently model such loss, and which can be extended to model other 2D PC based devices. The method is based on modal techniques developed to model diffraction gratings[1].

[1] L. Li, J. Mod. Optics, **40**, 553 (1993)

AOS PMO 28

Entanglement Cycles and Conditional Quantum Evolution

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Entanglement cycles are exhibited by systems that oscillate between a number of pure entangled states via the stochastic emission of photons. We demonstrate the existence of such behavior within a cascaded cavity system using quantum trajectory methods, and show that under appropriate conditions the system oscillates indefinitely between two perfectly entangled Bell states. Such systems may show vastly different behaviour along a single trajectory, although they possess a uniquely define steady state. The phenomenon has various possible applications; for example, in the generation of entanglement and quantum measurement.

AOS PMO 29

Optical Fibre and Its Role in High-Power Lasers and Amplifiers

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First invented in the 1960’s, the fibre laser is almost as old as the laser itself[1][2]. Moreover it has a number of distinct advantages over alternative solid state laser technologies including size, reliability, wavelength selectivity, heat dissipation, wall-plug efficiency and operational cost. Nevertheless, immature optical design of the fibre had meant that fibre lasers were sidelined from real world applications. Very recently a series of advances in both fibre and pump-diode design have facilitated a revival in interest, with diffraction-limited, single-polarisation, kW-level output powers from a single fibre laser[3]. In this paper we discuss the technological advancements in fibre design that underpin this revolution.

[1] E.Snitzer, “Neodymium glass laser”, Proc. 3rd International Conference of Quantum Electronics, Paris, 999 (1963)

[2] C.J.Koester and E.Snitzer, “Amplification in a fiber laser”, App. Opt., **3**, 1182 (1964)

[3] C.-H.Liu, A.Galvanauskas, B.Ehlers, F.Doerfel, S.Heinemann, A.Carter, K.Tankala, J.Farroni, “810-W single transverse mode Yb-doped fiber laser”, Advanced Solid-State Photonics conference, **PD2** (2004)

AOS PMO 30

Latest Results for Silver Atomic Form Factors in the Relativistic Regime—a New Frontier

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Complex X-Ray form factors are used in crystallography, material science, medical diagnosis, refractive index studies and XAFS. Determinations of the complex component for silver typically differ by over 10% or 10 standard deviations. We apply the X-Ray Extended-Range Technique [Phys. Lett. A286 (2001) 338, PRA 69 (2004) 022717–1, PRL 90 (2003) 257401–1] for accurate measurements of the mass attenuation coefficient and the imaginary component of the atomic form factor. The accuracy of 0.3% challenges available theoretical calculations and suggests that new methods of computation are required to approach the accuracy of the experimental data.

AOS PMO 31

New Experimental Approach to QED Tests in Medium-Z Systems

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We have installed, built, aligned and operated a new X-ray spectrometer to our new specifications on the NIST Electron Beam Ion Trap. This has major advances over previous spectrometry, especially regarding the stability of the system in response to mechanical and thermal fluctuations, and the capacity for accurate absolute calibrations over the full range of its dispersion function. Other developments include a novel multiple detector investigation of systematics. Early signs of significant advances with respect to the analysis of systematic and statistical error budgets will be presented. Opportunities for further and future developments will be discussed.

AOS PMO 32

Two-photon Induced Photo-enhancement of Densely Packed CdSe/ZnSe/ZnS Nanocrystal Solids and Its Application to Multi-layer Optical Data Storage

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We report on a two-photon absorption induced photo-enhancement effect on a densely packed CdSe/ZnSe/ZnS core-shell semiconductor nanocrystal solid film. The enhancement is found to be irreversible without a noticeable blue-shift in emission spectra, hence we attribute the enhancement to the photo-annealing of interface defects rather than to the photo-oxidation or surface passivation by other molecules. The two-photon enhancement allows us to record the enhanced spots three-dimensionally, hence demonstrating the feasibility of its application to multi-layered optical data storage based on NC solids.

AOS PMO 33

Resonant Photothermal Dynamics in Fiber Fabry Perot Cavities

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Resonant photothermal effects in fiber Fabry-Perot cavities are caused by the conversion of circulating optical energy into heat due to absorption. This results in thermal change in resonator optical path length, the roundtrip phase, and hence the resonance condition. These effects impact on the performance of DFB lasers, characterisation of passive fiber resonators, as well as frequency stability when these resonators are used as optical filters. We describe a simplified dynamic numerical model for photothermal effects in passive fiber Bragg grating resonators, and present results of their experimental observation.

AOS PMO 34

Energy Transfer up-conversion in Tm-doped Silica Fibres

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Thulium-doped glasses have attracted considerable interest in recent years, due to their potential use as optical amplifiers and mid infrared lasers sources. As a result, a significant amount of research has been focused on the spectroscopy of the Tm^{3+} ion. In this work, we report the observation of up-conversion luminescence from the $^3H_4$ level of thulium-doped silica fibres when excited at 1586 nm. The up-conversion luminescence was observed with modest pump powers, in fibres with relatively low thulium concentrations. The decay characteristics of the up-conversion luminescence verify that the energy transfer up-conversion process ($^3F_4$, $^3F_4$ ‡ $^3H_4$, $^3H_6$) participates in populating the $^3F_4$ energy level.

AOS PMO 35

Chirped Fibre Bragg Grating Distributed Temperature Sensor

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A Chirped Fibre Bragg Grating (CFBG) distributed temperature sensor based on the analysis of the reflected power spectrum to extract nonuniform temperature distribution along the grating will be presented. The technique uses a combination of a discrete Fourier Transform (FFT) and a CFBG sensor. The measured reflectivity of the CFBG due to localised temperature change was simulated using the FFT grating design model representative of an applied temperature disturbance. Accuracies of a three-parameter function-fitting algorithm, operating on position, width and amplitude of temperature change, to a temperature disturbance to the measured spectra, will be discussed.

AOS PMO 36

Annealing Dynamics of Erbium Doped Fiber Bragg Gratings

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Experimental annealing curves of fiber Bragg gratings (FBG) written in H_2 loaded Er doped fiber can deviate from those expected by conventional power law fitting or log-time aging curves that model thermal removal of photorefractive contributions from a density of states function with an initially Gaussian population vs. activation energy. Annealing dynamics of Er doped Bragg gratings with a non-Gaussian and mobile defect population are examined. The process of creating erbium doped FBGs for high temperature sensors composed only of states with a high activation energy is discussed.

AOS PMO 37

States for Phase Estimation

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For a single shot measurement of the phase φ of a quantum state with no prior information the spin squeezing parameter, ξ^2 [1,2], is not a good figure of merit. This is due to the fact that the uncertainty of a phase estimate ϕ is what is relevant in a single shot measurement—not the signal to noise ratio. In light of this understanding a new phase squeezing parameter is introduced, $\zeta^2 = 2N(1-S)$, where N is the number of spins in the ensemble and the sharpness of the phase distribution is labelled as $S = \langle \exp[i\phi-\varphi] \rangle$ An experimental realisation of maximally phase-squeezed states is opportune in light of recent mode-mashing experiments[3]. It is also noted that states generated by the two axis counter-twisting Hamiltonian[1] are practically optimally phase-squeezed and easier to generate than their maximally spin-squeezed counter states.

[1] M. Kitagawa and M. Ueda, Phys. Rev. A, **47**, 5138 (1993)

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[3] W. M. Mitchell, J. S. Lundeen and A. M. Steinberg, Nature, **409**, 161 (2004)

AOS PMO 38

Solving the Hubbard Model with Phase-space Methods

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The Hubbard model is the simplest model of interacting Fermions on a lattice. Of importance in solid-state physics, it also provides an accurate model of ultracold fermionic atoms in an optical lattice. While solutions of the Hubbard model are known in 1D, first-principle results in higher dimensions have relied on Quantum Monte Carlo methods, which suffer from intractable 'Fermi sign' problems.
We introduce an exact method for simulating many-body quantum systems based a Gaussian phase-space representation for Fermions[1]. The method can perform dynamical or thermal equilibrium calculations. We use it to solve higher-dimensional Hubbard models without sign problems.

[1] J. F. Corney and P. D. Drummond, quant-ph/0404052.

AOS PMO 39

Multi-Wavelength Sources for Colour High Speed Imaging Applications

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A novel 3-d high speed imaging technique we have developed requires a multi-wavelength source spanning the visible spectrum. Here we describe such source based on cascaded stimulated Raman scattering in optical fibres. An essential source requirement is an even energy distribution amongst at least seven Stokes orders (+ pump). Modelling results show that while CW conversion in single mode fibres predicts sequential generation of each Stokes order with complete depletion of the pump and each previous order, a Gaussian pulse produces multiple orders. Multiple order output spectra are obtained with mJ pulse energies suitable for the high speed imaging application.

AOS PMO 40

Interaction of Matter-wave Gap Solitons in Optical Lattices

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We study mobility and interaction of matter-wave gap solitons in a Bose-Einstein condensate (BEC) confined by a periodic potential of an optical lattice. Such localized wavepackets can exist only in the gaps of the matter-wave band-gap spectrum, and their interaction properties are shown to serve as a measure of discreteness imposed onto a BEC by the lattice potential. We show that inelastic collisions of two weakly localized near-band-edge gap solitons can generate strongly localized in-gap solitons through soliton fusion[1]. Furthermore, for a broad range of incident velocities, inelastic collisions with an immobile soliton can lead to a total energy transfer that can be implemented in a soliton-based switching scheme and applied in atomic interferometry. In addition, we investigate a novel method for generating trains of gap solitons, and show that the BEC gap solitons can emerge as a result of nonlinear evolution of a periodic matter wave triggered by its modulational instability.

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AOS PMO 41

Two-Mode Theory of BEC Interferometry

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A theory of BEC interferometry for modest boson numbers in an unsymmetrical double-well trap has been developed using the two-mode approximation, extending previous work[1]. Possible fragmentations into separate BEC states in each well during the splitting/recombination process are allowed for. Self-consistent sets of equations for the amplitudes of fragmented states and for the two single boson orbitals are obtained, the latter being coupled Gross-Pitaevski equations. Another version of the two-mode theory extending other work[2] has also been developed, treating the BEC as a giant spin system. Numerical studies are aimed at finding conditions where BEC interferometry is possible.

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AOS PMO 42

Quantum Computing with Optical Clusters

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The theoretical potential of quantum computers and the technical challenges in their construction have seen extensive efforts to build working prototypes of the basic technology. One promising proposal involves the encoding of quantum data in the spatial modes of a single photon[1], and recently a key component of such a computer has been demonstrated[2].

Any quantum computer, however, will inevitably be subject to noise which will cause its basic components to occasionally malfunction. In this presentation we will discuss recent work[3],[4] on techniques for successfully operating an optical quantum computer in the presence of noise.

[1] E. Knill, R. Laflamme, G. J. Milburn, Nature, **209**, 46–52 (2001)

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AOS PMO 43

Optimising the Length of Doped Polymer Light Mixers

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Transparent Refractive Index Matched Micro-particles (TRIMM) in polymer rods are highly efficient light mixers[1]. This paper addresses the problem of readily estimating the optimum length for the mixing rods, for a given TRIMM-to-matrix refractive index ratio and concentration. Light mixing can thus be maximised and loss minimised, without computer ray tracing simulations. The probability density function and mean angle for a single TRIMM sphere ray deviation are derived, and are used in modelling an expression for a critical mixer length for rays of normal incidence. Similar models could be very useful design tools with further development.

[1] C. Deller, G. Smith, J. Franklin, Opt. Express, **12** (15), 3327 (2004)

AOS PMO 44

Two-dimensional Optically Indused Anisotropic Nonlinear Photonic Lattices

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Periodic modulation of the refractive index modifies the linear spectrum and wave diffraction and consequently strongly affects the nonlinear propagation and localization of light[1]. Self-trapped periodic waves are used to create nonlinear photonic lattices by optical induction and provide a simple realization of the concept of flexible nonlinear photonic crystals[2]. We describe theoretically and generate experimentally two-dimensional flexible photonic lattices in a nonlinear photorefractive medium. We demonstrate that the light-induced periodically modulated nonlinear refractive index is highly anisotropic and nonlocal, and it depends on the lattice orientation relative to the crystal axis. We discuss stability of these induced photonic structures and their guiding properties.

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AOS PMO 45

Ultracompact Microfluidic Interferometer

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We present the compact, single beam, microfluidic Mach-Zender interferometer. Phase delay is achieved through a beam divided across a fluid meniscus, the compactness arising from the high refractive index contrast between the fluid and the surrounding air (Dn = 0.33). The optical effect of meniscus curvature is explored using the three dimensional Beam Propagation Method. We engineer a flat meniscus using mono-layer surface chemistry and find that the experimental spectrum corresponds well with simulation. The device has a resonance at 1.3 mm whose 25 dB extinction ratio can be tuned by shifting the meniscus position, using a pressure gradient.

AOS PMO 46

Energy as an Entanglement Witness in Quantum Many-Body Systems

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In quantum many-body systems, such as spin lattices, entanglement plays an important but poorly-understood role. We study systems where all low-energy states are entangled, and utilise a correspondence between the Hamiltonian and the concept of an entanglement witness from the theory of mixed-state entanglement[1]. For bipartite spin lattices we prove that the difference in energy between the lowest-energy classical configuration and the true ground state necessarily decreases as the coordination number increased. On frustrated lattices we show that the low-energy states can be entangled, even though this entanglement cannot be detected by measuring any two neighbouring spins.

[1] Mark R. Dowling, Andrew C. Doherty and Stephen D. Bartlett, arXiv: quant-ph/0408086

AOS PMO 47

Quantitative Phase Imaging-Based Method for Investigation of Arc-Fusion Spliced Single-Mode Optical Fibres

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Conventional electric-arc fusion splicing of optical fibres is a common method for permanently joining optical fibres. A 'good' fibre splice should exhibit both low insertion loss and low back reflection from any features in the junction. Controlling the splicing process, while achieving the lowest power-loss, represents a big challenge. A non-destructive and simple technique to examine arc fusion splicing based on quantitative phase imaging technique is presented in this work. The method is used to investigate the refractive index changes of various arc-fusion spliced single-mode optical fibres. The results provide a way to quantify the effects of thermal dopant diffusion for various dopants and host species.

AOS PMO 48

Molecular BEC via the Association of Ultracold Fermionic Atoms

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A relatively new advance in ultracold quantum gases involves the use of fermionic, rather than bosonic, atoms. Recent investigations[1] have produced stable BECs of $^6Li_2$ molecules, exhibiting lifetimes of tens of seconds. We will give details of our work towards the production of a molecular BEC of ^{6}Li dimers. In our experimental set-up a Zeeman slowed beam of atoms loads the MOT, which are then transferred to a far-off-resonant optical dipole trap (FORT). Atoms and molecules are evaporated from the FORT, where the scattering length can be controlled via Feshbach resonances in high magnetic fields.

[1] See e.g. S. Jochim et al., Science **302**, 2101 (2003)

AOS PMO 49

Extraction of Trapped Light From Luminescent Solar Concentrators

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A number of modern light sources, such as luminescent solar concentrators (LSC's), and LED's utilise radiation emitted within a light-guiding structure of high refractive index. Unless the system is carefully designed, half of the emitted light may be unable to escape. A variety of devices to extract trapped light from a LSC have been studied experimentally and by computer simulation. The computer models show that one can expect a luminous gain of 1.6–1.8 compared to a standard rectangular LSC sheet. Gain values in the range 1.15–1.30 were achieved experimentally. An improved joining method gives closer to the theoretical predictions.

AOS PMO 51

Effect of Distortion on the Performance of Large-Aperture Etalon Filters

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Fabry-Perot etalon filters are widely used as tunable, narrow-bandpass optical filters. One area of application is in spectroscopic astronomy, where the presence of hydrogen, nitrogen, etc. are measured through their absorption bands. To achieve a high finesse (the ratio of spectral range to spectral width), the two sides of the etalon must be flat and parallel to within nanometres. We show that distortion of an etalon (for example, due to coating or mounting stress) can significantly degrade the performance and the effect is exacerbated for increasing angles of incidence. This is demonstrated through both theory and experiments.

AOS PMO 52

Windowed Fourier Wavefront Reconstruction

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Fast, accurate wavefront reconstruction from sheared phase maps is important for a number of applications, for example, in astronomical adaptive optics systems, and in speckle shearing interferometry. Numerical solution methods typically cast the problem as a least-squares minimisation, requiring iterative calculation of a pseudoinverse matrix. This scales poorly with data size. The integration problem can be solved instead by a Fourier method, taking advantage of numerically-efficient implementations, as well as the orthogonality of the Fourier transform (hence also allowing efficient differentiation). The Fourier method, however, suffers from periodicity constraints. A windowed approach is proposed that improves the fidelity and accuracy.

AOS PMO 53

Bistability and Diode Action in Left-handed Band-gap Structures

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Periodic structures made from layers of right-handed and left-handed material exhibit in addition to the conventional Bragg-scattering band-gap a novel band gap around the frequency of vanishing average refractive index[1,2]. Using the transfer-matrix method and the pseudospectral time-domain method we study the properties of linear and nonlinear defect layers in this novel band gap and compare them with a Bragg gap. The defect modes in these two types of band gaps show differences with respect to sensitivity to defect layer position, bistability, transmission tunability, and diode effects[3].

[1] J. Li, L. Zhou, C.T. Chan, and P. Sheng, Phys. Rev. Lett. **90**, 08901 (2003)

[2] I.V. Shadrivov, A.A. Sukhorukov, and Yu.S. Kivshar, Appl. Phys. Lett. **82**, 3820 (2003)

[3] M.W. Feise, I.V. Shadrivov, and Yu.S. Kivshar, Appl. Phys. Lett. **85**, 1451 (2003)

AOS PMO 54

Tracking Energy Transfer Mechanisms in Er-doped Crystalline Silicon

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A detailed study of energy transfer mechanisms in erbium(Er)-doped crystalline silicon is presented, since the trivalent Er ion emits at a wavelength of 1.54 μm that is suitable for telecommunication applications. Spectroscopic investigations at helium temperatures have been done in a two-color experiments using the Nd:YAG pulsed laser as a primary band-to-band excitation and a tunable mid infrared radiation (7–17 μm) from a free electron laser as the secondary beam. Changing the delay time and pump power, we reveal afterglow and optical memory effect which are directly linked to defects in the silicon band gap. Finally and based on recent results in FZ-Si, a new excitation mechanism is proposed.

AOS PMO 55

Cell Micromechanics: Micromanipulation of a Cell Model System

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The knowledge about viscoelasticity inside a living cell is highly valuable information. Changes in the viscosity are thought to occur during metabolic and functional processes and their measurement would give an insight into these complex mechanisms.

We approach this problem by using laser tweezers and rotating micron sized particles to access viscosities in smallest amounts of liquid. The laser tweezers trap the probe particle stably in three dimensions and rotate it by transfer of angular momentum. The drag torque which the particle experiences is measured by optical means. We applied this method to measure viscosities inside micelles[1]. Now we take it one step further and investigate the viscosity inside a cell model system (liposome). In future experiments, we will inject our probe particles into living cells.

[1] A.I. Bishop et al., Phys. Rev. Lett, **92**(19), 198104-1 (2004)

AOS PMO 56

Study on Correlation between Rayleigh Scattering, Absorption and Inhomogeneous Birefringence in Large-size Single Crystal Sapphire

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Advanced laser interferometric gravitational wave detectors require very high laser power to minimize the photon shot noise. The use of a high power requires extremely low loss optical materials. Sapphire is one of the most promising test mass materials for advanced laser interferometric gravitational wave detectors.

However, it is difficult for manufacturers to grow large-size high-quality samples. Due to point defects and inhomogeneity in test masses, the interaction between high-optical power and defect test mass materials is usually resulted in various thermal effects that can lead to damage, introducing excess noise and thus reducing the sensitivity. It is essential to evaluated high-grade large sapphire test mass samples to ensure that an adequate high level of optical performance is achieved.

Optical properties such as absorption, Rayleigh scattering, and, in the case of sapphire, inhomogeneous birefringence are related to impurity and defects in the material, and thus are not independent process. Here we present the study of correlation between Rayleigh scattering, absorption and inhomogeneous birefringence in bulk sapphire samples.

AOS PMO 57

Tunable Lens for Thermal Lensing Compensation in Laser Gravitational Wave Detectors

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Experimental results from a tunable focal length lens prototype are presented. This low cost adaptive system will be essential to compensate dynamically thermal lensing occurring in high optical power laser gravitational wave detectors. The lens is composed of a fused silica window encircled with a heating mount. The heating power generates a temperature gradient inside the plate substrate which induces a refractive index gradient due to the thermo-optic effect. A focal length ranging from infinity to –210 meters has been measured depending on the heating power.

AOS TUESDAY

AOS TUA11
Tuesday 1040–1120 hrs

Microphotonic crystal fibres

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After maturation in long-haul telecommunications, fibre optic technology is enjoying a renaissance in the form of microstructured optical fibres (MOF). These fibres, unlike conventional single mode fibres, have air inclusions running along their length, which can dramatically modify the transmission nature of the fibre, providing a degree of control over the propagation of the light and enabling important new applications.

Whilst MOFs have many interesting properties in and of their own right, a whole host of varied devices may be realized through post-fabrication engineering of these fibres[1]. Additional functionality is achieved by modification of the MOF itself, via tapering[2], the introduction of fluids into the microstructure of the fiber (microfludics)[3,4] or using the MOFs in novel geometries[5]. In this paper, we review our recent progress in the post-engineering of MOFs, via tapering and microfluidics and demonstrate a new class of photonic devices fabricated using these post-engineering techniques[5–8].

[1] B. J. Eggleton, et al., Microstructured optical fiber devices," Optics Express vol. 9, pp 698–713 (2001).

[2] E. C. Mägi, P. Steinvurzel, B. J. Eggleton, "Tapered photonic crystal fibers,"Optics Express Vol. 12, pp. 776 (2004).

[3] P. Domachuk, H.C. Nguyen, B. J. Eggleton, M. Straub, M. Gu, "Microfluidic tunable photonic band-gap device," Applied Physics Letters Vol. 84 (11): pp.1838–1840 (2004).

[4] P. Steinvurzel et al., "Long wavelength anti-resonant guidance in high index inclusion microstructured fibers," Optics Express, Vol. 12 Issue 22 pp. 5424 (2004).

[5] H.C. Nguyen et al., "Experimental and finite difference time domain technique characterization of transverse in-line photonic crystal fiber"IEEE Photonics Technology Letters Vol. 16 (8): 1852–1854 (2004).

[6] C. Grillet et al., "Compact tunable Microfluidic Interferometer" Optics Express, Vol. 12 Issue 22 pp. 5440 (2004).

[7] Y. K. Lize et al., "Microstructured optical fiber photonic wires with subwavelength core diameter," Optics Express Vol. 12 (14): pp.3209–3217 (2004).

[8] A.Fuerbach, P. Steinvurzel, J. Bolger, A. Nilson, B. J. Eggleton, "Nonlinear pulse propagation in arrow photonic crystal fibers," in press Optics Letters (2005).

AOS TUA13
Tuesday 1120–1140 hrs

Multiple Dissipative Soliton Interactions in a Passively Mode-Locked Fiber Laser

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In integrable systems, two bright solitons having different velocities undergo elastic collision, but they cannot form a stable bound state. In the case of dissipative solitons, stable asymmetric soliton pairs can be formed, when we model the system by the complex Ginzburg-Landau equation[1]. These stable soliton pairs were observed experimentally[2]. The key feature of asymmetric soliton pairs with their phases in quadrature is their group velocity that is different from the group velocity of a single soliton. When the soliton pair and a soliton singlet exist simultaneously in the cavity they must collide. We studied such interactions in a fiber laser.

[1] N. Akhmediev, A. Ankiewicz, and J. M. Soto-Crespo, J. Opt. Soc. Am. B 15, 515 (1998).

[2] Ph. Grelu, F. Belhache, F. Gutty and J. M. Soto-Crespo, Opt. Lett. 27, 966 (2002).

AOS TUA14
Tuesday 1140–1200 hrs

Dark Soliton Formation and Interaction in Nonlocal Nonlinear Thermal Media

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This paper investigates formation of dark solitons and their mutual interaction in nonlocal bulk thermal media through numerical simulation and experiment. A model for the absorption of light and diffusion of thermal energy in the medium by means of the heat equation is presented. This process for creating the self-induced waveguides that support the formation and propagation of dark solitons is investigated in simulation and experiment. The mutual attraction of dark solitons due to nonlocal effects predicted by simulation is investigated in experiment involving propagation of an intense laser beam in weakly absorbing liquids.

AOS TUA15
Tuesday 1200–1220 hrs

Air-clad Fibres with Diffractive Intra-modal Cross Coupling

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Recent advances in nano-structured air-cladding technologies used in optical fibre manufacturing have allowed the development of ultra-high numerical aperture (NA) fibres. As a second cladding in high-power fibre lasers, these fibres can accept unprecedented levels of hard-to-focus low coherence pump light, thus promising to

enable lasers operating in the multi kW regime. To understand in detail how different components of the low-coherence pump light propagates inside the fibre; we present experimental results examining the length dependency of the transmissivity of light with large skew ray components in the fibre as a function of input angle. We also show far-field images of concentric rings emerging from the fibre other than the specular. These are proposed to originate from diffraction off the periodically corrugated surface of the air-clad core.

AOS TUA21
Tuesday 1400–1420 hrs

Optical Quantum Computing: Science-fiction, Horror-story or News?

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Quantum computing requires massive nonlinear interactions between particles, which is notoriously difficult to achieve with photons. Consequently, there is a flurry of interest in the futuristic idea that optical quantum computing is possible using measurement-induced nonlinearities[1]. Indeed, the first unambiguous experimental demonstration of quantum controlled-NOT gate operation, and the first complete characterisation of a quantum gate, have both been achieved optically[2,3]. To achieve fault-tolerance, current schemes require horrific numbers of physical gates to implement just one logical gate. We highlight the benefits for our experimental program of recently proposed schemes that reduce requirements from the order of 10,000 to 50 [4–6].

[1] E. Knill, R. Laflamme, and G. J. Milburn, Nature 409, 46 (2001).

[2] J. L. O'Brien, G. J. Pryde, et al., Nature 426, 264 (2003) .

[3] J. L. O'Brien, G. J. Pryde, et al., Physical Review Letters 93, 080502 (2004).

[4] M. A. Nielsen, Physical Review Letters 93, 040503 (2004).

[5] D. E. Browne and T. Rudolph, quant-ph/0405157 (2004).

[6] K. Nemoto and W. J. Munro, quant-ph/0408118 (2004).

AOS TUA22
Tuesday 1420–1440 hrs

Quantum Optics with Solid State Optical Centres

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Recent schemes[1] for manipulating and generating few photon states using "atomic" ensembles are attractive because of their simplicity of implementation and because the interaction of a photon with a collective mode of many atoms can be much larger that than with a single atom. We describe the unique advantages of implementing the schemes not with atoms but with solid state optical centres and present the results of experiments working toward the implementation of these schemes.

[1] M. D. Lukin, Reviews of Modern Physics, **75**, 257, (2003)

AOS TUA23
Tuesday 1440–1500 hrs

BEC Analogues of Quantum Field Theory in Curved Space-time

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Hawking's prediction of radiation from black holes is one of the most surprising outcomes of the quest to unify quantum mechanics and general relativity[1]. It is problematic that such an important theoretical prediction has no immediate prospect of direct experimental investigation. Consequently, Unruh's observation of a deep analogy between quantum fields in curved space-time and sound waves in fluids has stimulated much theoretical work[2].

We discuss the kinds of experiments that might be performed in realistic dilute gas BECs, the associated difficulties, and how they might be overcome[3,4].

[1] S.W. Hawking, Nature **248**, 30 (1974); Commun. Math. Phys. **43**, 199 (1975).

[2] W.G. Unruh, Phys. Rev. Lett. **46**, 1351 (1981).

[3] M. Visser, in *Artificial Black Holes*, edited by M. Novello, M.Visser and G. Volovik (World Scientific, Singapore, 2002).

[4] L.J. Garay, J.R. Anglin, J.I. Cirac, and P. Zoller, Phys. Rev. Lett. **85**, 4643 (2000); Phys. Rev. A **63**, 023611 (2001).

AOS TUA24
Tuesday 1500–1540 hrs

Nonlinear Light Propagation in Periodic Structures—Experiment vs. Theory

D. Neshev[1], A. A. Sukhorukov[1,2], B. Hanna[3], W. Krolikowski[2,3], and Yu. S. Kivshar[1,2]

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Nonlinear wave propagation in periodic structures is a generic phenomena appearing in many branches of physics, such as biological molecules, solid-state systems, Bose-Einstein condensates, and arrays of optical waveguides. Only in optics, however, the nonlinear effects can be directly observed and examined in close details. By using the optically-induced lattice in photorefractive crystals we are able to demonstrate experimentally novel nonlinear phenomena of light localization and beam interaction. In particular we demonstrate generation of discrete, gap and multi-gap optical solitons. These are believed to be the building blocks for the future high-bandwidth all-optical technology that would allow control and manipulation of light on an optical chip.

AOS TUA31
Tuesday 1620–1700 hrs

Quantum Phase-space Applied to Ultra-cold Atoms

P. D. Drummond

The world of ultra-cold atoms is an extraordinary one. In only a decade, experimentalists have thrown out the rule-book of cryogenics, broken every temperature record, and moved the finish-line for cooling experiments down to the nano-Kelvin arena.What does this mean for physics? The first thing one can say is that we don't know yet. Such enormous changes in experimental conditions have always in the past led to major new discoveries, either in fundamental science or in new technology.

I'll review some of the possibilities, with an emphasis on how these developments will challenge theorists in the future, and what progress we are making to meet the challenges. In particular, I'll focus on the question of first-principles calculations. I introduce a new unified quantum operator representation for cold atoms, using the most general possible multi-mode Gaussian operator basis. The representation extends phase-space approaches to Bose and Fermi systems, enabling first-principles simulations.

This idea maps exponentially complex many-body operator equations into nonlinear stochastic differential equations. These can be simulated numerically, without incurring the huge memory costs associated with number-state based matrix calculations. Applications to the Fermi sign problem—and experiments—will be included.

AOS TUA33
Tuesday 1700–1720 hrs

Quantum Nonlocality without Entanglement

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Quantum nonlocality was thought to arise solely through the use of entanglement, until the recent theoretical prediction of a complementary form of nonlocality in unentangled systems. In contrast to nonlocality using entanglement, where locally-prepared systems exhibit nonlocal correlations when measured separately, this nonlocality without entanglement arises when independently-prepared systems are measured jointly, revealing more information than can be obtained by measuring them separately. We present a demonstration of quantum nonlocality without entanglement: two photons are prepared in classically correlated but *un*entangled states, and a joint measurement is shown to provide more information about the correlations than is possible using local measurements.

[1] A. Peres and W. K. Wootters, Phys. Rev. Lett. **66**, 1119 (1991).

[2] C. H. Bennett, D. P. DiVincenzo, C. A. Fuchs, T. Mor, E. Rains, P. W. Shor, J. A. Smolin, and W. K. Wootters, Phys. Rev. A **59**, 1070 (1999).

AOS TUA34
Tuesday 1720–1740 hrs

Experimental Demonstration of Coherent State Continuous Variable Quantum Cryptography

Andrew M. Lance[1], Tomas Symul[1], Vikram Sharma[1], Christian Weedbrook[1,2], Timothy C. Ralph[2] and Ping Koy Lam[1]

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We experimentally demonstrate a new coherent state quantum key distribution protocol that eliminates the need to randomly switch between measurement basis[1]. In this protocol, the sender (Alice) encodes information onto the amplitude and phase quadratures of a bright light beam. The beam is transmitted through a potentially insecure quantum channel to the receiver (Bob), who simultaneously measures both quadratures of the beam. We demonstrate that by using post-selection key distillation techniques[2] we can achieve a positive secret key for line transmission efficiency of greater than

[1] C. Weedbrook, A. M. Lance, W. P. Bowen, T. Symul, T. C. Ralph and P. K. Lam, *Phys. Rev. Lett.* (To be published).

[2] Ch. Silberhorn, T. C. Ralph, N. Lutkenhaus, and G. Leuchs, *Phys. Rev. Lett.* **89**, 167901 (2002).

AOS TUA35
Tuesday 1740–1800 hrs

Quantum Non-Demolition Measurements on Qubits

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Quantum Non-Demolition (QND) measurements, in which information about a quantum observable is obtained non-destructively, have been performed in the continuous variable regime of optics[1]. QND measurements on the qubit states of single photons are more difficult[2]. Recently we have demonstrated a non-deterministic scheme for making such measurements[3]. We will discuss this scheme and particularly focus on the fundamental tests of quantum mechanics that can be made when the scheme is used to make generalized QND measurements. In this situation only partial information is extracted from the quantum system, but is done so coherently.

[1] For example: B.C.Buchler, P.K.Lam, H.-A.Bachor, U.L.Andersen, and T.C.Ralph, *Phys Rev A* **65**, 011803 (2002).

[2] Nogues et al, *Nature* **400** 239 (1999).

[3] G.J.Pryde, J. L. O'Brien, A.G.White, S.D.Bartlett, and T.C.Ralph, *Phys Rev Lett* **92** 190402 (2004).

POSTERS

AOS PTU 1

An Electromagnetics Simulator for the Nanoscale

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An overview of nanoscale electromagnetic analysis is presented investigating the use of Frequency Dependent Finite Difference Time Domain and Frequency Dependent Vector Potential Time Domain algorithms for the analysis of Nanoscale Electromagnetic Structures. In these algorithms Z transform methods are applied to empirical data to obtain expressions that enable frequency dependent material properties to be modelled using popular time domain techniques. Traditionally used for the analysis of biomedical and geological problems, the use of these techniques for nanoscale electromagnetics offers the promise of new insights into optical and electronic properties of nano structures.

AOS PTU 2

Vortex Pairing in Two-dimensional Bose-Einstein Condensates

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The classical field method is increasingly becoming accepted as a computational tool for investigating the properties of Bose-Einstein condensates at finite temperature[1,2,3]. To date it has been shown to reproduce condensate fractions, critical temperature shifts, and correlation functions. However, a condensate itself is not predicted to form in a homogeneous Bose gas in two-dimensions. Instead another type of phase transition known as the Kosterlitz-Thouless transition can take place, which involves the pairing of vortices with opposite circulations[4]. In this paper we investigate the formation and dynamics of vortices in a two-dimensional Bose gas in the quantum degenerate regime using the classical field method.

[1] M. J. Davis, S. A. Morgan and K. Burnett, Phys. Rev. Lett. **87**, 160402 (2001).

[2] M. J. Davis, S. A. Morgan and K. Burnett, Phys. Rev. A **66**, 053618 (2002).

[3] K. Goral *et al.*, Phys. Rev. A **66**, 051602, (2002).

[4] M. Kosterlitz and D. Thouless, J. Phys. C **6**, 1181 (1973).

AOS PTU 3

Experimental Observation of Scattering in Gratings at Extreme Angles

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We present an experimental and theoretical investigation of scattering of electromagnetic waves in volume holographic gratings at grazing angles, i.e. when the +1 diffracted order propagates almost parallel with the grating boundaries. A grating was written in photorefractive lithium niobate via two-wave mixing. A wide beam, normally incident onto the grating, was scattered at a grazing angle. The profile of the scattered beam registered at about 1 m away from the grating was observed to be asymmetric in nature. The non-steady-state coupled wave theory for scattering at grazing angles and Fourier analysis were used to interpret the experimental results.

AOS PTU 4

Investigation of Surface Diffusion of Atoms and Nanoparticles in the Presence of Surface Plasmon-induced Temperature Patterns

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Using the Ermak algorithm for Brownian dynamics, we investigate diffusion of atoms and nanoparticles on a periodically heated surface by means of interfering surface plasmons. Particle trajectories are obtained by solving the Langevin equation in the case of a two-dimensional periodic potential and the periodic temperature distribution. The resultant redistribution of particles and their localisation (trapping) on non-uniformly heated smooth surfaces are investigated numerically. Equivalent trapping forces resulting from non-uniform and anisotropic surface diffusion are determined. Possibility of manipulation of nanoparticles using non-uniform surface temperature distributions for applications to controlled formation of micro- and nano-structures is discussed.

AOS PTU 5

Theoretical and Numerical Analyses of a New Type of Sub-wavelength Plasmonic Waveguide with Strongly Localized Gap Plasmons

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A new type of sub-wavelength plasmonic waveguide using gap plasmons strongly localised in two dimensions are proposed and analysed. Finite-difference time-domain algorithm and analytical method based on effective medium approach and Fourier analysis are developed and justified for the description of such waveguides. Plasmon dispersion, dissipation, and field structure are considered. Typical structural parameters ensuring sub-wavelength waveguiding are determined. Comparison of different methods of analysis is carried out, and the applicability conditions are derived. Stability of the considered plasmons with respect to structural imperfections is investigated. Feasible applications are in the area of nano-optics, nano-photonics, optical sensors, etc. are considered.

AOS PTU 6

Optimal Estimates and Joint Measurement Uncertainty Relations

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Consider an estimate of some quantum observable, A, made on the basis of the measurement of a second observable, $M=\Sigma_m\, m\, |m\rangle\langle m|$, on quantum state $|y\rangle$. There is a fundamental lower bound for the inaccuracy of any such estimate[1]:

$$\langle (A-A_{est})^2 \rangle \geq \Sigma_m\, [\mathrm{Im} \langle m|A|y\rangle / \langle m|y\rangle\,]^2 \,,$$

which is far stronger than the Heisenberg uncertainty relation for A and M. The lower bound is achievable when the state prior to measurement is known, yielding an `exact' uncertainty relation. Applications include optimal quadrature estimates from heterodyne detection.

Further, any measurement M can be used as the basis for simultaneously estimating the values of any *two* observables A and B (this is the most general possible definition of a joint measurement). Universal joint uncertainty relations have been obtained for such pairs of estimates, and applied to joint measurements on EPR-correlated particles[1].

[1] M.J.W. Hall, Phys. Rev. A, 69, 052113 (2004)

AOS PTU 7

Mini-Differential Absorption Lidar for Atmospheric Water Vapour Profiling

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We report on progress towards developing a small Differential Absorption Lidar system for measuring the profile of water vapour concentration in the lower troposphere. Because of the extreme variability of water vapour concentration, there is a lack of data for meteorological modelling and quantitative precipitation forecasting. Our aim is to develop a sufficiently low cost system that measurements can be made routinely with with both greater temporal and spatial frequency than is presently the case. The compromises that are necessary to achieve a low-cost instrument will be discussed, and we will present our scheme for achieving accurate wavelength control of the two laser sources.

AOS PTU 8

Photostability of Nitrogen-Vacancy Centres in Diamond

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The nitrogen-vacancy colour centre is of interest as a potential single photon source[1,2] and for solid state quantum computing applications[3,4]. The centre can exist in both a neutrally charged, $[NV]^0$, and negatively charged, $[NV]^-$, state. Both centres are readily identified by their emission spectra, with characteristic zero phonon lines at 575nm and 637nm respectively, and both are considered to be photostable. We have investigated the photostability of single [NV]- centres using confocal fluorescence microscopy and the results are presented here. These results, along with those from ealier ensemble averaged measurements, lead us to conclude that the NV centre is not photostable.

[1] C. Kurtsiefer et al., PRL, **348**, 285 (2000)

[2] R. Brouri et al., Optics Lett., **25**, 1294 (2000)

[3] J. Wrachtrup et al., Optics and Spectra, **91**, 459 (2001)

[4] P. R. Hemmer et al., Optics Lett., **26**, 261 (2001)

AOS PTU 9

Measuring Thin Films by Transmission Spectroscopy

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The refractive index, extinction coefficient and thickness of thin dielectric films are important parameters for device manufacturers and experimenters. We have developed a method which allows these values to be determined from

a single transmission spectrum of the film as deposited on a known substrate. The technique exploits the interference fringes seen in such a transmission spectrum to establish envelope functions of the turning points in the spectrum[1]. From these envelope functions the refractive index and extinction coefficient of the film is determined at each turning point. Consequently we can determine the film's thickness with a single measurement step.

[1] P Meredith, et al, Applied Optics 32, 5619 (1993)

AOS PTU 10

Entanglement, Correlations, and Error-correction in the Ground States of Many-body Systems

H. L. Haselgrove[1,2], M. A. Nielsen[1,3], and T. J. Osborne[4]

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What generic properties are shared by the ground states of all physically realistic many-body quantum systems? We start with simple physically-motivated assumptions about the locality of interactions in the (otherwise arbitrary) system Hamiltonian. We show that this imposes strict conditions on the type of correlations and entanglement that can appear in the ground state[2]. Also, all such physically-reasonable ground states are provably far away from an important class of states known as *nondegenerate quantum error-correcting codes*[2]. Thus, nature places severe restrictions on the type of state which can act as a many-body ground state.

[1] H. L. Haselgrove, M. A. Nielsen, and T. J. Osborne, Phys. Rev. Lett. **91**, 210401 (2003)

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AOS PTU 11

Er:Yb:glass Coherent Laser Radar

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Q-switched Er:glass lasers that are injection seeded by a cw master laser are useful for eye-safe (1.535μm) coherent laser radars (CLR). Previously, we used an injection seeded, Q-switched, lamp-pumped Er:glass laser, obtaining velocity measurements of a hard target with a single shot resolution of about 1ms^{-1} [1]. The transmitted pulse energy was only about 1mJ however, which severely restricted the range of the radar.

We shall describe the development and performance of a new, Q-switched, diode-pumped Er:Yb:glass slab laser that can produce gain-switched, transform limited, TEM_{00} pulses. The spectral content of the laser output, suitable for CLR will be discussed.

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AOS PTU 12

Non-crystalline Diffraction: A Method for Beam Characterisation

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X-ray Free Electron Lasers are being developed around the world. A major application is the possibility of imaging a single molecule, which disintegrates on interaction with the beam. We have developed a new phase recovery algorithm suitable for this application. However, it requires precise knowledge of the phase curvature across the beam illuminating the sample.

Characterisation of the phase across a beam has been achieved. This is done by imaging a well characterised object placed in the beam's path and using the above algorithm. Experimental results are presented.

AOS PTU 13

Stationary and Dynamic Entanglement in a Coupled Spins System

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With the advent of quantum information theory, entanglement is now regarded as a physical resource that can be utilized to perform numerous quantum computational and communication tasks[1]. This has motivated the study of the entanglement characteristics of quantum systems, and in turn, how these characteristics relate to other properties of the system. Using the example of coupled giant spins, we consider both the stationary and dynamic entanglement and its relation to the underlying classical dynamics of the system. Specifically, we demonstrate how the entanglement between the spins in ground state corresponds to a pitchfork bifurcation of the classical fixed points. Furthermore, we consider the role of classical chaos in the dynamical generation of entanglement and spin-tunnelling.

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AOS PTU 14

Cooling and Trapping of Rubidium Atoms: Progress on the Way to a BEC

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We report progress on the construction of a BEC of rubidium atoms in a dipole trap, which is formed by a focused CO_2 laser. We have constructed a double MOT

setup, which emphasises good optical access to the BEC. We describe the optical set-up, loading efficiencies and sizes of both traps, along with the construction and imaging of the dipole trap to date. We discuss the experiments planned involving the condensate, which include ramping up a standing wave component to the dipole trap, effectively separating the atoms into groups. These can then be individually addressed by using focused laser beams, and used as qubits for quantum information experiments.

AOS PTU 15

Diffusion Resonances in the Atom Optics Kicked Rotor: Experiments for Small Numbers of Kicks

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The classical delta kicked rotor, a point mass freely rotating about a fixed pivot subjected to gravity being pulsed on and off, shows chaotic behaviour. In a quantum system, the linearity of quantum mechanics prohibits chaos. We realise a quantum kicked rotor system in a laser cooled cloud of atoms subjected to a pulsed standing wave of laser light. In this system, the commutator between the reduced position and momentum operators, establishing an effective Planck's constant, depends on the kick period, which is an easily accessible experimental parameter. Thus we are able to vary the degree of `classicality' in the experiment.

We present our latest results in which we experimentally verify the analytical expressions that exist for the diffusion rate in the quantum delta kicked rotor system for small numbers of kicks. We show that the results are periodic in the effective Planck's constant. For larger numbers of kicks, our experimental results show some novel details around the 'quantum resonances'.

AOS PTU 16

Quantum Trajectories for Many-atom Cavity Quantum Electrodynamics

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In this paper we report on the deficiencies of the weak-field formulas used to describe second-order correlation measurements (SCMs) in cavity quantum electrodynamics (CQED). To characterise SCM, we present a rigorous theoretical modeling of many-atom CQED experiments using a quantum trajectory treatment valid in the vicinity of the weak-field limit. Effects due to the atomic motion are considered in detail, for both standing and traveling wave cavities. We also demonstrate sensitivities of the measured correlations to atomic beam fluctuations and discuss the effects of spontaneous emission as the weak-field limit is relaxed.

AOS PTU 17

Polarisation Self-Rotation Optical Squeezing with Hot Atoms

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Recently there has been a lot of interest in the study of interactions between non-classical light states and atomic systems. The applications of this research range from the realisation of quantum memory[1,2] to single atom lasers[3]. It has been demonstrated that squeezed light can be produced via atomic Kerr non-linearity. Usually, cold trapped atoms has to be generated to enhance this non-linear process[4,5]. Recently, Ries *et al.*[6] demonstrated that squeezing can also be achieved in hot atomic systems. In our experiment, light is transmitted single-pass through a ^{87}Rb cell heated to 70˚C. An intensity dependent polarisation rotation is observed without any applied magnetic field. We present the latest results in the generation of optical squeezing via this polarisation self-rotation phenomenon.

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AOS PTU 18

Verdet Constants of Chalcogenide Glasses

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The wavelength dispersion of the magneto-optical properties of bulk As-S, As-Se-S, Ge-As-Se and Ga-La-S-based chalcogenide glasses have been investigated at visible and infrared wavelengths. $Ge_{33}As_{12}Se_{55}$ was found to have the highest Verdet constant, corresponding to the lowest band gap energy compared with the other chalcogenide glasses. Its Verdet constant is 0.0485 min/G_cm at 1550nm, 30 times that of silica, and is the highest Verdet constant reported to date for chalcogenide glasses. Further improvement of the Verdet constants of the Ge-Se-based chalcogenide glasses by engineering of their compositions will make them a very promising material for future integrated magneto-optical devices.

AOS PTU 19

Production of Macroscopic Superposition States with Small Kerr Nonlinearity

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Production of macroscopic superposition states (Schrodinger cat states) is not only of fundamental interest but have potential usefulness for quantum information processing. Even though it has been theoretically known that macroscopic superposition states can be generated using Kerr media, nonlinearity of currently available media is too small to produce such states. We suggest a scheme to generate macroscopic superposition states of free-traveling optical fields using a beam splitter, homodyne measurement and a very small Kerr nonlinearity (quant-ph/0405041). Our scheme enables one to considerably reduce the required nonlinearity to generate optical macroscopic superposition states using simple and efficient optical elements.

AOS PTU 20

Direct Characterization of a Pure Evanescent Focus of a High Numerical Aperture Objective Lens

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In this paper, intensity distributions of the tightly focused evanescent field generated by a centre blocked high numerical aperture (NA=1.65) objective lens are investigated by a scanning near-field optical microscope. The pure focused evanescent field is mapped and a splitting phenomenon of the focal spot along the direction of polarization, caused by depolarization, is observed. The measurement result is compared with the calculation based on vectorial diffraction theory; a good match has been found. The decaying nature of the focused evanescent wave also shows a good agreement with the theoretical predication, indicating that the field is purely evanescent and does not contain significant contribution from the propagating component.

AOS PTU 21

Entanglement Distribution by an Arbitrarily Inept Delivery Service

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Say an entanglement-manufacturing firm (call it *C*, in Canberra), produces entangled pairs of qubits (in bulk) and, for each pair, ships one qubit to one customer and the other to another customer. This should allow two customers, say *A* in Albuquerque and *B* in Brisbane, to undertake nonlocal quantum information tasks such as teleportation[1], or violating a Bell inequality[2]. We consider what happens if the delivery service used by *C* is incompetent, so that with probability 1– F either *A* or *B* end up with somebody else's qubit. Surprisingly, no matter how close the distribution fidelity F is to zero, it is still possible for *C* to distribute entanglement. This can be achieved by manufacturing *non-maximally* entangled qubits

$$|\psi\rangle = \alpha|0,0\rangle + \sqrt{1-\alpha^2}|1,1\rangle,$$

if (if and only if) $\alpha < F$ (without loss of generality, we consider only $\alpha \in [0,1/\sqrt{2}]$). In the limit $F \ll 1$, the entanglement of formation[3] per pair is maximized for $\alpha = F/2$, and equals $[F^4\log_2(F^{-1})]/4$. Thus in this limit, more than $4/[F^4\log_2(F^{-1})]$ deliveries are required for *A* and *B* to distill a single Bell pair. If *A* and *B* wish to use their undistilled pairs, then F cannot be arbitrarily small. For example, they can violate the CHSH-Bell inequality[4] if $F > 1/\sqrt{2}$.

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AOS PTU 22

Chaotic Semiconductor Lasers

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Many dynamically diverse outputs, including chaotic output, can be obtained from semiconductor laser systems using various methods such as optical feedback, optoelectronic feedback or optical injection. Analysis of long time streams of the output power versus time from chaotic semiconductor lasers, recorded using a measurement bandwidth of up to 4 GHz, has shown time variation in the dynamical output from these systems when operated in a constant configuration. Such dynamics in the dynamics has not been reported previously and represents a new complexity in these complex systems.

AOS PTU 23

Einstein-Podolsky-Rosen Correlations via Dissociation of a Molecular Bose-Einstein Condensate

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We combine two of Einstein's contributions to twentieth century physics, Bose-Einstein condensation and the Einstein-Podolsky-Rosen (EPR) paradox, to propose a test

of local realism with mesoscopic numbers of massive particles. Using dissociation of a condensate of homonuclear diatomic molecules into the constituent bosonic atoms, we demonstrate that strongly entangled output atomic beams may be produced which possess nonlocal EPR correlations in particular field quadratures. These are directly analogous to the position and momentum correlations originally considered by EPR. The proposal employs mode-matched local oscillators and is applicable to realistic nonuniform condensates, including molecular condensate depletion, s-wave scattering interaction and one-body losses.

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AOS PTU 24

The Superfluidity—Mott Insulator Quantum Phase Transition as an Instance of a Quantum Adiabatic Algorithm for Hilbert's Tenth Problem

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We point out that the superfluidity—Mott insulator quantum phase transition[1] can be regarded as a physical realisation of an instance of a quantum adiabatic algorithm for Hilbert's tenth problem[2,3,4,5] with simple linear Diophantine equations. This connection originates from the fact that the quantum phase transition itself is a quantum adiabatic process, which is also the process employed in the algorithm.

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AOS PTU 25

Multi-Channel Dispersion/Dispersion Slope Compensating Fibre Bragg Gratings

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Expansion of the capacities of optical fibre transmission systems towards 160 Gbit/s[1] requires both dispersion and dispersion slope compensation of the lines. Using fundamental properties of the Fourier transform, applying dephasing approach, and using functional optimization, we derive and optimise aperiodic sampling function, which plays pivotal role in multi-channel FBG design. We use this design to fabricate a sample multi-channel dispersion/ dispersion slop compensating fibre Bragg grating.

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AOS PTU 26

Demonstration of Bell Measurement Using a Linear Optics CNOT Gate

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Tasks such as teleportation and entanglement swapping have vital implications in quantum information processing for producing a scaleable quantum computer—currently a topic of great interest. Central to these tasks is the ability to discriminate the four maximally-entangled two-qubit states—the Bell states. A quantum controlled-NOT gate is a fundamental quantum gate[1]; it can perform Bell measurements by turning the Bell states into easily distinguishable, unentangled states. Using a simplified version of the post-selected CNOT gate demonstrated in[2], we provide the first experimental demonstration of a complete linear optics Bell measurement, characterise its operation, and discuss scale-up.

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AOS PTU 27

Squeezed Matter-wave Gap Solitons in Optical Lattices

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We study quantum squeezing of matter-wave gap solitons in optical lattices by employing a linearized quantum theory based on the mean-field Gross-Pitaevskii equation with a periodic potential. We find that optical lattice potential induces atom number squeezing in localized states inside the gap. In general, quantum fluctuations of gap solitons are more squeezed compared with the solitons in a lattice-free case. The quantum correlations of gap solitons in momentum space show high correlated patterns induced by the nature of Bloch waves. The squeezing effect is most profound near the band edges and is reduced in the depth of the gap.

AOS PTU 28

Quantum Cryptography: Security Criteria Reexamined

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We find that the generally accepted security criteria are flawed for a whole class of protocols for quantum cryptography. This is so because a standard assumption of the security analysis, namely the so-called square-root measurement is optimal for eavesdropping purposes, is not true in general. There are rather larger parameter regimes in which the optimal measurement extracts substantially more information than the square-root measurement.

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AOS PTU 29

Controlling Matter-wave Solitons in Optical Superlattices

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Optical lattices with multiple periodicities, such as optical superlattices, support the existence of nonlinearly localised states in a repulsive Bose-Einstein condensate (BEC)—*matter-wave gap solitons*. Employing the mean-field model of a condensate in a periodic potential, we show how changing the shape of an optical superlattice allows us to control the properties and interactions of these solitons[1,2]. We also demonstrate a method for controlled generation of matter-wave gap solitons in a stationary lattice by using the interference of two BECs[2]. The efficiency of this method is compared with that of gap soliton generation in a moving lattice recently demonstrated experimentally[3].

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AOS PTU 30

Adiabatic 3-Wavelength Planar Multiplexer/De-multiplexer

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A novel approach to the simultaneous multiplexing or de-multiplexing of 3 wavelengths for coarse wavelength channel separation is based on the geometrical evolution and transformation of the modes of a single few-mode planar device. An input fundamental mode is transformed into a particular higher-order mode, depending on its wavelength, and that is transformed and directed in turn into the fundamental mode of a particular output port. The functionality of the device is quantified and its performance optimised through appropriate design. The device overall size is minimised, taking into account the core spacing requirements for fibre pigtailing.

AOS PTU 31

Random Mixtures of Gaussian States

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The generation of non-Gaussian states in optics is of interest for their various uses in experiments concerned with quantum information theory. We examine the properties of mixtures of Gaussian states of the form $p\hat{p}_{vac} + (1 - p)\hat{p}_{TMS}$ where $\hat{p}_{vac}$ represents a two-mode vacuum state and ($\hat{p}_{TMS}$) a two-mode squeezed state. This state is non-Gaussian and entangled. It could be produced by randomly blocking a two-mode squeezed state with probability p and hence is an experimentally accessible non-Gaussian state. Although it has a positive W-representation it exhibits unique behaviour. In particular when this state and a pure two-mode squeezed vacuum have the same level of inseparability[1,2] the mixed version gives higher fidelity when used for continuous variable teleportation[3].

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AOS PTU 32

Nitrogen-vacancy Centre—Why the Interest?

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There is interest in the nitrogen-vacancy centre in diamond due to the demonstration of quantum logic operations of single centres at room temperature[1]. The demonstration was possible because the centre emits when in one spin state (M_S = 0) but not the other (M_S = ±1). However, this exceptional selection rule is brought into question through studies of single centers and ensembles. A new model of the electronic structure of the centre is proposed to account for the observations.

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AOS PTU 33

Bloch Oscillations of Optical Beams in Spatially Varying Periodic Gratings

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Bloch oscillations of optical beams have been observed in chirped waveguide gratings where the total internal reflection effect arises from a refractive index gradient across the grating.[1,2]

Here we present numerical simulations of Bloch oscillations of optical beams in periodic gratings where the period is spatially varied in the transverse direction. The effect of the total internal reflection required for these oscillations is achieved by the different coupling constants between adjacent waveguides. We show that Bloch oscilllations can be observed when the period of the gratings varies both in a linear and exponential manner. The Bloch oscillations are demonstrated for gratings composed of waveguides with a fixed width and also in those where the width of the waveguides varies continuously.

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AOS PTU 34

Measurement of Thermal Lensing in a Diode-pumped Nd:YVO4 Laser Using a Hartman Wavefront Analyser

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We measured the thermal distortion[1] induced on an optical probe beam passing through a diode-end-pumped Nd:YVO_4 laser crystal under lasing and non-lasing conditions. A Hartmann wavefront analyser[2] was used to measure the probe beam wavefront, which was analysed with a Zernike polynomial basis. The resulting thermal distortions were compared with a model of thermal lensing[3]. For high pump powers, good agreement was found. Some limitations in the use of the Hartmann analyser were identified. Our ultimate goal is to use a deformable mirror to compensate in real time for the beam distortions.

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AOS PTU 35

Low Noise Photonic-based Tuneable Microwave Source

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Photomixing the output of a two-frequency solid-state laser[1,2] on a PIN photodiode generates a microwave signal, leading to a photonic-based microwave source. This is a potential alternative to traditional low-power broadband microwave generators such as voltage controlled oscillators (VCO)[3] where low noise and wide frequency tuneability are required. The intensity noise (RIN) and optical modulation index (OMI) are important quantities qualifying the noise spectrum near the microwave region of interest and are experimentally investigated using a two-frequency diode-pumped Nd:YAG laser. Using a variable birefringent intra-cavity element the frequency of the beat-note is controlled and in this case greater than 2 GHz bandwidth is shown.

[1] G. W. Baxter et al., IEEE Photonics Technology Letters **8**, 1015 (1996)

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[3] N.-M. Kwak et al., Microwave and Optical Technology Letters **42**, 3 (2004)

AOS PTU 36

Magneto-optical Film-based Grooved Microstructures for Manipulating Cold Atoms

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In our ongoing program to develop permanent magnet-based atom optical elements, we have recently fabricated a microstructure by depositing a film of GdTbFeCo

magneto-optical material onto a 1.5 mm-period grooved silicon substrate. The magneto-optical material exhibits characteristics that are attractive for magnetic atom optics, including perpendicular magnetisation, high remanent magnetic field (~ 3.8 kG), high coercivity (~ 2.5 kOe) and excellent magnetic homogeneity. Progress on testing the microstructure by observing the specularity of the reflection of cold rubidium atoms from the mirror surface will be reported. The prospects of applying such microstructures as diffraction grating-based atomic matter-wave beamsplitters will be discussed.

AOS WEA11
Wednesday 1040–1120 hrs

BEC of $^6Li_2$ Molecules: Exploring the BEC-BCS Crossover

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We report on recent experiments with an ultracold degenerate Fermi gas of ^{6}Li atoms. We start with Bose-Einstein condensation of Li_2 molecules in an optical trap[1]. Using a Feshbach resonance we can then investigate the BEC-BCS crossover where the molecular condensate is transformed into a strongly interacting gas of fermions. We probe the crossover with several methods like measurements of the trapped cloud size[2], collective oscillation excitations[3] and binding energy measurements with radio frequency[4]. In these measurements we have been able to show the existence of a pairing gap[4] on the BCS side of the resonance. This strongly suggests the presence of a superfluid phase on the BCS side of the crossover.

[1] S. Jochim et al., Science 302, 2103 (2003); Published online 13 November 2003; 10.1126/science.1093280

[2] M. Bartenstein et al., Phys. Rev. Lett. 92, 120401 (2004).

[3] M. Bartenstein et al., Phys. Rev. Lett. 92, 203201 (2004).

[4] C. Chin et al., Science 305, 1133 (2004); Published online 22 July 2003;

AOS WEA13
Wednesday 1120–1140 hrs

Optimal Estimates and Joint Measurement Uncertainty Relations

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Consider an estimate of some quantum observable, A, made on the basis of the measurement of a second observable, $M=\Sigma_m\, m\, |m><m|$, on quantum state $|\varphi>$. There is a fundamental lower bound for the inaccuracy of any such estimate[1]:

$$< (A-A_{est})^2 > \geq \Sigma_m\, [\mathrm{Im} <m|A|\varphi>/<m|\varphi>]^2 ,$$

which is far stronger than the Heisenberg uncertainty relation for A and M. The lower bound is achievable when the state prior to measurement is known, yielding an 'exact' uncertainty relation. Applications include optimal quadrature estimates from heterodyne detection.

Further, any measurement M can be used as the basis for simultaneously estimating the values of any two observables A and B (this is the most general possible definition of a joint measurement). Universal joint uncertainty relations have been obtained for such pairs of estimates, and applied to joint measurements on EPR-correlated particles[1].

[1] M.J.W. Hall, Phys. Rev. A, 69, 052113 (2004)

AOS WEA14
Wednesday 1140–1200 hrs

Bose-Einstein Condensates on Atom Chips

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Atom chips are a reliable and versatile tool for the production and control of Bose-Einstein Condensates (BECs). They also offer the possibility of realising new, chip-based quantum devices. We have recently produced BECs on an atom chip fabricated with silver foil[1]. Because of its high current capacity, our chip can produce moderately tight traps at distances further from the chip surface, avoiding losses and fragmentation of condensates seen on other experiments[2,3]. We will also report on our progress towards efficient atom detection using a STIRAP based photoionisation scheme.

[1] C. J. Vale et al., J. Phys. B 37, 2959 (2004)

[2] M. P. A. Jones et al., Phys. Rev. Lett 91, 080401 (2003)

[3] J. Estéve et al., Preprint physics/0403020 (2004).

AOS WEA15
Wednesday 1200–1220 hrs

Vortices in Bose-Einstein Condensates Confined by Optical Lattices

E. A. Ostrovskaya[1,2], T. J. Alexander[1,2], A. A. Sukhorukov[1], and Yu. S. Kivshar[1,2]

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We study the band-gap spectrum and nonlinear localization of coherent matter waves in two- and three-dimensional periodic potentials formed by optical lattices. We predict the existence and dynamical stability of gap vortices[1]—novel types of matter-wave solitons with a phase singularity, localized within a complete Bragg-reflection gap of a multidimensional periodic structure.

Stability of localized vortices of truly three-dimensional nature as well as of two-dimensional vortex lines in three-dimensional lattices is considered. Finally, we explore possible routes to dynamical generation of gap vortices in "square" optical lattices from the viewpoint of current experimental capabilities.

[1] E. A. Ostrovskaya and Yu. S. Kivshar, Phys. Rev. Lett. 93 (2004), in press.

POSTERS

AOS PWE 1

Athermal Birefringence in a Photonic Crystal Fibre

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A highly birefringent (HiBi) photonic crystal fibre (PCF) has been characterised as a function of temperature. Temperature independent birefringence was observed from –25 to 800°C. PCFs that offer the design flexibility for special properties such as birefringence but without the need for athermal packages may greatly reduce the manufacturing costs of some photonic devices. The fibre was characterised with an improved, all fibre, crossed polariser configuration that operates in reflection rather than transmission[1]. This configuration allowed the entire test fibre sample to be placed inside a 600mm long tube furnace, as alignment optics were not required.

[1] Ortigosa-Blanche, J.C. Knight, W.J. Wadsworth, J.Arriaga, B.J.Mangan,T.A. Birks, and P.St.J. Russell, "Highly birefringent photonic crystal fibers," Opt. Lett. **25** (18), 1325–1327 (2000).

AOS PWE 2

Fano Resonance with Photonic Crystals

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Fano resonance[1] is well-known across different branches of physics as "asymmetric lineshape". We show the existence of Fano resonance in variety of Photonic Crystal configurations[2–3]. Based on the Fano-Anderson model, we study the Fano resonance as a simple "destructive interference" phenomenon, which manifests itself as "resonant reflection". This model gives a very good qualitative agreement with real numerical calculations of Photonic Cristals, and it can be used to show how to tune this resonance for a desired configuration.

[1] U. Fano, Phys. Rev., **124**, 1866 (1961).

[2] S. Fan, Appl. Phys. Lett,. **80**, 908 (2002).

[3] V. Lousse and J. P. Vigneron, Phys. Rev., B **69**, 155106 (2004).

AOS PWE 3

Selective Area Epitaxy of Quantum Dots

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We investigate selective-area-epitaxy (SAE) as a tool for selectively controlling the physical and optical properties of quantum-dots (QDs), aiming at integration of QD devices. MOCVD growth of InGaAs/InAs QDs on GaAs wafers patterned with pairs of SiO_2 stripes is studied. Atomic force microscopy and cathodoluminescence are used for characterisation of these QDs. We show that InGaAs QD luminescence can be tuned over a range of 100nm by varying the dimensions of and/or spacings between the SiO_2 stripes. Growth of InGaAs quantum-well and QDs on different parts of the same wafer, without using etch and regrowth techniques is also demonstrated. Results for the InAs/GaAs system are also presented.

AOS PWE 4

Surface Modes and Directed Emissions from Photonic Crystals

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A new twist in the study of surface modes in photonic crystals is the recent discovery of enhanced transmission and highly directed emission from photonic crystal waveguides using surface modes[1]. We demonstrate that by engineering the surface structure of photonic crystals we can control and enhance the directed emissions. These improvements are achieved by controlling the coupling to the surface and radiating modes, and by controlling the phase and amplitude of the diffracted light from the photonic crystal surface. Additionally, we suggest a method to provide control over the directed emission, through manipulation of the refractive index of the surface structure.

[1] E. Moreno, F. J. Garcia-Vidal and L. Martin-Moreno, Phys. Rev. B, **69**, 121402(R) (2004)

AOS PWE 5

High Power, Double-Clad, CW Nd:YAG Slab Laser

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We describe a new zigzag end-pumped, double-clad cw Nd:YAG slab laser. A five layer composite slab and pump geometry optimises the gain distribution and thermal lens behaviour, while minimizing the effects of thermally induced birefringence. The power scalable slab design

supports a folded zigzag laser mode[1] and is side-cooled, with the top and bottom temperature controlled. It is designed to produce >100W single frequency diffraction-limited output for remote sensing applications in general and for the Australian Consortium for Interferometric Gravitational Astronomy (ACIGA), in particular. Lasing performance will be reported.

[1] J. Richards and A. McInnes, *Opt. Lett.* **20**, 371, 1995.

AOS PWE 6

Radiation Dynamics in Tapered Photonic Crystal Fibres

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Photonic crystals were originally conceived of to suppress spontaneous emission within the structure[1]. We report the transverse optical characterisation of tapered hollow-core photonic crystal fibre, in order to study spontaneous emission of dye molecules from the hollow core of the fibre. Broadband transmission measurements of the structure have been carried out in tapered fibres, and weak stopgaps have been observed and compared to theoretically predicted stopgaps. After selectively introducing laser dye into only the central hole of the fibre, we observe the effect of the stopgaps on the fluorescence spectra.

[1] E. Yablonovitch, *Phys Rev Lett* **58**, 2059–2062 (1987)

AOS PWE 7

Control and Steering of Gap Solitons in Optically-induced Lattices

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Optical gap solitons exist in the transmission gaps of nonlinear periodic structures, where no linear waves can propagate. They possess unique properties not present for conventional solitons, and hold promises for realizing of novel schemes for light control. By inducing a periodic structure in a biased photorefractive crystal and using a two-beam excitation scheme, we excited immobile spatial gap solitons[1]. This opens the possibility to study their unique properties. In this work we demonstrate the interaction of gap solitons with beams originating from other bands and test the possibilities to control gap solitons mobility by modifying the magnitude of the refractive index modulation. We believe this opens the way for realizing novel all-optical switching devices.

[1] D. Neshev, A. A. Sukhorukov, B. Hanna, W. Krolikowski, and Yu. S. Kivshar, Phys. Rev. Lett. **93**, 083905(4) (2004).

AOS PWE 8

Application of Cascaded Four-Wave Mixing to Optical Signal to Noise Monitoring

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Monitoring the signal to noise ratio of an optical signal (OSNR) is important to maintaining high-speed optical networks. At ultra-high bit-rates, when electronics are no longer practical, OSNR monitoring will be performed using optical techniques. We propose an OSNR monitor based on ultra-fast nonlinear effects in an optical parametric amplifier (OPA). OPAs generate cascaded four-wave mixing terms which have a quadratic response to the input signal[1,2], allowing the OSNR of the signal to be monitored through a simple average power measurement[3]. Experiments show that changing the OSNR produces an error function response from cascaded four-wave mixing at the OPA output.

[1] T. Ng, J. Blows, J. Mok, P. Hu, J. Bolger, P. Hambley and B. Eggleton, Opt. Exp., **11**, 3122 (2003).

[2] T. Ng, J. Blows, J. Mok, R. McKerracher and B. Eggleton, J. Lightwave Technol. *(in Press)*

[3] S. Wielandy, M. Fishteyn and B. Zhu, J. Lightwave Technol., **22**, 784 (2004)

AOS PWE 9

Entangled Photonic Qutrits

R. B. Dalton, N. K. Langford, M. D. Harvey, J. L. O'Brien, G. J. Pryde. A. Gilchrist, S. D. Bartlett, and A. G. White

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We produce and holographically measure entangled qutrits encoded in transverse spatial modes of single photons[1]. With the novel use of a quantum state tomography method that only requires two-state superpositions, we achieve the most complete characterization of entangled qutrits to date. Ideally, entangled qutrits provide better security than qubits in quantum bit commitment: we model the sensitivity of this to mixture and show experimentally and theoretically that qutrits with even a small amount of decoherence cannot offer increased security over qubits. Finally, we implement an entanglement concentration protocol.

[1] N K Langford, R B Dalton, M D Harvey, J L O'Brien, G J Pryde, A Gilchrist, S D Bartlett and A G White, Phys. Rev. Lett. **93**, 053601 (2004)

AOS PWE 10

Small Quantum Circuits for Optical Quantum Computing

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The recent demonstration of a non-deterministic two-photon controlled-NOT gate[1,2] paves the way for the realisation of simple quantum circuits[3]. We have designed and experimentally implemented an interferometer-free simplified CNOT gate operating according to the same principles. The advantage comes from using custom-designed partially polarising beam splitters that operate asymmetrically on the two polarisation modes of the qubits. We describe the performance of this CNOT gate in isolation and in simple quantum circuits designed to generate multi-qubit cluster state entanglement. Cluster state generation is the starting point for measurement based optical quantum computing[4].

[1] J L O'Brien, G J Pryde, A G White, T C Ralph and D Branning, Nature **426**, 264 (2003)

[2] J L O'Brien, G J Pryde, A Gilchrist, D F V James, N K Langford, T C Ralph and A G White, Phys. Rev. Lett. **93**, 080502 (2004)

[3] T C Ralph, Phys. Rev. A **70**, 012312 (2004)

[4] M A Nielsen, Phys. Rev. Lett. **93**, 040503 (2004)

AOS PWE 11

Quantum Phase-space Analysis of the Pendular Cavity

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Using the positive-P representation, we show that, in the analysis of an optical cavity with one oscillating mirror, the quantum state of the mirror must be taken into account. This is somewhat surprising as the mirror is a macroscopic object, but we show that linearised analyses which treat the mirror as a classical object can lead to faulty predictions. This work may be of importance for proposed gravitational wave detectors.

AOS PWE 12

Ultra-Narrowband, Nanosecond-Pulsed OPO-OPA Spectroscopic System

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A novel nonlinear-optical source of pulsed tunable coherent light is designed for wide-ranging applications to high-resolution spectroscopy from the mid-infrared to the vacuum ultraviolet. It comprises a periodically poled $KTiOPO_4$ optical parametric oscillator (OPO) and one or more $LiNbO_3$ optical parametric amplifier (OPA) stages. The high-performance injection-seeded OPO generates continuously tunable narrowband output pulses with ~25-ns duration and ~18-MHz Fourier-transform-limited optical bandwidth. Optical heterodyne techniques are used to control its frequency chirp (as low as ~10 MHz)[1] and to optimise its single-longitudinal-mode operation[2]. Recent experiments indicate that OPA stages do not degrade this performance appreciably.

[1] R.T. White, Y. He, B.J. Orr, M. Kono and K.G.H. Baldwin, Opt. Lett., **28**, 1248 (2003); J. Opt. Soc. Am. B, **21**, 1577 (2004); J. Opt. Soc. Am. B, 21, 1586 (2004)

[2] R.T. White, Y. He, B.J. Orr, M. Kono and K.G.H. Baldwin, submitted to Optics Express (September 2004)

AOS PWE 13

Rotational Microrheology

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To investigate the local viscoelastic response of a complex fluid, such as a polymer network, a microscopic probe particle is necessary. Such particles can be manipulated using optical tweezers[1]. Translational motion of a trapped particle can probe the rheology of the surrounding fluid[2,3,4], however the optical properties of the surrounding must be determined to make any measurements. We measure rotational motion of a birefringent particle by monitoring the polarisation of the trapping beam, with the advantage that the torque on the particle depends only on the refractive indices of the probe particle[5].

[1] A. Ashkin, J.M. Dziedzic, J.E. Bjorkholm, and S. Chu, Opt. Lett. **11**, 288 (1986).

[2] F. Gittes, B. Schnurr, P.D. Olmsted, F.C. MacKintosh, and C.F. Schmidt, Phys. Rev. Lett. **79**, 3286 (1997).

[3] T.G. Mason, K. Ganesan, J.H. van Zanten, D. Wirtz, and S.C. Kuo, Phys. Rev. Lett. 79, 3282 (1997).

[4] J.C. Crocker, M.T. Valentine, E.R. Weeks, T. Gisler, P.D. Kaplan, A.G. Yodh, and D.A. Weitz, Phys. Rev. Lett. **85**, 888 (2000).

[5] A. I. Bishop, T. A. Nieminen, N. R. Heckenberg, and H. Rubinsztein-Dunlop, Phys. Rev. Lett. **92**, 198104 (2004).

AOS PWE 14

Multipartite Entanglement in Quantum Optics

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According to Schrödinger, entanglement is “the characteristic trait of quantum mechanics”. It is also a resource that allows us to perform technological feats that are impossible within classical physics.

In this paper, we investigate the multipartite entanglement (entanglement involving three or more particles) present in a certain pure state involving numerous trapped atoms. The state is analogous to the steady-state intracavity state of the optical parametric amplifier. We show that it possesses interesting multipartite entanglement, which we then partially quantify.

We also explore multipartite entanglement constrained by superselection rules, showing how they reduce the amount of entanglement present in practice.

AOS PWE 16

Method of Improving Coupling Efficiency between Laser Diodes and Tapered Single Mode Optical Fiber

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This paper discusses a method to change the hemispherically lensed tapered single mode fiber’s (SMF) numerical aperture (NA) to improve coupling efficiency from a 1550 nm wavelength laser diode (LD). The tapered lenses were fabricated using a fusion splicer and modified using chemical etching. From the work, we have experimentally observed an improvement of coupling efficiency as high as 11.46% from its initial coupling value. The results indicate that the combination of both these techniques allow for a further increase in the coupling efficiency between the LD and SMF tapered fiber as compared to just tapering alone.

AOS PWE 17

Phase-modulation Interferometry for the Detection of Bose-Einstein Condensates

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Bose-Einstein Condensate dynamics have been extensively studied[1], but most experimental detection systems lead to condensate destruction. Non-destructive and highly sensitive techniques are essential for the understanding and achievement of a number of outstanding problems in cold atom physics, including the production of a continuous atom laser[2]. We propose here a non-destructive, high-speed continuous detection scheme for Rb BEC dynamics using phase-modulation interferometry. By using a heterodyne detection technique with a strong local oscillator and very low noise photodetectors we expect to achieve a shot-noise limited measurement of the BEC density fluctuations.

[1] W. Ketterle *et al.*, PRL **77**, 998 (1996)

[2] J. Lye *et al.*, PRA **69**, 023601 (2004)

AOS PWE 18

Mode-matching Effects in Linear Optics Quantum Computing

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We construct a model of a linear optics quantum computing controlled-NOT gate, which allows for arbitrary mode-matching effects. The model is shown to have superior predictive power over existing, ideal gate models. Using the model we demonstrate that it is possible to non-intrusively estimate the mode-matching characteristics of experimental gates, a powerful diagnostic tool. The model relies on parameters with an elegant, direct physical interpretation. The techniques described are non-specific and could easily be applied to other optical circuits.

AOS PWE 19

Beam Quality from a Large Mode Area Fibre Laser

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The quality of a laser beam can be described in a number of ways but the single figure most commonly used is the M^2 parameter which measures the product of spatial variance of the beam at its waist and angular variance of the beam departing from the waist. Most discussions of this parameter are restricted to Laguerre-Gaussian beams from bulk lasers. But with the growing importance of fibre lasers, it is necessary to understand how M2 varies for different fibre designs and operating regimes. We will present results on the calculation of M2 for several high-power fibre laser designs.

AOS PWE 20

Continuous Quantum Error Correction

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Quantum error correction is an essential ingredient for quantum computation. The standard descriptions of how to implement active error correction assume ideal resources such as projective measurements and instantaneous gate operations. Unfortunately in practice such resources are not realizable in most quantum computing architectures. Motivated by this we examine schemes for implementing active error correction that use a more modest set of resources. This leads to new implementations of error correction that are continuous in time, and thus described by continuous dynamical maps. We evaluate the performance of such schemes using numerical simulations and comment on the applicability and effectiveness of continuous error correction for quantum computing.

AOS PWE 21

Superradiant Scattering from a Hydrodynamic Vortex

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We show that sound waves scattered from a hydrodynamic vortex may be amplified. Such superradiant scattering follows from the physical analogy between spinning black holes and hydrodynamic vortices[1]. However a sonic horizon analogous to the black hole event horizon does not exist unless the vortex possesses a central drain, which is challenging to produce experimentally. In the astrophysical domain superradiance can occur even in the absence of an event horizon: we show that in the hydrodynamic analogue, a drain is not required and a conventional vortex scatters sound superradiantly. Possible experimental realisation in dilute gas Bose-Einstein condensates is discussed[2].

[1] M. Visser, in *Artificial Black Holes*, edited by M. Novello, M.Visser and G. Volovik (World Scientific, Singapore, 2002).

[2] L.J. Garay, J.R. Anglin, J.I. Cirac, and P. Zoller, Phys. Rev. Lett. **85**, 4643 (2000); Phys. Rev. A **63**, 023611 (2001).

AOS PWE 22

Near-Field Optical Properties of Thin Randomly Nanostructured Silver Films

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We will present AFM-SNOM measurements for randomly structured thin silver films, prepared by inverse nanosphere lithography to create circular holes in the metal film. Care is taken to create continuous films, which show none of the “worm”-like structures of semi-continuous metal films. Two sphere/hole concentrations are studied. The higher hole concentration samples show a strong similarity between the near-field intensity and topology, while the low hole concentration samples show almost no correlation between intensity and topology, but rather wave-like patterns which originate from surface protrusions or holes. Possible mechanisms and reasons for the differences will be discussed.

AOS PWE 23

Coherent Blue Light from a Rubidium Vapour Cell

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We have demonstrated efficient production of 420nm blue light from a rubidium vapour cell, using the method of Zibrov et al.[1]. An atomic coherence is created in the vapour using two infrared low-power (~10mW) lasers tuned to the two-photon 5S-5P-5D step transition in Rb. Some atoms decay to the 6P level and then via 420nm emission to the ground state. The latter is coherently amplified because the ground state is effectively unpopulated. We have measured the optical coherence of the 420nm output by two-slit diffraction, and modelled the system using semiclassical optical Bloch equations.

[1] AS Zibrov, MD LUkin, L Hollberg and MO Scully, Phys. Rev. A **65**, 051801 (2002)

AOS PWE 24

Frequency Feedback Control Theory for External Cavity Diode Lasers

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External cavity diode lasers are an integral component of many experiments in physics and chemistry. Such lasers have short-term linewidths of below 100kHz, but typically achieve linewidths not much better than 2 MHz for measurement times of a few seconds, even when locked to an atomic or molecular reference. We have carefully investigated the origins of the frequency noise[1], and applied detailed control theory to design an effective two-channel servo feedback system. Our implementation provides a robust and user-friendly controller with dramatically improved performance.

[1] LD Turner, KP Weber, CJ Hawthorn, RE Scholten, Opt. Commun. **201** 391 (2002)

AOS PWE 25

Diffraction-contrast Phase Imaging of Cold Atoms

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Diffraction of coherent light is inherently invertible: that is, if a known propagating field is scattered by an object and then measured after some distance, it is possible to computationally back-propagate and determine the field at the object, and hence determine the object structure. In practice, only the intensity of a field can be measured and thus the inversion is not unique, leading to Gabor's famous twin image problem. We show that, for *monomorphous* objects in which both the phase retardance and absorption are linearly related to the object density, the propagation can be linearised and algebraically inverted (in Fourier space). That is, the object structure can be retrieved from a single diffracted intensity image, with no optical elements such as lenses, apertures or phase retarders. The method is valid for weakly-absorbing objects and is particularly well suited to non-destructive imaging of cold atom clouds. It is inherently aberration free, quantitative, and has holographic depth of field, allowing post-acquisition refocussing.

AOS PWE 26

An Achromatic Lens for Atoms

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Light can be used to focus thermal neutral atom beams to nanometre-scale dimensions[1,2]. We demonstrate a simple lens for atoms based on a travelling TEM01-mode light field[3]. The lens is more convenient than previous simple lenses[1] because it uses light propagating perpendicular to the atomic beam rather than coaxially. By tilting the lens, the Doppler effect can be used to compensate chromatic aberrations[3]. We present detailed trajectory simulations and experimental results for focussing a slightly supersonic atom beam.

[1] JJ McClelland and MR Scheinfein, J Opt Soc Am B **8**, 1974 (1991)

[2] JJ McClelland, RE Scholten, EC Palm and RJ Celotta, Science **262**, 877 (1993)

[3] RE Scholten, TJ O'Kane, TR Mackin, TA Hunt and PM Farrell, Aust J Phys **52**, 493 (1999)

[4] M Drewsen, RJC Spreeuw, and J Mlynek, Opt Commun **125**, 77 (1996)

AOS PWE 27

Quantum Computing Using Fully Concentrated Crystals Containing Europium

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The main obstacle to quantum computing experiments using ensembles of solid state optical centres is the residual randomness in the ensemble[1]. In earlier work we have demonstrated one and two qubit quantum gate operations using crystals randomly doped with rare-earth ions[2,3]. In these demonstrations the disorder in the ensemble was removed using optical pumping techniques. These techniques have little scope for scaling. To scale to higher qubit numbers we propose to produce highly order ensembles using fully concentrated samples. In this work we describe the growth and characterization of $EuCl_3.6(H_2O)$ and report on its suitability for quantum computing.

[1] M. J. Sellars, E. Fravel, and J. J. Longdell, "Investigation of static dipole-dipole coupling induced optical inhomogeneous broadening in in Eu^{3+}:Y_2SiO_5", **J of Lumin. 107**, 150–154 (2004)

[2] J.J. Longdell, and M. J. Sellars, "Experimental demonstration of quantum-state tomography and qubit-qubit interactions for rare-earth-ion-based solid-state qubits", **Phys. Rev. A, 69**, 032307–311(2004).

[3] J. J. Longdell, M. J. Sellars, and N. B. Manson , "Demonstration of Conditional Quantum Phase Shift Between Ions in a Solid", **Phys. Rev. Lett. 93**, 130503 (2004)

AOS PWE 28

Experimental Demonstration of Arm-Locking for the Laser Interferometer Space Antenna

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The Laser Interferometer Space Antenna is a space-based gravitational wave detector[1]. In this interferometer the free-running laser frequency noise is so enormous in the gravitational wave signal that a combination of techniques will likely be needed to remove it. Recently an additional technique for stabilization of the laser frequency to interferometer arm-lengths was proposed[2]. We present results from an experiment which stabilizes the frequency of a Nd:YAG NPRO laser to a Mach-Zehnder interferometer with an optical path length difference of 30 km. The control bandwidth encompasses approximately a hundred nulls in the interferometer frequency response, demonstrating the arm-locking technique.

[1] The LISA Study Team *Laser Interferometer Space Antenna for the detection and observation of gravitational waves: Pre-Phase A Report, 2nd Edition* Max-Plank-Institüt für Quantenoptik **MPQ233** (1998).

[2] B.S. Sheard, M.B. Gray, D.E. McClelland, and D.A. Shaddock, Phys. Lett. A, **320**, 9 (2003)

AOS PWE 29

Analytic Properties of Photonic Crystal Superprims

M. J. Steel[1,2], R. Zoli[2,3], C. Grillet[2], R. C. McPhedran[2], C. M. de Sterke[2], A. Norton[4], P. Bassi[3], and B. J. Eggleton[2]

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We study the analytic properties of the photonic crystal superprism resolution parameters introduced by Baba *et al*[1]. We find closed form expressions for these quantities that greatly simplify their accurate evaluation and lead to significant insights about their behaviour. The expressions reveal general properties of the parameters which are true for all bands and all photonic crystals. In this way, we demonstrate that all three exhibit infinite resolution at certain points in any photonic band. Moreover, the angular resolution parameter p is shown to be given by the product of a Snell's law factor and the curvature of the equi-frequency contours.

[1] T. Baba and T. Matsumoto, Appl. Phys. Lett., **81**, 2325 (2002)

AOS PWE 30

The Orbital and Spin Components of the Angular Momentum of a General Electromagnetic Field

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By means of the Helmholtz theorem, the angular momentum of the general classical electromagnetic field is decomposed, in a general and manifestly gauge invariant manner, into a spin component and an orbital component.

AOS PWE 31

Fibre Optic Distributed Temperature Sensor (DTS) with Integrated Background Correction Function

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Distributed temperature sensing based on Raman scattering in optical fibres is now a relatively mature technology. However, more widespread industrial application of the technology continues to be restricted by cost, accuracy and fibre degradation issues. We report a prototype DTS system that incorporates optical time-domain reflectometry functionality for fibre background corrections. The system is cost competitive as it is based on a single, fixed optical filter and a single light source for both measurement modes. This arrangement has been shown to provide an accuracy of about 1–2˚C over distances of 2–3 km, independent of fibre transmission fluctuations and environmental changes.

AOS PWE 32

Coherence Controlled Soliton Interactions

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Spatial optical solitons are nonlinear localized beams which do not diffract[1]. Solitons interact as particles, and may experience mutual attraction or repulsion depending on the relative phase. We demonstrate theoretically and subsequently observe in experiment a novel type of soliton interaction when a pair of closely spaced spatial optical solitons as a whole is made *partially incoherent*. We explain how the character of the soliton interaction can be controlled by the total partial incoherence, and show a

possibility to change the soliton interaction from attractive to repulsive, or vice versa, near a certain threshold in the coherence parameter.

[1] Yu. S. Kivshar and G. P. Agrawal, Optical Solitons: From Fibers to Photonic Crystals (Academic Press, San Diego, 2003).

AOS PWE 33

Packing Density in Conventional Waveguides and Photonic Crystals

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Waveguides that are in close proximity to each other exhibit evanescent coupling. While crucial in the operation of directional couplers, here we consider a situation in which this effect is minimized, so that light in the waveguides propagates essentially independently. Subject to this condition, we compare the minimum mutual distance between conventional planar waveguides and waveguides in one-dimensional photonic crystals, to find which of these guides can be spaced more closely. Using Bloch-mode analysis for photonic crystal based waveguides[1] and standard analytical results for conventional structures, we find that photonic crystal waveguides can be packed more tightly.

[1] P. Yeh, A. Yariv, and C-S. Hong, *J. Opt. Soc. Am.*, **67**, 423 (1977).

AOS PWE 34

Coupling between Low Index Dissimilar Defects in Photonic Crystals

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Photonic crystals containing multiple defects exhibit interesting coupling behaviour. We investigate coupling between low index (dissimilar) defects in periodic media using two models. This situation is not possible in conventional waveguides where a high index core guides the light. We obtain coupling from a fundamental mode to another fundamental mode or a higher-order one. We study a 1D model and another based on a square lattice of rods. We compare coupling lengths with high-to-high index cases[1,2]. The field width can be changed considerably. This work can allow realization of new types of spot size converters and mode converters.

[1] S. Tomljenovic-Hanic and A. Ankiewicz, *Optics Communic.*, **237**, 351, (2004).

[2] S. Tomljenovic-Hanic and A. Ankiewicz, *ICTON*, Wroclaw, Poland, **1**, 105 (2004).

AOS PWE 35

Correlations in Synchrotron Beams Measured using Phase-space Tomography

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Understanding coherent properties of photon beams is crucial for information retrieval processes. For thermal sources, the second-order correlation function (or the mutual coherence function) gives all extractable information, of both the source and the object, contained in the beam. We will discuss our recent investigations of coherence properties of x-ray beams produced from a third generation synchrotron using the phase-space tomography technique. The results are far more complete and accurate compared to those obtained from alternative techniques.

AOS PWE 36

The He* LVIS: An Ultracold Metastable Atomic Beam

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We present the results of experiments on a compact He* MOT experiment and “Low Velocity Intense Source” (LVIS) of metastable helium atoms. Our system produces up to 7 x 109 He* atoms/sec at a velocity of ~ 30 m/s, making it the coldest continuous beam of metastable He atoms ever reported. The beam is ideal for loading metastable helium atoms into magnetic guides and traps, or delivering a high density beam to electron scattering experiments.

AOS PWE 37

Pulse Propagation in a Medium with Opposite Signs of Self- and Cross-Phase Modulation Terms

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We study the pulse dynamics in the modified Manakov model with different signs of cross-phase and self-phase modulation. Depending on the signs on the nonlinear terms the system describes wave propagation in the medium with either focusing or defocusing nonlinearity. The mixed case is also possible. In all of these cases, the equations are integrable. The initial value problem can be

solved using the inverse scattering transform technique. We calculated the asymptotic values of soliton parameters as well as the field profile in the non-solitons regime at large distances of propagation.

AOS PWE 38

Planar Microcavity Modes Observed in Woodpile Type Void Channel Photonic Crystal Lattices

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Woodpile-type photonic crystals consisting of stacks of submicron-size void channels generated in a transparent solid polymer using femtosecond-pulsed focused laser light feature pronounced photonic bandgaps at mid-infrared wavelengths[1,2]. The introduction of localised microcavities into these structures is an important step towards the realisation of photonic crystal micro-devices. Here we report on woodpile-type photonic crystal structures with planar microcavities. Woodpile-type cavity structures were fabricated, then examined spectroscopically and exhibited a sharp mode peak in transmission within the main photonic bandgap. By varying the planar cavity height, the position of the peak could be tuned throughout the bandgap.

[1] M. J. Ventura, M. Straub, and M. Gu, Appl. Phys. Lett. **82**, 1649 (2003).

[2] M. Straub, M. Ventura, and M. Gu, Phys. Rev. Lett. **91**, 043901 (2003).

AOS PWE 39

Quantum Cryptography without Switching of Measurement Basis

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Quantum cryptography[1] is a form of secret communication between two parties that guarantees absolute security. The original quantum cryptography scheme was developed in 1984 which utilised discrete variables[2] while a continuous variable version was conceived in 1999[3]. One common step of both these protocols involves the random switching of measurement bases by one party. We present a new continuous variable quantum cryptography protocol that does not require random switching. Furthermore we show that the elimination of switching results in a significantly higher secret key rate than any other known quantum cryptographic protocol[4].

[1] N. Gisin, G. Ribordy, W. Tittel, and H. Zbinden, Rev. Mod. Phys. **74**, 145 (2002)

[2] C. H. Bennett and G. Brassard, in *Proceedings IEEE International Conference on Computers, Systems and Signal Proceedings (Bangalore)* (IEEE, New York, 1984), pp. 175–179; S. Wiesner, SIGACT News **15**, 78 (1983).

[3] T.C. Ralph, Phys. Rev. A **61**, 010303 (1999).

[4] Our work has been accepted for publication in *Phys. Rev. Lett.* (ls9383 2004).

AOS PWE 40

Small Quantum Circuits for Optical Quantum Computing

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The recent demonstration of a non-deterministic two-photon controlled-NOT gate[1,2] paves the way for the realisation of simple quantum circuits[3]. We have designed and experimentally implemented an interferometer-free simplified CNOT gate operating according to the same principles. The advantage comes from using custom-designed partially polarising beam splitters that operate asymmetrically on the two polarisation modes of the qubits. We describe the performance of this CNOT gate in isolation and in simple quantum circuits designed to generate multi-qubit cluster state entanglement. Cluster state generation is the starting point for measurement based optical quantum computing[4].

[1] J L O'Brien, G J Pryde, A G White, T C Ralph and D Branning, Nature 426, 264 (2003)

[2] J L O'Brien, G J Pryde, A Gilchrist, D F V James, N K Langford, T C Ralph and A G White, Phys. Rev. Lett. 93, 080502 (2004)

[3] T C Ralph, Phys. Rev. A 70, 012312 (2004)

[4] M A Nielsen, Phys. Rev. Lett. 93, 040503 (2004)

AOS PWE 41

Atom Interferometry with an Asymmetric Double-well Potential

S. M. Whitlock, F. Scharnberg, B. J. Dalton, T. Kieu, B. R. Hall, R. J. McLean, P. Hannaford and A. I. Sidorov

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The creation of Bose-Einstein condensates using microfabricated magnetic structures has stimulated a great interest towards the implementation of an on-chip atom interferometer. We discuss the effect of asymmetric potentials on single atom double-well interferometry. A small asymmetric component to the double-well potential has a negative influence on interference contrast. A Bloch sphere model adequately describes the dynamics of the interferometer within the two-mode approximation. Full numerical simulations of the time-dependent Schrödinger equation highlight multi-mode effects. The study finds optimal conditions for splitting and recombination processes for a broad range of asymmetries.

AOS PWE 42

Towards Robust Quantum Feedback Control for Cooling and Confinement

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The continuous position measurement of an atom in a cavity is described by a stochastic master equation (SME), and under a gaussianity assumptions, is described by the evolution of a five parameter gaussian state[1]. There exists an exact correspondence with the LQG problem[2], for which the Kalman filter, or best state estimate, is the solution. Here the SME corresponds to the Kalman filter for a classical particle in a noisy potential with a noisy signal. Classical robust control is applied to the corresponding classical system, while a quantum formulation of robust control[3] is applied to the SME. A distinction is noted in the resulting modified Kalman filters.

[1] A.C. Doherty and K. Jacobs, Phys. Rev. A,**60**, 2700 (1999)

[2] H. Wiseman and A.C.Doherty, arXiv:quantum-ph/0408099, Sept. (2004)

[3] M.R. James, Phys. Rev. A, **69**, 032108 (2004)

AOS PWE 43

Collapsing Bose-Einstein Condensates beyond the Gross-Pitaevskii Approximation

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We investigate the collapse of a ^{85}Rb Bose-Einstein condensate, controlled by a Feshbach resonance[1], by numerically solving the equations of motion for the lowest order correlation functions in a case with spherical symmetry[2] as well as treating the condensate in the truncated Wigner approximation[3]. We are motivated by the observation, that the discrepancy between predictions of the Gross-Pitaevskii (GP) equation and experimental results for the collapse time could be attributed to the stronger mean field interaction between condensed and uncondensed atoms[4]. Our results show, that for realistic temperatures collapse occurs slightly accelerated, but exclude the explanation of the discrepancy as a finite temperature effect. Thus an open question remains: what explains the deviation of the measured collapse times from those predicted by GP theory?

[1] E.A. Donley *et al.*, Nature, **412**, 295 (2001)

[2] J.N. Milstein *et al.*, New. J. Phys., **5** 52 (2003)

[3] M.J. Steel *et al.*, Phys. Rev. A, **58**, 4824 (1998)

[4] C.M. Savage *et al.*, Phys. Rev. A, **67**, 014304 (2003)

AOS PWE 44

Modulational Instability in the Nonlocal (χ^2- model

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We investigate the modulational instability (MI) properties of the plane waves of the nonlocal χ^2– model formulated by Nikolov et. al.[1] as a function of the effective degree of nonlocality and the squared normalized carrier wave number. Regions in the parameter space for which fundamental gain band, higher order gain bands and modulational stability exist are identified. The stability results are shown to be consistent with MI of the full χ^2–model by means of a singular perturbational approach.

[1] N .I. Nikolov, D. Neshev, O. Bang and W. Krolikowski, Phys.Rev.E **68** 036614 (2003)

Joint AOS/AMPQC Session

AOS THA11
Thursday 1040–1120 hrs

New Physics with Degenerate Fermi Gases

G.V. Shlyapnikov

Laboratoire Physique Th\'eorique et Mod\`eles Statistiques, Universit\'e Paris Sud, B\^at. Orsay Cedex, France
Van der Waals—Zeeman Institute, University of Amsterdam, The Netherlands

I will discuss two-component ultracold atomic Fermi gases, on both sides of the Feshbach resonance for the interspecies interaction. On the side where the scattering length is positive, fermionic atoms of different species form weakly bound (vibrationally excited) molecules. I will show how the interaction between these bosonic molecules provides their remarkable collisional stability and supports Bose-Einstein condensation, observed in recent experiments. I then turn to mixtures of heavy and light fermions, such as fermionic isotopes of K and Li.

I will demonstrate that for a very large scattering length for the interaction between heavy and light atoms, the light fermions mediate an attractive long-range interaction between the heavy atoms, which provides new possibilities for superfluid pairing and phase transition.

AOS THA13
Thursday 1120–1140 hrs

See AMPQC THA13

Reflection of Dilute Gas Bose-Einstein Condensates off a Silicon Surface

A.M. Martin[1], R.G. Scott[2], T.M. Fromhold[2] and F.W. Sheard[2]

AOS THA14
Thursday 1140–1200 hrs

Limits to the Flux of a Continuous Atom Laser

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We present a detailed study of a quasi-continuous atom laser derived from a Bose-Einstein condensate (BEC). A previous investigation revealed that there is a trade off between flux and fluctuations in an atom laser due to complex interactions between the BEC and atom laser output[1]. A recent upgrade of our BEC apparatus has allowed us to extend this work into the weak-coupling regime of a quasi-continuous atom laser, allowing us to test the flux-limiting hypothesis of our previous strong coupling studies.

[1] Fluctuations and flux: The limits of multistate atom lasers, N. P. Robins , C. M. Savage , J. J. Hope , J. E. Lye , C. S. Fletcher , S. A. Haine , and J. D. Close, Phys. Rev. A 69 , 051602 (2004)

AOS THA15
Thursday 1200–1220 hrs

Dynamical Tunneling with Bose-Einstein Condensates on Atom Chips

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A generic feature of conservative classical dynamical systems with two or more degrees of freedom is that their trajectories form complicated phase-space structures where chaos and regular motion are closely intertwined. Among these structures are islands of regular motion that a classical system can not escape from but between which a quantum particle may tunnel.

Dynamical tunneling of ultra-cold atoms in standing wave has previously been observed[1,2] but deep inside the quantum dynamical regime. Here we investigate the prospects for improved experiments with Bose-Einstein condensates on atom chips that are closer to the classical regime. In particular we concentrate on the effect of classical chaos on the tunnelling, an issue of some controversy in the literature[3].

[1] W. K. Hensinger *et al.*, Nature **412**, 52 (2001).

[2] D. A. Steck, W. H. Oskay, and M. G. Raizen, Science **293**, 274 (2001).

[3] A. Mouchet and D. Delalande, Phys. Rev. E **67**, 046216 (2003) and references within.

AOS THA21
Thursday 1400–1420 hrs

Stable Phase Imaging and Measurement

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We present a novel interferometer based on polarising beam-displacers which enjoys common-mode rejection to translation of any constituent element in any direction. Consequently it has unparalleled stability without active locking. Further, the design has demonstrated intrinsically high visibility; we achieved visibilities of up to 99.6% in less than half a day from initial setup. Using our interferometer we implement a fringeless phase imaging technique based on taking Stokes' images[1]. We obtained phase profiles of a number of objects, including a hologram used to generate optical vortices. From these we estimate the resolution of the technique to be _/100[2].

[1] G.G. Stokes, Transactions of the Cambridge Philosophical Society **9**, 339 (1852).

[2] A. Gilchrist, M. D. Harvey, and A.G. White, *(in preparation)* 2004.

AOS THA22
Thursday 1420–1440 hrs

Experimental Study of Full-field Fourier-Domain Optical Coherence Tomography

A. V. Zvyagin[1,2], P. Blazkiewicz[1], P. M. Gourlay[1], J. R. Tucker[2], A. D. Rakic[2], M. Gujrathi[2]

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We report a new approach in optical coherence tomography (OCT) termed full-field Fourier-domain OCT (3F-OCT)[1]. A three-dimensional image of the sample is obtained by digital reconstruction of a three-dimensional data cube acquired using a Fourier digital holography recording system illuminated with a frequency-tunable (swept) laser source. A 3D-imaging performance of this system is demonstrated. Also, this paper presents theoretical and experimental study of signal-to-noise ratio of the full-field approach versus serial image acquisition approach, represented by 3F-OCT and "flying-spot" OCT systems, respectively.

[1] A. V. Zvyagin, Opt. Comm., in press (2004).

AOS THA23
Thursday 1440–1500 hrs

Impurity Centers in Solids: Suppression and Enhancement of Matrix Induced Dephasing in Strong Optical Fields

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Linewidths of impurity centers (ICs) in solids are broaden due to dephasing. One part of this dephasing determines the lifetime-limited linewidth $^1/T_1$. A second contribution to the dephasing $1/T^*_2$ is due to fluctuations in the surrounding matrix. The total dephasing rate $1/T^*_2 = 1/(2T_1) + 1/T^*_2$ and a Rabi frequency Ω_R enter the optical Bloch equations which describe an IC interacting with a laser field. However, if $1/\Omega_R$ is comparable to the correlation time of the matrix fluctuations, the Bloch equations break down. The measurements were done using single molecule spectroscopy. It is essential for interpretation, that contributions to the signal from molecules which have different transition frequencies do not obscure the effect.

AOS THA24
Thursday 1500–1540 hrs

When is a Transparent Particle not Transparent?

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Experimental laser cleaning of micron and sub-micron sized, spherical, silica particles from silica surfaces, using a UV pulsed excimer laser (KrF at 248 nm) have clearly shown the silica particles are highly absorbing, contrary to expectation based on the bulk material properties of silica. This is a positive result for developing methodologies for removing and manipulating small particles, including nano-particles, of "transparent" materials on surfaces. When the propagation of the UV laser radiation by the particle is modelled appropriately the high absorption is as predicted theoretically. The different optical properties of small particles is a subject of interest to nanotechnology.

AOS THA31
Thursday 1620–1640 hrs

Squeezing in the Audio Gravitational Wave Detection Band

Kirk McKenzie[1], Nicolai Grosse[2], Stanley E. Whitcomb[3], Malcolm B. Gray[1], Warwick P. Bowen[2], David E. McClelland[1] and Ping Koy Lam[2]

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Low frequency squeezing can improve the sensitivity of audio frequency measuring devices such as gravitational wave detectors. We demonstrate the generation of broad-band continuous-wave optical squeezing down to 280Hz using a below threshold optical parametric oscillator (OPO). We show that low frequency noise sources, such as seed noise, pump noise and detuning fluctuations, present in squeezed states generated by optical parametric amplifiers have negligible effect on squeezing produced by a below threshold OPO.

AOS THA32
Thursday 1640–1700 hrs

Universality for Quantum Computation of Many-Body Systems with Fast Local Control

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An important question in quantum information theory is, “What types of quantum dynamics are universal for quantum computation?” A good understanding of the answer will contribute to the practical design of quantum computers, as well as providing insight into the physics of information.

I present simple criteria for when a quantum system evolving under a fixed Hamiltonian can quantum compute. Specifically, a Hamiltonian acting on *n* systems of dimension *d* is universal for quantum computation (given fast local control) provided it can create entanglement between any two of the systems. Our techniques provide a constructive approach to performing quantum computation with such systems.

[1] M.J. Bremner, J.L. Dodd, M.A. Nielsen, D. Bacon, Phys. Rev. A, **69**, 012313 (2004)

[2] M.J. Bremner, D. Bacon, M.A. Nielsen, arXiv:quant-ph/0405115 (2004)

AOS THA33
Thursday 1700–1720 hrs

Classical Robustness of Quantum Unravellings

D.J. Atkins[1,2], Z. Brady[1], K. Jacobs[1,2] and H.M. Wiseman[1,2]

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In this work, we introduce three measures which quantify the degree to which quantum systems possess the robustness exhibited by classical systems when subjected to continuous observation. We apply these measures to two canonical systems (a single particle undergoing quantum Brownian motion and a two level atom in a cavity). Using these two systems, we show that for a fixed environmental interaction, the level of robustness depends on the measurement strategy, or unravelling and that no single strategy is maximally robust in all ways. We also apply this work to the feedback control of a quantum system.

AOS THA34
Thursday 1720–1740 hrs

Population Inversion in a Strongly Driven Two-level System

Andrew C. Doherty[1] , T. M. Stace[2] and S. D. Barrett[3]

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Efforts to find suitable physical systems for quantum information processing have renewed interest in driven two-level systems. For example, a recent experiment investigated microwave driving of a single electron in a double quantum dot[1]. In contrast to atomic systems, a regime where the Rabi frequency is comparable to the level splitting is readily achieved, requiring a more general analysis than standard quantum optical treatments. One result is that the system couples to its environment at widely separated frequencies. We show that the strong frequency dependence of coupling to phonons provides a possible mechanism for the population inversion observed experimentally[1].

[1] J. R. Petta, A. C. Johnson, C. M. Marcus, M. P. Hanson and A. C. Gossard, arXiv: cond-mat/0408139.

AOS THA35
Thursday 1740–1800 hrs

Quantum Nondemolition Measurement of the Polarisation of a Single Photon

J. L. O'Brien[1,2], G. J. Pryde[1,2], S. D. Bartlett[2], T. C. Ralph[1,2] and A. G. White[1,2]

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Measuring the polarisation of a single photon typically results in its destruction. We propose, demonstrate, and completely characterise a quantum non-demolition (QND) scheme for realising such a measurement non-destructively[1]. This scheme uses only linear optics and photo-detection of ancillary modes to induce a strong non-linearity at the single photon level, non-deterministically. We vary this QND measurement continuously into the weak regime, and use it to perform a non-destructive test of complementarity in quantum mechanics. Our scheme realises the most advanced general measurement of a qubit: it is non-destructive, can be made in any basis, and with arbitrary strength.

[1] G J Pryde, J L O'Brien, A G White, S D Bartlett and T C Ralph, Phys. Rev. Lett. 92, 190402 (2004)

AOS FRA11
Friday 0820–0840 hrs

Fabrication of Large Aperture Fabry Perot Etalons with Sub-nanometer Thickness Uniformity

J. Seckold, E. Puhanic, W. Stuart, K. Green, S. Dligatch, M. Gross, N. Pereira, R. Netterfield, B. Oreb, D. Farrant, I. Underhill, J. Arkwright

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Large aperture Lithium Niobate etalons are being increasingly used for Solar imaging spectroscopy. Lithium Niobate is a preferred material because it can be tuned electrically; however, it is notoriously difficult to polish to sufficient flatness. Variations in thickness cause the transmitted wavelength to vary across the etalon aperture, hence causing drop outs in the recorded image, and the effect is exacerbated when multiple etalons are cascaded to increase the spectral selectivity. We demonstrate a process of polishing and subsequent surface correction that can provide substrates with sub-nanometre rms thickness uniformity suitable for use in tandem etalon configurations.

AOS FRA12
Friday 0840–0900 hrs

Ultra High Throughput Optical Fiber Probes

S.T. Huntington[1], B.C. Gibson[1], S.P. Prawer[1], J.D. Love[2], J. Canning[3], K. Lyytikainen[3], A. Lewis[4], S. P. Jarvis[5]

1. NANO-MRNF, School of Physics, University of Melbourne, Australia; 2. Applied Photonics Group, RSPSE, Australian National University, Australia; 3. Optical Fibre Technology Centre, University of Sydney, Australia; 4. Centre of Nanoscience and Nanotechnology, Hebrew University, Jerusalem, Israel; 5. SFI Physics Department, Trinity College, Dublin, Ireland

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During the course of the past 20 years, the Near-field Scanning Optical Microscope (NSOM) has undergone numerous improvements. However, the near-field probe itself still represents the limiting component for the system. We tackle the issue of excessive loss by reducing the interaction between the transmitted light and the probes metal coating. Using a combination of Holey Fibre technology and a new type of fibre called a Fractal Fibre we have fabricated a prototype of a new type of ultra high throughput probe that will maximize the potential of the Near-field Scanning Optical Microscope.

AOS FRA13
Friday 0900–0920 hrs

TEM_{10} Homodyne as an Optimal Small Displacement Measurement Scheme

V. Delaubert, M.T.L. Hsu, W.P. Bowen, H.-A. Bachor and P.K. Lam

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Using multi-modal analysis, we derive a quantum noise limit (QNL) for optical beam displacement. We present a scheme, involving the homodyne detection of higher order Hermite-Gauss modes, for the optimum measurement of small displacement at the QNL. In the case of Gaussian TEM_{00} beam displacement, homodyne detection with a TEM_{01} mode local oscillator is demonstrated to be optimal[1]. We also show that displacement measurement using split detectors, which is the conventional method for beam displacement measurements, is not optimal. Finally, we show that using squeezed light of appropriate spatial mode the QNL for beam displacement can be surpassed allowing sensitivity beyond the diffraction limit of light[2–4].

[1] M.T.L.Hsu, V.Delaubert, P.K.Lam and W.P.Bowen ; quant-ph/0407209.

[2] N.Treps, U.Andersen, B.C.Buchler, P.K.Lam, A.Maitre, H.-A.Bachor and C.Fabre, Phys.Rev.Lett., 88, 203601 (2002).

[3] N.Treps, N.Grosse, W.P.Bowen, C.Fabre, H.-A.Bachor and P.K.Lam, Science, 301, 940 (2003).

[4] N.Treps, N.Grosse, W.P.Bowen, M.T.L.Hsu, A.Maitre, C.Fabre, H.-A.Bachor and P.K.Lam, J.Opt.B 8, 664 (2004).

AOS FRA14
Friday 0920–1000 hrs

Optical Phased Array Technology Development

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Optical phased arrays can provide random access beam steering with no moving parts. Traditionally microwave phased arrays use individual transmit / receive modules. Due to a 4 orders of magnitude change in wavelength it is easier to implement one dimensional phase shifters to steer an optical beam which has already been formed. The main method used for phase modulation has been liquid crystal technology due to the large available change in index of refraction. Other approaches, such as micro-mirrors can also be used. It is difficult to obtain half wavelength spacing of controllable apertures so basic non-mechanical steering approaches are limited to < 10 degrees. Holographic glass or bi-refringent prisms, or other techniques, are then used to increase the angle over which we can provide random access non-mechanical beam steering. Over 40 degrees steering in one direction has been demonstrated. The largest continuous beam steering angles have been about a 45 degree by 45 degree field of regard. Non-mechanical techniques used to steer the beams are limited to relatively small apertures. We anticipate scaling of individual apertures no larger then 5–7 cm in one dimension. We are now working on sub-aperture approaches to allow scaling to arbitrarily large apertures.

AOS FRA21
Friday 1040–1120 hrs

Quantum Trajectory Treatment of the Continuous Variable Teleportation of Quantum Fields

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A treatment of continuous variable teleportation within quantum trajectory theory is presented, which includes (1) continuous generation of broadband squeezed light, (2) continuous measurements by Alice and Victor and continuous dispersal of Alice's measurement results to Bob, and (3) photocurrents and photocounts realized as classical measurement records (time series of real numbers), explicitly distinguished from quantum operators and quantum states. Stochastic Schrödinger equations are derived to treat filtered homodyne, heterodyne, and photoelectron counting measurements by Victor. The formalism is applied to the teleportation of a quantum field (e.g. resonance fluorescence), where the evaluation of successful teleportation is made in terms of Victor's measured first- and second-order statistics.

AOS FRA23
Friday 1120–1140 hrs

Relativistically Invariant Quantum Information

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Relativistic effects have been shown to have a deleterious effect on quantum information. We show that relativistically invariant quantum information can be encoded into entangled states of multiple, indistinguishable particles with well-defined momenta using the techniques of noiseless subsystems. This encoding allows any inertial observer to prepare and manipulate quantum information in a way that is independent of their particular frame of reference. In particular, two observers can share entanglement and thus perform any quantum information processing task (teleportation, communication, etc.) without sharing a reference frame. We consider both massive spin-1/2 particles and massless photons.

[1] A. Peres and D. R. Terno, Rev. Mod. Phys. 76, 93 (2004).

[2] S. D. Bartlett, T. Rudolph and R. W. Spekkens, Phys. Rev. Lett. 91, 027901 (2003).

[3] S. D. Bartlett and D. R. Terno, quant-ph/0403014.

AOS FRA24
Friday 1140–1200 hrs

The Preferred Ensemble Fact with Applications to Quantum Feedback Control

H. M. Wiseman[1], A. C. Doherty[2], and J. A. Vaccaro[3]

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The preferred ensemble fallacy[1] is that a mixed quantum state ρ should be represented by one particular ensemble ($E = \{(\psi_k, \wp_k) : k = 1 \mathrm{L}\ K\}$) satisfying $\rho = \sum_{k=1}^{K} \wp_k |\psi_k\rangle\langle\psi_k|$, rather than any one of the infinitude of other ensembles satisfying this. For open quantum systems at steady state, obeying $\rho = \mathrm{L}\rho = 0$, there is a preferred ensemble fact: only some ensembles are physically realizable. That is, it is only some ensembles for which an observer can know at all times which pure state $|\psi_k\rangle$ the system is in; and $\wp_k$ is the proportion of time the system spends in pure state $|\psi_k\rangle$. This fact has applications in quantum feedback control of LQG (linear quadratic gaussian) systems[3].

[1] P. Kok and S.L. Braunstein, Phys. Rev. A **61**, 042304 (2000).

[2] H.M. Wiseman and J.A. Vaccaro, Phys. Rev. Lett. **87**, 240402 (2001).

[3] H. M. Wiseman, and A. C. Doherty, quant-ph/0408099

AOS FRA25
Friday 1200–1220 hrs

Quantum Logic in a Decoherence-suppressed Subspace with Atomic Qubits

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We investigate encoding and manipulating a logical qubit constructed from physical qubits comprised of electric-dipole coupled two-level atoms, which admit a decoherence-free subspace (DFS). We examine three atoms and use two-photon Raman transitions to perform arbitary rotations within a DFS. We give timescales for quantum information processing tasks outside the Dicke limit, without making the restrictive assumption of nearest-neighbour coupling, and relate these timescales to the limiting DF case. Although we employ an atomic model for creating and transforming a qubit, our results are relevant to generic techniques for exploiting decoherence-free subspaces for qubits.

AOS FRF21
Friday 1040–1100 hrs

10W, Single Frequency, CW Nd:YAG Laser

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We describe the development and characterisation of a 10W cw Nd:YAG travelling-wave laser[1] that is injection-locked to produce a low noise, single frequency, diffraction limited TEM_{00} output[2,3]. The 10W slave laser uses the side pumped, top and bottom cooled, coplanar folded zigzag slab (CPFS) architecture[4] and has been optimised for portability and reliability. This laser is used at the high power test facility of the Australian Consortium for Interferometric Gravitational Astronomy (ACIGA), with another version to be installed on the Japanese TAMA long-baseline gravitational wave interferometer. We shall report on laser performance including amplitude and frequency stability.

[1] D.J. Hosken, D. Mudge, C. Hollitt, K. Takeno, P.J. Veitch, M.W. Hamilton and J. Munch, Prog. Theor. Phys. Suppl. 151, 216, 2003.

[2] D.J. Ottaway, P.J. Veitch, M.W. Hamilton, C. Hollitt, D. Mudge and J. Munch, IEEE J. Quantum Electron. 34, 2006, 1998.

[3] D.J Ottaway, P.J. Veitch, C. Hollitt, D. Mudge, M.W Hamilton and J. Munch, Appl. Physics B, 71, 163, 2000.

[4] J. Richards and A. McInnes, Opt. Lett. 20, 371, 1995.

AOS FRF22
Friday 1100–1120 hrs

Design of an Optical Filter for Suppression of Higher Order Modes in High Power Continuous Wave Lasers

Pablo Barriga[1], Chunnong Zhao[2], Andrew Woolley[1], David G. Blair[1]

1. Department of Physics, University of Western Australia, Crawley, WA Australia; 2. Computer and Information Science, Edith Cowan University, Mount Lawley, WA, Australia

Reducing temporal and spatial instabilities in continuous wave lasers has special importance when applied to gravitational wave detectors. In this paper we present the effects of using a three mirror resonant vibration isolated optical filter for the suppression of higher order modes in continuous laser beams. The use of a triangular ring cavity presents some advantages, but creates some new challenges. We quantify the astigmatism produced inside the cavity due to the thermal effects induced in the mirrors and the effect on the suppression of the higher order modes. The suspension system designed for this optical filter is also presented.

AOS FRF23
Friday 1120–1140 hrs

Solid-state Raman Lasers: Efficient Multi-wavelength Lasers for the Green-yellow-red Region

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Diode-pumped solid-state Raman lasers are a versatile class of pulsed (multi-kilohertz) laser devices, well-suited to accessing the “hard to reach” yellow-orange spectral region. We report on an intracavity Raman laser based on Nd:YAG which produce average output powers up to 1.8W at 579nm, conversion efficiencies up to 8% with respect to diode output power, output which is easily selectable between 532nm, 555nm, 579nm and 605nm. We present our results with an emphasis on highlighting the underlying physics and key design considerations for this class of laser devices.

AOS FRF24
Friday 1140–1200 hrs

Stimulated Raman Gain Cavity Ringdown (SRG-CRD) Spectroscopy for High-Resolution Gas Sensing

F.V. Englich, Y. He and B.J. Orr

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A new form of high-resolution continuous-wave (cw) laser spectroscopy employs a cavity ringdown (CRD) technique[1] for the first time to detect stimulated Raman gain (SRG) effects[2]. Two cw laser beams (pump and Stokes) are overlapped in the gas-phase sample. The resulting SRG is probed by CRD at the Stokes wavelength of a cw tunable diode laser. The ringdown cavity is located inside the ring cavity of a cw Nd:YAG laser, to enhance the pump power. This novel SRG-CRD approach extends the scope of CRD spectroscopy. It is demonstrated by recording molecular rovibrational Raman spectra of methane gas.

[1] Y. He and B.J. Orr, Appl. Phys. B, **75**, 267 (2002)

[2] P. Esherick and A. Owyoung, Advan. Infrared and Raman Spectroscopy, **9**, 130 (1982)

AOS FRF25
Friday 1200–1220 hrs

First Lock of an 80m Baseline Suspended Fabry-Perot Cavity

Bram J. J. Slagmolen

on behalf of the Australian Consortium for Interferometric Gravitational Astronomy
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In this paper we report on the first lock of the High Optical Power Test Facility's 77~m long suspended Fabry-Perot cavity. Two suspended cavity mirrors were installed into the large vacuum envelope. Lock was achieved by mode-matching a 500~mW Nd:YAG NPRO onto a pre-mode cleaner, the output of which was then mode-matched to the suspended cavity. The longitudinal control of the suspended cavity was done by keeping the cavity resonant by feeding back to the laser frequency actuator. Further implementation of the auto-alignment of the input beam onto the suspended cavity enhanced the stability of the circulating power inside the cavity. Preliminary results will be presented.

Astronomy (ASA)

ASA THF11
Thursday 1040–1100 hrs

Interferometric Gravitational Wave Antenna

D.E. McClelland

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Long baseline laser interferometer type gravitational wave detectors are now on line in the USA, and Europe. With upgrades to these instruments over the next few years, direct detection of gravity waves will occur opening the new field of gravitational wave astronomy. I will outline Australian partnership in this endeavour, the case and conditions for a southern hemisphere antenna and a possible timescale for its construction.

ASA THF12
Thursday 1100–1120 hrs

Future High Energy Cosmic Ray Detection Facilities

Roger Clay

The study of high energy cosmic rays should have deep relevance to the broad spread of astrophysics. Cosmic rays are believed to originate in the most exotic objects, and they interact with many of the key fields in the universe. At modest energies their sources may well be in supernovae, and the particles interact symbiotically with galactic magnetic fields. At the highest energies, AGN are prime source candidates, and the particles are expected to interact strongly with the CMB.

Our understanding of the highest energy cosmic rays is limited by a paucity of observed particles above an energy of 10^{19} eV. The deficiency is being addressed through the Pierre Auger Project and planned space missions. This talk will briefly address the physics to be studied at the highest particle energies known in Nature, and will look at the new facilities for those studies.

ASA THF13
Thursday 1120–1140 hrs

Antarctic Astronomy

J.W.V. Storey, M.C.B. Ashley, M.G. Burton & J.L. Lawrence

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The recent discovery that the world's best optical/infrared observing sites lie within the Australian Antarctic Territory creates a remarkable opportunity for Australia. Plans are now well advanced to deploy PILOT, a 2-metre optical/infrared telescope to Dome C, Antarctica. Despite its modest size, PILOT will take advantage of the exceptionally good observing conditions to address some of the most pressing questions of modern astrophysics. PILOT also serves as a pathfinder for future large telescopes , such as the proposed 25-metre Giant Magellan Telescope Antarctica. In partnership with international teams, plans are also being developed to deploy an infrared interferometer and a robotic terahertz observatory.

ASA THF14
Thursday 1140–1200 hrs

ELTs: The Next Generation of Extremely Large Optical/Infrared Telescopes

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Extremely Large Telescopes (ELTs) represent the next quantum leap forward in optical/infrared telescope design and light-gathering capability. Their enormous main mirrors, anticipated to be 20–100 meters in diameter, will collect 10–100 times as much light as the world's largest existing telescopes, and will produce images far sharper than those of the Hubble Space Telescope. They will be able to see the first stars forming in the universe billions of years ago and search out Earth-like planets around nearby stars for signs of life. This talk will describe the already significant steps that have been taken to design and build ELTs, focussing on the several major international consortia that have formed so far, the concepts they have developed, and the opportunities this presents for Australia to become a key player in ELT technological and scientific development.

ASA THF15
Thursday 1200–1220 hrs

The Square Kilometre Array and the Next Generation Radio Telescope

Brian Boyle

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Australia stands poised to benefit from a once-in-a-lifetime opportunity to play a leading role, and potentially host, one of the major scientific facilities of the 21st century. The Square Kilometre Array (SKA) is a 16-nation project to builda USD1b radio-telescope that will explore stategic advances in ICT technology and provide a scientific facility capable of answering fundamental questions on the nature of matter and energy and the history of the Universe. Australia has already established technology leadership, science leadership and site advantage. Over the next two years, Australia is building the MNRF-funded New Technology Demonstrator radio telescope (with a planned upgrade to increase the scientific utility of this telescope). To be sited in Western Australia, this telescope will serve as a demonstrator for the SKA Pathfinder Telescope—an internationally funded USD100–200Million telescope scheduled for construction 2008–11. The USD1 Billion SKA will follow the pathfinder telescope, and is scheduled for construction in the middle of the next decade.

JOINT ASA/ASRG SESSION

ASA THF21
Thursday 1400–1420 hrs

See ASGRG THF21

Testing Foundations of Physics in Space—and European Plans in This Matter

Martin C.E. Huber

ASA THF22
Thursday 1420–1440 hrs

See ASGRG THF22

The Current Status of LIGO

David H. Reitze

ASA THF23
Thursday 1440–1500 hrs

See ASGRG THF23

Correlated Global Noise in Gravitational Wave Astronomy

Susan M. Scott, Antony C. Searle and Karl W. Wette

ASA THF24
Thursday 1500–1520 hrs

Detection of Gravitational Waves Using a Pulsar Timing Array

R N Manchester[1], F A Jenet[2] and G B Hobbs[1]

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2. Center for Gravitational Wave Astronomy, University of Texas, Brownsville

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Theories of gravitation predict that accelerating masses will emit gravitational waves (GW). Although pulsars have provided indirect evidence for GW, up to now there has been no direct detection. Ground-based laser interferometer systems such as LIGO have the potential to detect GW in the frequency range 10–1000 Hz and space-based laser systems such as LISA are sensitive in the 10^{-5}–10^{-3} Hz range. Millisecond pulsars are very stable clocks. Timing observations of an array of such pulsars widely distributed on the sky can detect GW in the range 10^{-8}–10^{-6} Hz range, complementing the laser interferometer systems. Pulsar timing array observations using the Parkes 64-m radio telescope have recently commenced, with a sample of about 15 millisecond pulsars. Timing precisions as good as 100 ns are being achieved with some of these pulsars. After 3–5 years, these observations should have the sensitivity to detect the a stochastic background of GW. The dominant component of this background probably originates from super-massive black-hole binary systems in the centre of galaxies throughout the Universe.

ASA THF25
Thursday 1520–1540 hrs

Pulsar Timing and General Relativity

Matthew Bailes

Radio pulsars are exquisite clocks, with their immense moments of inertia and relatively small braking torques. I will describe how new instrumentation is being used to measure the pulse arrival times to astounding accuracies that are enabling new tests of General Relativity and the search for a cosmological background of gravitational waves.

Relativity and Gravitation (ASGRG)

ASGRG TUE11
Tuesday 1040–1100 hrs

AIGO: The Australian International Gravitational Observatory

David Blair

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The worldwide array of gravitational wave observatories requires a southern hemisphere node. In the 1990's a site for AIGO was selected about 70km north of Perth, and since 1997 funds have been provided for the development of this site. In just over 5 years the site has been developed from a bushland wilderness to a significant science and education centre, under the auspices of the Australian Consortium for Interferometric Gravitational Astronomy (ACIGA). It includes a major research facility into high optical power techniques for the next generation of Advanced Interferometers. These advanced detectors are almost certain to have a large number of signal sources if they can achieve their predicted sensitivity. The AIGO site also includes a major education centre for the promotion of science and a large public optical observatory. The site has been shown to be optimally located and to have advantageous seismic properties. Maximal effort is being put into collaborative development of high optical power techniques with the US LIGO project. This will be followed by the development of a full advanced interferometer of 80 meter baseline.

This talk will present a brief overview of the Gingin science precinct to introduce more specialised talks and posters that will follow.

ASGRG TUE12
Tuesday 1100–1120 hrs

Off-axis Wavefront Sensors in High Power Gravitational Wave Interferometers

Aidan Brooks, Peter Veitch and Jesper Munch

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The performance of a gravitational wave interferometer (GWI) is degraded by distortion of the optics due to absorption of optical power. To maintain performance, detection and active compensation of the distortion are necessary[1]. We are developing an off-axis Hartmann wavefront sensor that can measure the distortion without interfering with the circulating optical power in the interferometer. Our measurement analysis yields the axial and radial distribution of the optical distortion. This allows us to resolve different thermo-refractive and thermo-elastic effects from a single measurement. We shall discuss the development of the sensor, analysis of off-axis measurements and the latest results.

[1] R. Lawrence, M. Zucker, P. Fritschel, P. Marfuta, and D. Shoemaker, Classical and Quantum Gravity. 19(7), 1803, 2002.

ASGRG TUE13
Tuesday 1120–1140 hrs

Advanced Interferometry for Gravitational Wave Detection

Mal Gray

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We report on experimental developments at the ANU Centre for Gravitational Physics utilising advanced interferometric techniques to enhance the sensitivity of second-generation gravitational wave detectors. Currently the CGP is pursuing quantum optics and non-linear interferometry and advanced interferometer configurations in order to improve sensitivity. We present recent progress in these research areas.

ASGRG TUE14
Tuesday 1140–1200 hrs

Tracking the Unity Gain Frequency of the Open Loop Gain Function in LIGO Interferometers

Michael Ashley

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The complicated control systems used to lock the LIGO interferometers are modelled using systems control theory. One of the most important measurements for the calibration of interferometer data is that of the gain of the control loop with no input impetus i.e. the complex-valued open loop gain function G(f). The value of the frequency for which $|G(f)|=1$ (termed the unity gain frequency) and the phase of G at this value are important measures of the stability of the locking mechanism.

Using test calibration signals, injected into the interferometer and online software calibration tools it is possible to produce near-real time evaluation of the unity gain frequency and the phase of G at this point. I describe the status of software to determine the unity gain frequency and the use of its output.

ASGRG TUE15
Tuesday 1200–1220 hrs

Measuring LISA Phase

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The Laser Interferometer Space Antenna (LISA) is a mission to detect gravitational waves in the frequency region from 0.1 mHz to 1 Hz. LISA is composed of three spacecraft flying in a heliocentric orbit with separations of millions of kilometers. The fractional length stability required to detect gravitational waves is much more stringent than the fractional frequency stability of any

available laser. The phasemeter must have sufficient range to allow reconstruction of a gravitational wave signal that is approximately 10^8 times smaller than the laser noise. We present a proposed design of the LISA phasemeter, and results from simulations.

ASGRG TUE21
Tuesday 1400–1420 hrs

Carmeli's Cosmology Indicates No Dark Matter in the Universe

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Carmeli's 5D brane cosmology[1] has been applied to the expanding accelerating universe and it has been found that the distance redshift relation followed the data of the high-z supernova teams without the need for dark matter. Carmeli predicted the accelerating universe in 1996, now it is shown that no dark matter is required. The model does not explicitly involve the cosmological constant but by a comparison with the standard model the vacuum energy contribution to gravity, Ω_Λ indicates that the universe is asymptotically expanding towards a spatially flat state, where the total mass/energy density $\Omega + \Omega_\Lambda \rightarrow 1$.

[1] M. Carmeli, Cosmological Special Relativity, 2nd ed. Singapore: World Scientific, 2002.

ASGRG TUE22
Tuesday 1420–1440 hrs

Curvature Singularity Theorems for Space-time

Michael J.S.L. Ashley[1] and Susan M. Scott[2]

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The existence of singularities in a universe governed by General Relativity has been inferred principally by the Penrose-Hawking singularity theorems. These theorems predict causal geodesic incompleteness under generic physical conditions. These theorems fall short, however, since they do not predict the expected presence of unbounded curvature. Recent efforts using the abstract boundary construction of Scott and Szekeres and the notion of strong curvature singularities have brought us close to completing a famous singularity theorem of Hawking. We describe this research and the clarification of this important cosmological singularity theorem by Hawking.

ASGRG TUE23
Tuesday 1440–1500 hrs

Transit Time of a Freely-falling Quantum Particle in a Background Gravitational Field

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Using a model quantum clock, I evaluate an expression for the time of a non-relativistic quantum particle to transit a piecewise geodesic path in a background gravitational field with small spacetime curvature (gravity gradient), in the case that the apparatus is in free fall. This calculation complements and extends an earlier one in which the apparatus is fixed to the surface of the Earth. The result confirms that, for particle velocities not too low, the quantum and classical transit times coincide, in conformity with the principle of equivalence. I also calculate the quantum corrections to the transit time when the de Broglie wavelengths are long enough to probe the spacetime curvature. The results are compared with the recent calculation of Chaio and Speliotopoulos, who propose an experiment to measure the foregoing effects.

ASGRG TUE24
Tuesday 1500–1520 hrs

Causal Geodesics in Space-time and the Existence of Singularities

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The Abstract Boundary[1] is a scheme for constructing and classifying singular points of space-times in General Relativity. We present a classification of the behaviour of causal geodesics by examining their limit points, both in the space-time itself and on its boundary, and apply this to the Abstract Boundary Singularity Theorem[2]. In particular, we look at the 'winding' behaviour of both complete and incomplete precompact geodesics, such as those found in the Misner and Carter space-times, and examine the question of their existence in space-times satisfying certain causality conditions.

[1] S.M. Scott and P. Szekeres, "The abstract boundary—a new approach to singularities of manifolds", J. Geom. Phys. 13 (1994) 223–253.

[2] M. Ashley, PhD Thesis, http://eprints.anu.edu.au/perl/search, (2002)

ASGRG TUE25
Tuesday 1520–1540

Cosmological Gamma-ray Bursts: Singlets, Doublets? Triplets!

Maurice H.P.M. van Putten

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Cosmological gamma-ray bursts represent a fraction of about 0.2–0.4% of Type Ib/c supernovae. In the scenario of core-collapse of massive stars, we identify these rare events with high-mass rapidly rotating black holes formed with low kick velocity ("centered" events). Non-GRB Type Ib/c events are identified with low-mass black holes leaving the core prematurely with high kick velocity ("decentered" events). This scenario predicts long bursts in gravitational radiation contemporaneous with GRB-supernovae ("triplets"), and quiescence or short bursts of gravitational radiation in Type Ib/c supernovae. Efficient searches for gravitational radiation from GRB-supernovae by LIGO and Virgo obtain in combination with all-sky optical-radio supernova surveys. This poses some interesting new challenges in high-performance computing on gravitational-wave/optical/radio-data analysis[1,2].

[1] Maurice H.P.M. van Putten, "Gravitational Radiation, Luminous Black Holes and Gamma-ray burst Supernovae," Cambridge University Press, in production

[2] Maurice H.P.M. van Putten, Amir Levinson, Hyun-Kyu Lee, Tania Regimbau, Michele Punturo, & Gregory M. Harry, Phys. Rev. D., 69, 044007 (2004)

POSTERS

ASGRG PTU 38

Reflection on Event Horizon of Black Holes

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It has been argued recently[1] that the event horizon of black holes can reflect particles; in other words a particle approaching a black hole can bounce on its horizon back into the outside world. This phenomenon has purely quantum origins; classically the horizon is transparent for incoming particles. The effect is strong for low energy particles, transforming black holes into "mirrors" in this region, which is surprising. A summary of recent progress related to this phenomenon, including interrelations with the Hawking radiation, is given.

[1] M. Yu. Kuchiev, Phys. Rev. D **69**, 124031 (2004); Europhys. Lett. **65**, 445 (2004)

ASGRG PTU 39

Radiation Pressure Noise Measurement in an Interferometer

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Quantum noise of light (shot noise and radiation pressure noise) plays an important role in the sensitivity limits of interferometric measurements such as gravitational wave detector. Presently, various methods are being theoretically investigated to beat this quantum limit. However, experimental researches are not tested. Even radiation pressure noise has not yet been observed for macroscopic system. We propose an interferometer with small test mass cavity, in order to measure remarkable effect of radiation pressure noise around 200Hz.

ASGRG PTU 40

Simplified Derivations of the Space-Time Geometry Equations

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For most people, understanding the complexities of Einstein's field equations and their solution by Schwarzschild precludes an easy understanding of the physics governing general relativity. Commencing with the same starting position used by Einstein, it has been demonstrated that there exists a shorter path to the derivation of the space-time geometry equations, which path yields answers indistinguishable from Schwarzschild's solution. The physics behind the curvature of space-time becomes easy to comprehend. Knowing the physics involved makes further results much simpler to understand and calculate. The predictions match experimental observations.

ASGRG PTU 41

Rotating Michelson-Morley Experiment Based on a Dual Cavity Cryogenic Sapphire Oscillator

P.L. Stanwix[1], M.E. Tobar[1], J. Winterflood[1], P. Wolf[2,3], E.N. Ivanov[1], M. Susli[1], J.G. Hartnett[1] and F. van Kann[1]

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Local Lorentz invariance (LLI) is a constituent element of the Einstein equivalence principle (EEP), a cornerstone of modern physics. Experiments that test the isotropy of the speed of light (Michelson-Morley experiment) have placed upper limits on any violation of LLI to a few parts in 10^{15} using data accumulated over one year[1,2,3]. We have constructed a new rotating Michelson-Morley experiment consisting of two cryogenic sapphire resonators.

By rotating the experiment we have achieved the same level of sensitivity to light speed anisotropy as[2,3] with 16 hours of data. The experiment is ongoing and the latest results will be presented.

[1] P. Wolf, S. Bize, A. Clairon, et al., Phys. Rev. Lett., **90**, 6, 060402, (2003)

[2] P. Wolf, M.E. Tobar, S. Bize, et al., Phys. Rev. D Rapid Comm., accepted, (2004).

[3] H. Muller, S. Herrmann, C. Braxmaier, et al., Phys. Rev. Lett., **91**, 2, 020401, (2003)

ASGRG PTU 42

Parametrical Optics Effects at the Presence of Gravitation

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In the frame of optical-mechanical analogy in general relativity it has been shown that the change of refractive index of the space can be presented as the function of gravitation field with a coupling coefficient. The gravitation coefficient G (or time) in this relation plays the role of material coefficients of flat space (or corresponding optical medium) and should therefore obey von Neumann principle. Due to the Neumann principle, the symmetry group of the flat space should depend on the field configuration and, following the Curie symmetry principle, it should be a subgroup of symmetry group of the time.

ASGRG PTU 43

Spinor Fields and Inflationary Cosmology in Einstein-Cartan Theory

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We present the cosmological model with the Dirac fields or the Rarita-Schwinger fields, which is constructed in the framework of the Einstein-Cartan theory to explain the origin of the accelerated expansion of the universe. We definitely derive the correction to the energy momentum due to the spin in the Einstein equation without introducing the thermodynamical variables assumed in the existing models of the spinning matter. The results obtained in our approach imply that the spinor fields can provide the negative pressure and be an alternative to false vacuum in the early stage of the universe.

ASGRG PTU 44

An Experiment to Study Parametric Instabilities in Optical Cavities at ACIGA High Optical Power Test Facility

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The Australian Consortium for Gravitational Astronomy (ACIGA) is building a High optical Power Test Facility (HPTF) for Advanced LIGO and the future Australian International Gravitational Observatory (AIGO). The goal of HPTF is to study and control various predicted effects associated with very high optical power cavities. One of these effects is the parametric instability. This is the result of the non-linear coupling between the test mass mechanical modes and the optical cavity modes through radiation pressure forces acting on the test masses. This coupling can excite the oscillation of the mechanical modes which decrease the detector sensitivity or even make it disfunctional.

This article presents the proposed experiment to test the parametric instability on HPTF. Detailed analysis of the test mass internal mode structures and the conditions of parametric instability will be given. We propose control schemes to control instabilities.

ASGRG THF21
Thursday 1400–1420 hrs

Testing Foundations of Physics in Space—and European Plans in this Matter

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The two great theories of the 20th century, general relativity and quantum mechanics, have undergone serious tests, both in the laboratory und through observations of the Universe. Yet, in spite of positive results, theoretical problems in developing a coherent physical model of the Universe, encompassing both quantum theory and general relativity, remain at the forefront of today's physics research. More accurate experimental tests, particularly in the areas of Cosmology, Gravitation and Particle Physics, are needed.

Access to space makes it possible to perform experiments with a precision that goes far beyond that which can be achieved in ground-based laboratories: gravity and noise—both inescapable on Earth—are much reduced by use of 'drag-free', and cryogenic, space platforms that provide an extremely quiet environment at the pico-gravity level. Testing the range, over which a physical theory is valid, or testing how far an assumption, which is the basis of a given theory, is holding, can then be achieved with greatly improved accuracy over that

available in ground-based investigations. If (and when) such tests reveal discrepancies between prediction and measurement, or between assumption and reality, the measured divergence will provide guidance on where the accepted theories need to be complemented or modified.

Following a brief overview of extraterrestrial fundamental-physics experiments that have been carried out in the past, we will discuss current experiments and then describe future plans for fundamental-physics investigations in space, specifically with a view towards European plans in this matter.

ASGRG THF22
Thursday 1420–1440 hrs

The Current Status of LIGO

David H. Reitze

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In 2004, the Laser Interferometer Gravitational Wave Observatory (LIGO) Science Collaboration reported the first searches for gravitational waves from pulsars[1], 'burst' sources[2], binary neutron star systems[3], and remnant stochastic gravitational radiation[4] using the LIGO and GEO600 detectors[5]. Recent significant improvements in the detector sensitivities have allowed us to place better upper limits on these sources. In this talk, we review the current status of LIGO and present an overview of selected results from the S2 science run. In addition, we will discuss prospects for improving the sensitivity of LIGO and plans for upgrading the detectors.

[1] B. Abbott, et al. (LIGO Science Collaboration), Phys. Rev. D69: 082004 (2004).

[2] B. Abbott, et al. (LIGO Science Collaboration), Phys. Rev. D69: 102001 (2004).

[3] B. Abbott, et al. (LIGO Science Collaboration), Phys. Rev. D69: 122001 (2004).

[4] B. Abbott, et al. (LIGO Science Collaboration), Phys. Rev. D69: 122004 (2004).

[5] B. Abbott, et al. (LIGO Science Collaboration), Nuc. Instr. Meth. A 517, 154–179 (2004).

ASGRG THF23
Thursday 1440–1500 hrs

Correlated Global Noise in Gravitational Wave Astronomy

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Gravitational wave astronomy will require the cooperation of a world-wide network of gravitational wave observatories, including a possible future observatory in Australia. Globally correlated environmental noise—ranging from earthquakes to anthropogenic time standards—may limit sensitivity. We have established a physical environment monitoring station at The Australian National University to measure seismic and electromagnetic environmental noise in the frequency bands relevant to terrestrial interferometric gravitational wave observatories. Using the Australian Consortium for Interferometric Gravitational-wave Astronomy's (ACIGA's) Data Analysis Cluster (ADAC) we have performed extensive correlation studies between environmental noise from Australia and that from interferometers in the USA and Europe. We present our findings, with particular emphasis on their implications for an Australian gravitational wave observatory.

ASGRG THF24
Thursday 1500–1520 hrs

See ASA THF24

Detection of Gravitational Waves Using a Pulsar Timing Array

R N Manchester, F A Jenet and G B Hobbs

ASGRG THF25
Thursday 1500–1520 hrs

See ASA THF25

Pulsar Timing and General Relativity

Matthew Bailes

Synchrotron Science (ASRP)

ASRP MOC11
Monday 1040–1120 hrs

The Australian Synchrotron—A Status Report

J. W. Boldeman

Principal Scientific Advisor, Australian Synchrotron, Melbourne

A high performance, third-generation synchrotron facility is being constructed as a National Facility on a site in Clayton, Victoria. First light is scheduled for early June 2006 and the experimental program will begin on 1st April, 2007. This paper will very briefly outline the development of the Australian synchrotron research community leading to the decision to build the facility, the design specifications of the facility will be described and the planned experimental facilities and some preliminary design details will be discussed. The present status of the construction will be outlined.

ASRP MOC13
Monday 1120–1140 hrs

X-ray Lithography—An Australian Perspective

A.G. Peele[1], K.D. Vora[1], E. Harvey[2], R. Barber[2] and C.G. Chen[2]

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X-ray lithography (XRL) typically uses a synchrotron source in order to provide the requisite x-ray exposure in a practical time. For Australian workers one access model is to participate in a multi-project wafer. A multi-project XRL run is currently being co-ordinated by MiniFAB enabling industrial participants to evaluate the process. However, where extensive optimization or invention is required this approach can be difficult as long periods of time are required to perfect the methods used. We present a case study describing how Australian researchers are managing to develop XRL processes and show some new results regarding a successful process improvement.

ASRP MOC14
Monday 1140–1220 hrs

4GLS: The UK's Fourth Generation Light Source at Daresbury

E Townes-Andrews, E A Seddon

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4GLS is a suite of accelerator-based light sources planned to provide state-of-the-art radiation in the low energy photon regime[1]. Superconducting energy recovery linac (ERL) technology will be utilised in combination with a variety of free electron lasers (IR to XUV), undulators and bending magnets. The 4GLS undulators will be optimised to generate spontaneous high flux, high brightness radiation, of variable polarisation, from 3–100 eV. However, they will also generate usable radiation (in the higher harmonics) up to around 800 eV. The ERL technology of 4GLS will allow shorter bunches and higher peak photon fluxes than possible from storage ring sources. It will also give users the added bonuses of pulse structure flexibility and effectively an infinite beam lifetime. VUV and XUV FELs will be used to generate short pulses (in the fs regime) of extreme ultraviolet light that is broadly tuneable and more than a million times more intense than the equivalent spontaneous undulator radiation. A strong feature of the scientific programme planned for 4GLS is dynamics experiments in a wide range of fields. Pump probe experiments will allow the study of chemical reactions and short-lived intermediates on the timescale of bond breaking and bond making, even for very dilute species. The high intensity of the FEL radiation will allow very high resolution in imaging applications. Funding for the first three years of the 4GLS project was announced by the UK Government in April 2003. This includes the research and development work necessary to produce a design study report, with the construction of an ERL-prototype. It is anticipated that the full facility will be available to users in 2010.

[1] http://www.4gls.ac.uk

ASRP MOF21
Monday 1400–1420 hrs

Structural Characterization of Ion Implanted Au Nanocrystals using Synchrotron-based Analytical Techniques

P.Kluth[1], B. Johannessen[1], C. J. Glover[1], G.J. Foran[2], S. M. Kluth[1] and M. C. Ridgway[1]

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Synchrotron based analytical techniques including extended x-ray absorption fine structure (EXAFS) spectroscopy provide powerful tools for structural characterization of nanocrystalline materials. Combining these techniques with conventional analytical methods such as x-ray diffraction and transmission electron microscopy we have investigated Au nanocrystals formed in thin SiO_2 using ion implantation. Furthermore, we have studied their structural evolution following ion irradiation. Non-irradiated nanocrystals show a significant bondlength contraction, essentially retaining the face-centred-cubic structure present in bulk material[1]. In contrast to bulk elemental metals, which cannot be rendered amorphous by ion irradiation, irradiated nanocrystals exhibit a significant structural change consistent with amorphous material.

[1] P. Kluth, B. Johannessen, V. Giraud, A. Cheung, C. J. Glover, G. de M. Azevedo, G. J. Foran, and M. C. Ridgway, Appl. Phys. Lett. (2004) in press

ASRP MOF22
Monday 1420–1440 hrs

Imaging of Nanocluster Using Coherent X-ray Diffraction and Computational Phase Retrieval Technique

B. B. Dhal[1], H. M. Quiney[1], A. G. Peele[2], D. J. Paterson[3], P. Mulvaney[4], I. McNulty[3] and K A Nugent[1]

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The availability of intense X-ray sources and of high quality focussing optics suggests the use of phase retrieval techniques based on diffraction from curved wavefield[1] to determine the structures of nanoscale particles. The ultimate aim of this approach is to develop practical methods for nanocrystallography and applications of the technique in the biological science. Here we investigate the solution of the structures of gold nanostructures.

A recent experiments was performed using 6.773 angstrom synchrotron radiation x-rays from an insertion device source, at beamline-2ID-B of Advanced Photon Source (APS), Chicago. Our phase retrieval algorithms have been devised which make use of this known beam information to achieve unambiguous reconstruction of the diffracting object in favourable cases[2].

We will discuss our recent experimental and theoretical results and the issues involved in extracting useful information from weakly diffracting objects.

[1] K A Nugent, A. G. Peele, H. N. Chapman and A. P. Mancuso, Phys. Rev. Lett. 91, 203902–1 , (2003).

[2] H. M. Quiney et al. Optics Express, 2004, (In Preparation).

ASRP MOF23
Monday 1440–1500 hrs

Applications of Synchrotron X-Ray Sources for Forensic Characterisation of Glass

I.M. Kempson[1], J.A. Denman[1], W.M. Skinner[1], K.P. Kirkbride[2]

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Microprobe techniques originating from synchrotron radiation sources offer significant advantages over conventional approaches when characterising minute amounts of material. The advantages of synchrotron techniques for forensic analysis of glass are discussed. Examples of applications in practical situations and fundamental studies are also offered. Synchrotron X-ray fluorescence (SXRF) can be used for non-destructive measurements of composition and for impurity profiling to match evidential samples. However, the integrity of samples is limited by microheterogeneity, for which, the sensitive and localised nature of SXRF allows detailed fundamental studies. In addition, the use of X-ray absorption near edge structure (XANES) and synchrotron X-ray micro-tomography allow for fundamental studies of glass and glass-containing gunshot residues (GSR). The complimentary use of time-of-flight secondary ion mass spectrometry (ToF-SIMS) in the study of microheterogeneity and the characterisation of GSR is also presented.

ASRP MOF24
Monday 1500–1540 hrs

High Energy Synchrotron X-rays: A Tool for Bulk Investigations in Physics and Materials Science

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High energy X-rays between 30 keV and 1 MeV, as provided by modern synchrotron sources like the ESRF and HASYLAB at DESY, bear the advantage of deep penetration into most materials. Even heavy element compositions can be accessed in their volume. The range of applications is huge and spreads from nuclear physics to the characterization of a metal deformation under industry-related conditions. This presentation compiles an overview of my experience with the most common instrumental techniques and selected applications. Triple axis diffractometry can be used for highest resolution purposes on single crystal characterization, even under heavy and dense sample environments. Thus artificial or ultrasonic superlattices can be characterized as well as structural changes around different kinds of phase transitions. Time resolved studies can be performed stroboscopically from a sub-nanosecond to a second time scale and are presented. Modern two-dimensional detectors are used to obtain rapid overviews in reciprocal space. Whole sets of Debye-Scherrer rings are registered onto the detector, their diameters and eccentricities or their intensity distribution along the rings relating to anisotropic strain or texture measurements, respectively. Imaging techniques such as topography, radiography and computed tomography allow to seize direct information in real space. Combinations of the different techniques will play a most important issue in the design of future beamlines and a flux estimate for a potential Australian beamline is given.

POSTERS

ASRP PMO 58

Preliminary Analysis to Achieve a High-precision Measurement of the Excitation Energy of the He (2p 3d) ^{1}P Doubly Excited State in Helium Using Landmark States in Neon

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We present the groundwork a scheme to employ both first- and third- harmonic undulator light to excite states of well-known energy in singly-excited neon and high excitation energy doubly-excited states in helium in a single scan. This simultaneous excitation superimposes the features of the two spectra, providing landmarks for accurate measurement of the helium features. We measured an excitation energy of 64.1198(14) for the He (2p 3d) ^{1}P which differs by 5.3 meV from the value calculated in _itnik et al.[1]. These measurements were performed at a resolving power more than 4 times the designed operating range of the BL 6.2 R gas-phase beamline at Elettra, where the data were recorded. This induced significant technical challenges in calibrating the energy scale.

[1] M. _itnik et al., Phys. Rev. A **65**, 032520 (2002).

ASRP PMO 59

Failure of XAFS interpretation for ab Initio Investigations—a New Way Forward

L.F. Smale, C. T. Chantler, E. C. Cosgriff, M. D. de Jonge, Z. Barnea, C. Q. Tran

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XAFS structures are solved routinely and many hundreds of publications appear per annum. We have collected the highest precision experimental data and used the most reliable existing technique to analyse the structure. We find major limitations in theoretical predictions and in XAFS analytical frameworks which lead to very large uncertainties in the derived results. However, we discuss appropriate methods for overcoming these limitations and increasing the accuracy of XAFS determinations by perhaps a factor of 10^4, which would thereby allow ab initio structural and radial solutions directly.

ASRP PMO 60

The X-ray Extended Range Technique for High Accuracy Atomic Structure in Simple Sstems

C. Q. Tran, C. T. Chantler, M. D. de Jonge, Z. Barnea and N. Rae

School of Physics, University of Melbourne, Parkville, VIC Australia

Over recent synchrotron experiments (PRA67 (2003) 042716,PRL90 (2003) 257401, PRA69 (2003) 257401, PRA69 (2004) 042101) we have developed methods for measuring the imaginary component of the atomic form factor (the transform of the electron orbital charge density) in neutral atoms to below 0.1%. This is 10–100 times more accurate than earlier methods, and 10–50 times more accurate than claimed uncertainties in theoretical computations for these systems. The experiments are sensitive to many theoretical and computational issues, including correlation. We will discuss key features of the method and results, including especially theoretical issues raised by the new accuracies.

ASRP PMO 61

Phase Separation in the Organic Solid State: Simultaneous Synchrotron SAXS / DSC Studies of Unstable n-alkane Blends

E.P. Gilbert[1], D. Sutton[1,2], A. Nelson[1], N. Terrill[3], C. Martin[4], J. Lal[5], E. Lang[5]

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Blends of normal alkanes form lamellar structures, when quenched from the melt, in which the separation of the individual chains may be controlled by the chain-length difference, molar composition, isotopic substitution and confinement. We have performed simultaneous synchrotron small-angle X-ray scattering and differential scanning calorimetry studies on 2:1 $C_{28}H_{58}$:$C_{36}D_{74}$ mixtures as a function of cooling protocol. Their simultaneous collection enables the temperature-dependent nanostructural changes to be correlated with phase transitions. The data are further complemented by small-angle neutron scattering highlighting the separation of the individual chains via isotopic contrast and optical microscopy indicating changes occurring on the macroscopic scale.

[1] E.P. Gilbert, D. Sutton, A. Nelson, N. Terrill, C. Martin, J. Lal and E. Lang, Mol. Cryst. Liq. Cryst., (2004) accepted

ASRP PMO 62

Structural Perturbations within Nanocrystalline Cu probed by EXAFS

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Extended x-ray absorption fine structure (EXAFS) spectroscopy has emerged as an invaluable synchrotron radiation technique for determining the short-range atomic structure in a vast range of diverse materials. Cu nanocrystals (NCs) were synthesised by high-energy ion beam implantation and thermal annealing. We present results of EXAFS measurements determining the first nearest neighbour Cu environment and quantify significant concentration- and annealing-temperature-dependent structural perturbations as compared to a bulk Cu standard. In particular we observe and explain an enhanced structural disorder involving both a suppressed coordination number and bondlength contraction.

ASRP PMO 63

On-line Readout of Detectors for High Spatial Resolution Dosimetry of Synchrotron Microbeams

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Synchrotron Microbeam Radiation Therapy (MRT) is an emerging technique for cancer treatment. Preclinical experiments are carried out with ~20–30 μm-wide, ~10 mm-high parallel microbeams with pitch about 200 mm of hard, broad-"white"-spectrum X rays (~50–600 keV). The main parameter responsible for quality of treatment is the peak-valley dose ratio. The required spatial resolution for microbeam dosimetry is about 1 mm or better and is a limiting factor for the application of traditional dosimetry. On-line, "edge on" MOSFET dosimetry was proposed and successfully implemented for MRT microbeams at ESRF. Good correlation exists between our experimental results compared to those using the PSI-version of the GEANT Monte Carlo code.

ASRP PMO 64

Physics of Radiological Protection at High energy Synchroton Light Sources

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Highly monochromatic, polarized, low energy x-rays, within a bandwidth ranging from tens to several hundred keV predominate the radiation environment at the user end of a Synchrotron-Light-Source (SLS). Therefore, the probability of an excessive radiation exposure to the synchrotron light users remains quite low. Consequently, the radiological safety procedures and associated regulatory and licensing conditions of a common diagnostic (clinical) x-ray laboratory could be implemented. On the other hand, the accelerator end of a SLS consists of an electron linac (50–200 MeV), a high-energy booster synchrotron (1–5 GeV) and a storage ring. As a result, in non-routine situations intense fields of high-energy photons and photoneutrons may be generated with considerable radiological consequences. These include, (a) radio-activation of accelerator components (b) activation of air circulating in the accelerator tunnel, (c) radiation leakage through the accelerator containment shielding (d) radiation induced degradation of permanent magnets of the wigglers and undulators and (e) radiation induced malfunction of the electronic instrument and control devices situated in the vicinity of the accelerator system. In this paper we will address the production mechanism of radiation fields in a modern SLS from the perspective of High-Energy-Physics and their interaction pathways. The above information encompasses the fundamentals of radiological protection of high energy particle accelerators.

ASRP PMO 65

Preferential Amorphisation of Ge Nanocrystals in a Silica Matrix

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Relative to bulk crystalline material, Ge nanocrystals in a silica matrix exhibit subtle structural perturbations including a non-Gaussian inter-atomic distance distribution. We now demonstrate such nanocrystals are extremely sensitive to ion irradiation. Using transmission electron microscopy, Raman spectroscopy and extended

x-ray absorption fine structure spectroscopy, the crystalline-to-amorphous phase transformation in ~8 nm diameter nanocrystals and bulk crystalline material has been compared. Amorphisation of Ge nanocrytals in a silica matrix was achieved at an ion dose ~100 times less than that required for bulk crystalline standards. This rapid amorphisation of Ge nanocrystals is attributed to the preferential nucleation of the amorphous phase at the nanocrystal/matrix interface, the pre-irradiation, higher-energy structural state of the nanocrystals themselves and an enhanced nanocrystal vacancy concentration due to the more effective trapping of irradiation-induced interstitials at the nanocrystal/matrix interface and inhibited Frenkel pair recombination when Ge interstitials are recoiled into the matrix. To demonstrate the significance of the latter, we show ion irradiation of ~2 nm diameter nanocrystals yields their dissolution when the range of recoiled Ge atoms exceeds the nanocrystal bounds.

ASRP PMO 66

Problems Encountered in the Measurement of Diffuse X-ray Scattering

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Although X-ray diffuse scattering has been observed since the earliest days of crystallography obtaining high-quality quantitative diffuse scattering data has been far from routine and has been attempted, even for limited regions of reciprocal space, by relatively few workers. Although diffuse scattering is very much weaker than Bragg scattering synchrotron sources should be more than sufficient to compensate for the disparity and fully three-dimensional data ought to be easily achievable. However, difficulties arise when measurement of such weak intensities is attempted in the presence of the very strong Bragg peaks. In this paper we describe our recent experiences in this area.

Biophysics and Medical Physics (BMP)

BMP MOF11
Monday 1040–1100 hrs

Protein Crystallography with Spallation Neutrons

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The Protein Crystallography Station at LANSCE[1] is a high performance neutron protein crystallography beam line at a spallation neutron source. The station is equipped with a large high resolution position sensitive He 3 detector with a total counting rate of over 1 million events per second. Neutron diffraction is a powerful technique for locating hydrogen atoms even at resolutions of 2A–2.5A and can therefore provide unique information about enzyme mechanism, protein hydrogen and hydrogen bonding. The beam-line exploits the pulsed nature of spallation neutrons in order collect wavelength resolved Laue patterns using all available neutrons in the wavelength range 1A to 5A.

[1] Langan,P; Greene,G; Schoenborn,B.P.; J. App.Cryst.37,24 (2004)

BMP MOF12
Monday 1100–1120 hrs

The Most Energetic Process in Biology

Elmars Krausz[1], Joseph L. Hughes[1], Paul J. Smith[2], Ron J. Pace[2], Sindra Peterson Årsköld[3]

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The reaction centre of Photosystem II of has the unique ability to oxidise water, making it the most potent and poisonous metallo-enzyme in nature. Using polarization and laser-selective spectroscopies on fully active PSII core complex preparations at ~2K we have penetrated the spectral complexity of the reaction centre, leading to a remarkable new vision of this vital system. The charge separating excited state lies lower in energy than previously assumed. It has dipole strength less than the equivalent of 1 chlorphyll pigment and is part of an exciton coupled system. It is homogeneously broadened pointing to strong electron phonon coupling.

BMP MOF13
Monday 1120–1140 hrs

The Melanins: Form Experiment to Quantum Chemistry to Many-Body Quantum Theory

B. J. Powell[1], J. Riesz[1], E. Moore[1], C. Giacomantonio[1], N. Bernstein[2], M. R. Pederson[2], T. Barauh[2,3], K. Brake[1], R. H. McKenzie[1] and P. Meredith[1]

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Melanins found thoughout the biosphere from fungi to man. In humans they are our primary photoprotectant (remember slip, slap, slop!) Melanins have many unexplained physical properties. Including a strong, monotonic, broad band absorption[1] and semiconducting behavior with a superexponential humidity dependant conductivity[2]. We will describe a holistic approach to the theoretical description of these molecules, including a targeted experimental program[2], quantum chemical studies[3] and many-body quantum theory. We will discuss the possibilities that chemical and structural disorder is responsible for optical absorption and that multiple conduction mechanisms (e.g. electronic and ionic) are at play in these materials.

[1] P. Meredith and J. Riesz, Photochem. Photobiol. 79, 211 (2004).

[2] P. Meredith, et al., Proceedings of ICSM 2004 and C. Giacomantonio et al., this conference.

[3] See for example B.J. Powell et al., J. Chem. Phys. 120, 8608 (2004).

BMP MOF14
Monday 1140–1200 hrs

Quantum Decoherence of Electronic Excitations of Biomolecules

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What is the role of quantum mechanics in biology? Although often ignored, quantum mechanics can be critical for the biological “functionality”, such as in photosynthesis and vision. We are investigating electronic excitations in biomolecules and the effect of decoherence due to the “hot and wet” environment of biology. We find that the interaction may be modeled quantum mechanically by the spin-boson model. This model is applied to systems of biomolecules coupled by Förster interaction, using parameters obtained directly from experiment and simulation, and used to investigate the presence and importance of entanglement and decoherence in biological systems.

BMP MOF15
Monday 1200–1220 hrs

Electrostatic Basis of Valence Selectivity in Biological Ion Channels

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To carry out numerous functions in the body, including conveying nerve impulses and sensory transduction, ion channels have to be able to open and close at the appropriate times and allow only the correct types of ion to pass. We use Brownian dynamics simulations to examine how the KcsA potassium, voltage gated sodium and L-type calcium channels discriminate between ions of differing charge. We demonstrate that none of these conduct anions and all conduct monovalent cations. As a result of the different charge distributions in the protein in each case, divalent cations can only pass through the calcium channel and block the others.

BMP MOF31
Monday 1620–1640 hrs

Visualising the Genetic Code

J. D. Bashford, E.Z. Chelkowska and P.D. Jarvis

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These days, new discoveries in molecular biology and advances in biotechnology are proceeding at breakneck pace. However, our understanding of some fundamental questions—such as the origin and evolution of the genetic code (not to mention the origin of life!)—remains rudimentary. The genetic code itself can be studied in terms of regularities in the physical and (bio)chemical properties of the codons, anticodons and amino acids which form its building blocks. We give several graphical presentations (including 3D plots) of such physico-chemical data. These visualisations can reveal otherwise hidden periodicities and other symmetries: the 'code within the code'.

[1] J. D. Bashford and P.D. Jarvis, BioSystems, **57**, 147 (2000)

BMP MOF32
Monday 1640–1700 hrs

Stability and Connectivity of the Brain

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The dynamics of a network of brain components can be described using a generalized continuum model. The linear stability of this network, determined by the model's dispersion relation, will act as a constraint on the possible structure of the network and hence on the physiology and anatomy of the brain. In this presentation the impact of stability on the structure of the brain will be investigated. A particular focus will be placed on resulting permitted patterns of the connectivity of brain components, with comparisons to the connectivity of real brains.

BMP MOF33
Monday 1700–1720 hrs

A Model-based Approach to EEG Spectral Analysis

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Spectral analysis of the electroencephalogram (EEG) commonly involves simply measuring total power in certain frequency bands. However an invertible model of EEG, combined with a suitably constrained optimization algorithm, provides an alternative quantification of spectra in terms of physiologically-relevant parameters. This is demonstrated in cases where data from simple experiments are used to infer the corresponding model parameters. Only a subset of parameters show significant changes related to the experiment, and this is more informative than traditional power changes.

BMP MOF34
Monday 1720–1740 hrs

A Phase-Transition Model for the Cycles of Natural Sleep

D.A. Steyn-Ross[1], M.L. Steyn-Ross[1], M.T. Wilson[1], J.W. Sleigh[2], I.P. Gillies[1] and J.J. Wright[3]

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This paper presents a model that describes the dramatic changes in brain electrical activity that occur during transition from slow-wave sleep (SWS) into rapid-eye-movement (REM) sleep. Our approach to the sleep cycle builds on earlier cortical-continuum models[1–5], and is most similar to our phase-transition model for

anaesthesia[6]. We describe the mathematical foundations of the model, calculate the predicted changes in EEG power and correlation time across the SWS! REM transition, then compare these predictions with clinical recordings from a human sleeper[7]. (The dynamical properties of the model are presented in a companion paper[8].)

The authors acknowledge support from the New Zealand Marsden Fund, contract UOW307.

[1] W.J. Freeman, Mass Action in the Nervous System, Academic Press, New York (1975)

[2] J.J. Wright and D.T.J. Liley, Behavioral and Brain Science 19, 285–316 (1996)

[3] P.A. Robinson, C.J. Rennie and J. J. Wright, Physical Review E 56, 826–840 (1997)

[4] D.T.J. Liley and P.J. Cadusch and J.J. Wright, Neurocomputing 26–27, 795–800 (1999)

[5] C.J. Rennie, J.J. Wright and P.A. Robinson, J. Theoretical Biology 205, 17–35 (2000)

[6] M.L. Steyn-Ross, D.A. Steyn-Ross and J.W. Sleigh, Progress in Biophysics and Molecular Biology 85, 369–385 (2004)

[7] I.P. Gillies, D.A. Steyn-Ross, M.L. Steyn-Ross, J.W. Sleigh and M.T. Wilson, "Evidence for cortical phase transitions in EEG recordings of human sleep", Poster: 16th National AIP Congress, Canberra, Australia (2005)

[8] M.T. Wilson, M.L. Steyn-Ross, D.A. Steyn-Ross and J.W. Sleigh, "Instabilities of the cortex during natural sleep", in: Proceedings of 16th National AIP Congress, Canberra, Australia (2005)

BMP MOF35
Monday 1740–1800 hrs

BOLD Responses to Stimuli: Dependence on Frequency, Stimulus Form, Amplitude and Repetition

P.A. Robinson, P.M. Drysdale, H. Van der Merwe, E. Kyriakou, B. Germanoska, M. Rigozzi and C.J. Rennie

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A quantitative theory is developed for the relationship between stimulus and the resulting Blood Oxygen Level Dependent (BOLD) functional MRI signal in the brain. A hemodynamic model is used to interrelate the neural activity and the BOLD response, where the neural activity is inferred from Evoked Response Potentials (ERPs). The BOLD response is studied for different forms, frequencies, and amplitudes of stimuli, in contrast with existing research which investigated only sustained pulses. It is found BOLD response depends strongly on both peak activity and profile. Stimulus sequences to optimize BOLD response signal-to-noise are derived using the hemodynamic transfer function.

POSTERS

BMP PMO 67

Ultra-Short Pulsed Laser Ablation for Dental Hard-tissue Treatments

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For some time now laser ablation for the purposes of hard-tissue dental treatment has been limited to Er:YAG and Er:YSGG based solid-state laser systems. Subpicosecond laser ablation has the potential to provide painless dental treatments with excellent surface preparation quality[1,2]. There exist issues with thermal deposition during the ablation process which may result in nerve and pulp tissue damage[3]. Both 800 nm and 400 nm laser pulses from a Ti:Sapphire based system (~120 fs pulses) were used to examine the effect of frequency doubling on the level of thermal loading, surface quality, ablation threshold and material removal efficiency. Preliminary results indicate there may be some advantage to using blue (400 nm) light for subpicosecond laser ablation as opposed to infrared.

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[2] M.H. Niemz et al., Appl. Phys. B **79** (2004), 269–271

[3] J.C. Chang, P. Wilder-Smith, Lasers in Surgery and Medicine, **22** (1997), 46–50

BMP PMO 68

Bio-nano-fabrication: Using Surface Plasmon Resonance to Study the Architecture and Kinetics of Construction of a Protein-based Biosensor

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The nanoscale assembly of protein-based biosensors is of critical importance to their function. Studied here is the coupling of the protein sensor element to a functionalised self-assembled monolayer on a gold substrate.

Surface Plasmon Resonance (SPR) was used to measure the kinetics of protein binding to functionalised surfaces. Proteins were immobilized using both histidine-Nickel affinity, and covalent amine coupling.

SPR results provide the reaction kinetics for the two coupling systems. The histidine-Nickel interaction is weaker but allows for a controlled molecular architecture, whereas the covalent coupling is significantly stronger, but involves random protein orientation.

BMP PMO 69

Modular Design of a Scanning Gantry for Animal SPECT, PET and CT Applications

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Using the modular design methodology, we have developed a scanning gantry system; custom designed for multi-modality nuclear imaging techniques (NITs) and the CoALA SPECT project[1]. This paper discusses the gantry's flexible modular design and how significant components and functionality have been reused in other medical physics related instrumentation developed at the Centre for Medical Radiation Physics, University of Wollongong. The gantry is designed to meet the exacting requirements of researchers in new radiotracer development who require accurate functional and anatomical information—the scanning gantry has a linear stepping accuracy of +/–12.5 microns and an angular accuracy of +/–0.03 degree. The scanning gantry is a precision instrument that is also affordable to research groups working in small laboratories or universities.

[1] S.R. Meikle, R. Wojcik, A.G. Weisenberger, M. F. Smith, S. Majewski, P. Kench, S. Eberl, R. Fulton, M. Lerch, A. B. Rozenfeld; **CoALA-SPECT: A Coded Aperture Laboratory Animal SPECT System for Pre Clinical Imaging**, Nuclear Science Symposium Conference Record, 2002, IEEE, Volume: 2, 10–16 Nov. 2002, Pages:1061–1065 vol.2.

BMP PMO 70

Comparison of Various Methods to Delineate Blood Vessel in Retinal Images

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We compare a number of methods to detect and delineate blood vessels in retinal images. The five methods include: Wavelet detection developed by ourselves[1], and matched-filtering[2], morphological processing[3], curvature estimation[4] and multi-threshold probing[5], developed by others. We test the methods against the publicly available STARE database which consists of twenty non-mydriatic colour retinal images and gold standards containing delineated vessels as determined by two ophthalmologists. The resultant vessel detections are compared against the gold standards using FROC methodology. It is found that the majority of vessel detection methods perform to similar ability to within the estimated uncertainty of the experiment.

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BMP PMO 71

Investigating a Novel Spectral Hole-Burning Mechanism in Photosystem II

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Photosystem II is a chlorophyll-containing trans-membrane protein complex. The PSII reaction centre (RC) contains a highly photo-oxidizable assembly of chlorophyll molecules. We have found highly efficient (up to ~1%) persistent spectral hole-burning in PSII core complexes occurs in chlorophyll's involved in energy transfer processes. The hole-burning mechanism, however, is associated with the primary charge separation process. We present results from investigation of the unusually symmetric photoproduct distribution and the (pseudo-) phonon sideband structure of spectral holes in PSII. We have also studied the wavelength dependence of the hole-burning quantum efficiency, and relate it to the QE of primary charge separation.

BMP PMO 72

Quantitative Study on the Effects of Sugars on Membrane Phase Transitions—Preliminary Investigations

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Severe dehydration is lethal for most biological species. However, there are a number of organisms which have evolved mechanisms to avoid damage during dehydration. One of these mechanisms is the accumulation of small solutes, which can inhibit deleterious membrane phase transitions at low hydration. Although these effects have been studied for some time, there is debate about whether the effects are caused by direct interactions between the solutes and the lipids, or by non-specific physical effects. In this paper we report on the preliminary investigations, using SAXS and DSC, of a project aimed at addressing this issue.

BMP PMO 73

Development of Models for Protein Aggregation Kinetics

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Protein self-association is of critical importance in a wide variety of situations, ranging from disease states (e.g., Alzheimer's disease) to protein-based drugs and food processing. The delicate nature of associating protein systems severely restricts the techniques available for probing the kinetics of association in such systems. Of these techniques, NMR diffusion measurements show great promise[1]. Theoretical development of models for aggregation kinetics has also been retarded by the paucity of experimental data. In this work we modify two existing, albeit simplistic, kinetic models[2] (i.e., (i) random polymerisation and (ii) nucleation-dependent polymerisation) into a form suitable for analysing NMR diffusion data[1,3]. These models were used as the basis for designing more cogent models of aggregation kinetics.

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BMP PMO 75

Infectious Disease Epidemic Evolution in Inhomogeneous Human Society

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Mathematical model of the epidemic evolution in the inhomogeneous human society, which consists of the population groups with different values of their immune system parameters such as susceptibility to disease, infection level, disease duration, and immunity duration is developed. The values of the most important parameters of the epidemic model are determined through the solutions of equations that describe the infection disease evolution in the human organism. The epidemic evolution in the society as well as in the separate groups of population is studied depending on the values of the human immune system parameters.

BMP PMO 76

Melanin and Melanoma: The Quantum Chemistry of Pheomelanin

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Melanins are pigments responsible for photoprotection in humans. In order to understand the photophysics of pheomelanin (the type of melanin more closely associated with the formation of melanoma skin cancer[1]) we have used first principles Density Functional Theory to calculate the electronic and vibrational properties of cysteinyldopa, the key precursor[2]. We have calculated realistic HOMO-LUMO gap energies, and determined the likely ratio of the two forms at room temperature. HOMO and LUMO electron densities have been calculated and compared with results from Huckel theory. These results take us one step closer to understanding the paradoxical behaviour of these mysterious molecules.

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[2] B. Powell, T. Baruah, N. Bernstein, K. Brake, R. McKenzie, P. Meredith, M. Pederson, Journal of Chemical Physics, 120 (18), 8608–8615 (2004)

BMP PMO 77

A Thermodynamics-Based Mechanism for the Slow Component of Oxygen Uptake Kinetics During High Power Exercise

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The profile of human oxygen consumption during high power exercise has captivated exercise physiologists for decades and the mechanism behind the slow component of this profile is still unclear[1,2]. The present study models this component from a thermodynamics perspective that considers the work associated with gas pressure, volume and temperature changes for the glucose-based equation of respiration. Model slow component curves closely match clinically measured curves[2] in shape and scale. Existing proposed mechanisms for the slow component are generally more qualitative or physiological in nature. Thus, the presented model may represent a significant contributing mechanism towards the slow component.

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BMP PMO 78

Instabilities of the Cortex during Natural Sleep

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We examine the electrical behaviour of the cortex during natural sleep. We use a macrocolumn-averaged model of cortical dynamics to analyse the stability of the stationary states. The model, developed from those introduced by Wright and Liley[1], Liley et al[2] and Robinson et al[3], allows the soma potentials to vary with time and space. The stability of the stationary states depends particularly on the inhibitory synaptic time constants. When unstable, the cortex moves into a limit cycle in time, but rapidly synchronises in space. High spatial frequencies are quickly removed. The results have similarities with the phenomenon of slow-wave bursting during sleep.

The authors acknowledge support from the New Zealand Marsden Fund, contract UOW307.

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BMP PMO 79

Evidence for Cortical Phase Transitions in EEG Recordings of Human Sleep

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Clinical electroencephalogram (EEG) records were obtained from human subjects during overnight sleep. Statistics derived included EEG power, correlation time, spectral entropy, and high-frequency/low-frequency power fractions. Time-series for power and correlation-time show coherent “sawtooth” patterns, with both quantities gradually increasing during SWS, then abruptly dropping away as the cortex transits into rapid-eye-movement (REM) sleep. The low- and high-frequency power fractions behave in antiphase, with growth in low-frequency power coinciding with decay in high-frequency power, and vice versa. These results are consistent with a first-order phase-change theory for sleep being developed at Waikato University[1,2]. This theory predicts a critical slowing down of the EEG signal on approach to the SWS ! REM transition.

Author IPG acknowledges Enterprise Scholarship support from the New Zealand Tertiary Education Commission.

[1] D.A. Steyn-Ross, M.L. Steyn-Ross, M.T. Wilson, J.W. Sleigh, I.P. Gillies and J.J. Wright, “A phase-transition model for the cycles of natural sleep”, in: Proceedings of 16th National AIP Congress, Canberra, Australia (2005)

[2] M.T. Wilson, M.L. Steyn-Ross, D.A. Steyn-Ross and J.W. Sleigh, “Instabilities of the cortex during natural sleep”, in: Proceedings of 16th National AIP Congress, Canberra, Australia (2005)

BMP PMO 80

Modelling the Readout Performance of a New Silicon Photodetector for Use in PET

G.J. Takacs[1], M.L.F. Lerch[1], R.D. Ward[1], P.E. Simmonds[1], V. Perevertaylo[2], and A.B. Rosenfeld[1]

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This paper discusses a Monte Carlo model of the readout performance of a new silicon photodetector (PD) when optically coupled to a scintillator for use in Positron Emission Tomography (PET). Results of the model for two PD-scintillator readout combinations have been compared with experimental results for the same readout configurations. The PDs were designed by the Centre for Medical Radiation Physics, University of Wollongong and manufactured by SPO BIT, Ukraine. We have found that the developed model could be a very useful tool in predicting the response of silicon PD-scintillator detectors for a variety of imaging applications.

BMP PMO 81

Application of Hard X-ray Phase-contrast Imaging to Biomedical and Clinical Medical Studies

S.W. Wilkins[1], D. Gao[1], T.E. Gureyev[1], S.C. Mayo[1], P.R. Miller[1], Y.I. Nesterets[1], D.M. Paganin2, D.J. Parry[1], A. Pogany[1], and A.W. Stevenson[1]

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Conventional X-ray radiography that has prevailed for the past 100 years relies on differential absorption in a sample to produce contrast. Recently, a variety of methods for producing additional x-ray contrast via phase effects have been proposed and explored[1–3]. Two of the most important classes of these methods are the double-crystal type (Analyzer-Based) and the simple Fresnel diffraction (In-Line) types. The present paper will briefly highlight the key features of these and some recent results obtained with them for biomedical applications using both synchrotron[2] and conventional sources[3]. It will also describe their current status for clinical medical applications.

[1] R. Fitzgerald, Phase-sensitive X-ray imaging, Phys. Today **53**, No7,23–26 (2000)

[2] A. Snigirev, I. Snigireva, M. Suvorov, M. Kocsis,., & V. Kohn, Rev. Sci. Instrum. (1995) **66**, 5486–92.

[3] S.W. Wilkins, T.E. Gureyev, D. Gao, A. Pogany, and A.W. Stevenson, Nature **384**, 335–8(1996).

BMP PMO 82

Nanodosimetric Cluster Size Distributions of a 250 MeV Therapeutic Proton Beam

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Nanodosimetry enables the energy deposition of ionizing radiation on a DNA scale to be determined. The purpose of this research is to conduct nanodosimetric measurements of proton radiation fields at the proton accelerator of Loma Linda University Medical Center (LLUMC) in an attempt to verify a Monte Carlo simulation system. To achieve this, these measurements will be compared to the output from a Monte Carlo simulation system that is being developed to simulate the nanodosimetric spectra of the LLUMC beamline. Once verified, this Monte Carlo system will provide a very powerful tool with which to measure the effect of radiation fields on a nanoscopic level without submitting humans or expensive electronics to such a potentially damaging environment.

BMP PMO 83

Protein Response to Electric Field Stress

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Proteins can change conformation under stress, which can lead to disruption of their biological function and result in a number of diseases[1].

In an effort to understand the effect of external stresses on protein conformation, we have performed long term molecular dynamics simulations of insulin chain β in several different environments. The conformational behaviour of the protein under thermal and electric field stresses was compared to the reference system under ambient conditions. We found the system under electric field stress to behave similarly to the system under thermal stress, both adopting conformations rarely seen under ambient conditions.

[1] L.C. Serpell, J.M. Smith, J. Mol. Biol., 299, 225 (2000)

BMP TUE31
Tuesday 1620–1640

Oligonucleotide Microarrays and Langmuir Adsorption Theory

C.J. Burden, Y. Pittelkow and S.R. Wilson

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Oligonucleotide microarrays are designed to enable evaluation of the simultaneous expression of large numbers of genes in prepared RNA samples. A microarray consists of a substrate onto which short, single strand DNA probes have been synthesized. Intensity measurements from fluorescent dye attached to RNA target molecules hybridized onto the microarray surface are intended as a measure of gene expression.

We develop a model based on Langmuir adsorption theory for relating measured intensity measurements to the underlying specific sequence RNA concentration. The model includes the effects of non-specific hybridization and acknowledges that hybridization is a two step process involving a rate determining nucleation step followed by a rapid zipping up step.

BMP TUE32
Tuesday 1640–1700

Nano-structured Surfaces for Guided Actomyosin Motility to Develop New Toxin Indicating Biosensors

D. Ramdutt[1] R.W. Boswell[1] and C. Charles[1], C. dos Remedios[2] and R. Martinez[2]

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We have developed techniques for producing nano-structured surfaces that will allow us to bind functional heavy meromyosin (HMM) in such a way that the velocity of the fluorescing actin filament can be easily measured. Methods trailed by Bunk et al[1] using different resist polymers has been repeated as well as techniques we have pioneered using Focused Ion Beams (FIB) and isotropic plasma etching to develop physical (non-time dependent) hydrophobic surfaces. Motility, including speed and density of actin filaments, has been measured on all surfaces. It is hoped that these surfaces will aid in the development of a new biosensor.

[1] R. Bunk et al, Biochem. Biophys. Res. Commun. 301, 783–788, 2003

BMP TUESDAY

BMP TUE33
Tuesday 1700–1720

Research and Development of Semiconductor-based Instrumentation with Application to Medical Physics

A.B. Rosenfeld

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Over the last ten years the Centre for Medical Radiation Physics at the University of Wollongong has established a research programme in the area of medical physics that is centred on new and novel silicon semiconductor detectors. Arising from this research is the development of innovative instrumentation with application to radiation medicine. This paper will describe the motivation and background research of several instruments, that are at different stages of development and commercialisation, including the Semiconductor Microdosimeter, Radiation Damage Monitoring System, MOSFET dosimetry System, Urethra Probe Mini-Spectroscopy System and Anti-Compton Probe. These instruments have found application in a wide variety of radiation medicine related areas includng Proton Therapy, Fast Neutron Therapy, Microbeam Radiation Therapy, Intensity Modulated Radiation Therapy, Permanent Seed Implant Prostate Brachytherapy, and Radionuclide Image Guided Surgery.

BMP TUE34
Tuesday 1720–1740

The Key Factors which Determine the Cooling Effect of Blood Flow Near Ultrasonically Heated Bone

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To determine the critical factors that produce cooling, a phantom simulating human fetal skull bone was immersed in a soft tissue mimicking material (TMM). This was exposed to clinically relevant pulsed Doppler ultrasound with power outputs of up to 255 mW. Water flowing in a 2-mm wall-less channel in the TMM, at various distances from the bone target, simulated blood flow. The temperature was measured at the inner surface of the bone. The cooling effect was more effective as the distance between the perfusing channel and bone was decreased, as the number of channels increased and as the ultrasound beamwidth increased.

BMP TUE35
Tuesday 1740–1800

Application of the Lattice Boltzmann Model to Hemodynamics with Arterial Stenosis Growth

J. Boyd[1], J.M. Buick[1], J.A. Cosgorve[2] and P. Stansell[2]

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Blood flow dynamics is an important feature in the study of many arterial diseases. There is a body of evidence that suggests there is a correlation between atherosclerosis and abnormal wall shear stress. The Lattice Boltzmann Model (LBM) can be used to study many of the flow features that are important in hemodynamic modelling. applications. In this paper, the LBM with an extrapolation boundary scheme is used to model blood flow through a carotid artery with increasingly severe stenosis. The simulations are two dimensional as a precursor to three dimensional simulations and give an indication of the flow characteristics.

Condensed Matter and Material, and Surface Physics (CMMSP)

CMMSP MOC21
Monday 1400–1440 hrs

Quantum Mechanics Rules

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While it is well known that magnetism is a macroscopic quantum phenomenon, a semi-classical picture is generally used and is often adequate. However in recent years a number of phenomena have been observed which cannot be understood at all without a full quantum mechanical treatment. Examples include spin liquid states, “order from disorder”, quantum phase transitions. I will give an overview of such phenomena, including both theory and experiment. Some of the recent work of our group at UNSW will be described.

CMMSP MOC23
Monday 1440–1500 hrs

The Locus of High Temperature Superconductivity in $YBa_2Cu_3O_{7-\delta}$

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Despite intensive (>30,000 technical publications) and sustained research over the past 18 years, a consensus regarding the pairing mechanism in cuprate superconductors remains elusive. Related to this issue is the question of the locus of high T_c superconductivity. At the outset a bold model[1] and more recent work[2,3] suggest that superconductivity is parallel to copper oxide planes but displaced along the c-axis. Such models are remarkable given that it is widely assumed that the superconductivity is confined to CuO_2 planes. We present experimental[4] and theoretical work[5] on YBCO that attempts to reconcile these contrasting views.

[1] K. H. Johnson, M. E. McHenry, C. Counterman, A. Collins, M. M. Donovan, R. C. O'Handley and G. Kalonji, Physica C, 153–155, 1165 (1988).

[2] A. Kumar, J. D. Dow and H. A. Blackstead, Philos. Mag. 84, 2249 (2004).

[3] J. D. Dow and D. R. Harshman, Philos. Mag., 82, 1055 (2002).

[4] J. D. Cashion, D. Jinks, G. Jakovidis, L. J. Brown, G. Ganakas and M. J. Morgan, J. Mater. Sci. Mater. Elec. 8, 39 (1997).

[5] A. E. Smith, S. Homolya and G. Jakovidis, 3rd International Conference on Computational Modelling and Simulation of Materials, Sicily (2004).

CMMSP MOC24
Monday 1500–1520 hrs

Toward Quantum-limited Detection with an Aluminium SQUID Amplifier

N.A. Court[1,2], D.J. Reilly[1,2], T.M. Buehler[1,2], V.C. Chan[1,3], R.P. Starrett[1,2] and R.G. Clark[1,2]

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The radio frequency single electron transistor (rf-SET) is a near quantum-limited electrometer, capable of sensing sub-electron charge signals on microsecond timescales[1]. In addition to applications in radio astronomy and nuclear magnetic resonance, this device holds promise as a read-out detector for solid state quantum computing[2]. At present the sensitivity of the rf-SET is limited by the noise contribution of the post amplifier which is typically a cryogenic transistor. In an effort to overcome this limitation we are currently exploiting the dc-SQUID (superconducting quantum interference device) as a near-quantum limited post amplifier of radio frequency signals[3]. This hybrid configuration, consisting of a near quantum-limited electrometer (rf-SET) coupled to a near quantum-limited post amplifier (dc-SQUID) opens the prospect of studying sub-electron charge motion in condensed matter systems with unheralded sensitivity. Here we present results to date in our effort to construct an all Aluminium microstrip SQUID amplifier. We include details of our fabrication process together with numerical simulations of the microwave circuits and compare these results to data taken at mK temperatures.

[1] R.J. Schoelkopf et al, Science 280, 1238 (1998)

[2] T.M Buehler et al, arXiv:cond-mat/0302085 (2003)

[3] R. Bradley et al, Rev. Mod. Phys. 75, 777 (2003)

CMMSP MOC25
Monday 1520–1540 hrs

Evolution of the Bilayer $\upsilon = 1$ Quantum Hall State under Charge Imbalance

W.R. Clarke[1], A.P. Micolich[1], A.R. Hamilton[1], M.Y. Simmons[1], C.B. Hanna[2], J.R. Rodriguez[2], M. Pepper[3] and D.A. Ritchie[3]

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We use high-mobility bilayer two-dimensional hole systems with negligible tunnelling to examine how the bilayer $\upsilon = 1$ quantum Hall state evolves as charge is transferred from one layer to the other at constant total density[1]. We map

bilayer υ = 1 state stability versus imbalance for five total densities spanning the range from strongly interlayer coherent to incoherent. We observe competition between single-layer correlations and interlayer coherence. Most significantly, we find that bilayer systems that are incoherent at balance can develop spontaneous interlayer coherence with imbalance, in agreement with recent theoretical predictions.

[1] W.R. Clarke et al., Cond-Mat/0403490 (2004).

[2] Y. N. Joglekar and A. H. MacDonald, Phys. Rev. B 65, 235319 (2002).

CMMSP MOC31
Monday 1620–1700 hrs

Inelastic Neutron Scattering and the Dynamics of Biomolecules

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Life is intrinsically a dynamic process. As such, the biophysical and biochemical processes which living systems rely upon are inherently dynamic as well. One particular manifestation of this is the molecular motion of proteins and enzymes, without which the functional specificity and efficiency would not be attained. Here, we will discuss the use of neutron spectroscopy to study the motions of proteins in solution in various folded sates. These experimental results will be directly compared with the results of molecular dynamics simulations enabling a detailed interpretation of the side-chain motions related to each individual amino acid residue. We will also describe how neutron scattering can be used to measure the suppression of these intrinsic motions and how this suppression correlates directly to the shelf-life of biopharmaceutical formulations.

CMMSP MOC33
Monday 1700–1720 hrs

Opportunities for Scientific Research at Australia's Replacement Research Reactor

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The 20-MW Australian Replacement Research Reactor represents possibly the greatest single research infrastructure investment in Australia's history. The project includes a large state-of-the-art liquid deuterium cold-neutron source and supermirror guides feeding a large modern guide hall, in which most of the instruments are placed. Alongside the guide hall, there is good provision of laboratory, office and space for support activities. While the facility has "space" for up to 18 instruments, the project has funding for an initial set of 8 instruments, which will be ready when the reactor is fully operational in July 2006. Instrument performance will be competitive with the best research-reactor facilities anywhere, and our goal is to be in the top 3 such facilities worldwide.

CMMSP MOC34
Monday 1720–1740 hrs

Time-resolved Studies of Neutron Diffraction Intensities in Association with Phase Transitions

J.E. Daniels[1], A.J. Studer[2], T.R. Finlayson[1] and M.E. Hagen[3]

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A neutron scattering capability has been developed, enabling time-resolved measurements, for example, in ferroelectric crystals. Neutrons detected at the position sensitive detector on TASS, are time-stamped allowing measurement of scattered intensities versus time. Samples are continually strobed by an electric field while detected neutrons are binned according to their scattering times from the sample, within the strobing period. The ferroelectric triglycine sulphate is being used as a model system for the development of the technique, owing to this material exhibiting some unusual changes in peak intensities with time, during poling[1].

[1] S.J. Payne, PhD Thesis, University of Keele (1998)

CMMSP MOC35
Monday 1740–1800 hrs

Neutron Reflectivity of Titania and Zirconia-based Films Self-assembled at the Solid/Liquid Interface

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Self-assembled orientated titania (TiO_2) and zirconia (ZrO_2) based films have been produced at the solid-liquid interface using sodium dodecyl sulfate (SDS) as the template. For the first time these new films are characterised by in situ grazing angle neutron reflectometry using the recently commissioned X172 instrument at HIFAR facility (Australian Nuclear Science and Technology Organisation). This work complements our recent study of the formation of these films at the air/water interface[1,2,3] using fast, time resolved energy dispersive x-ray reflectometry.

[1] Henderson, M. J., King, D., White, J. W., Langmuir, 2004, 20, 2305–2308.

[2] Henderson, M. J., King, D., White, J. W., Aust. J. Chem., 2003, 56, 933–939.

[3] Henderson, M. J., Gibaud, A., Bardeau, J. F., Rennie, A., White, J. W., Physica B submitted, 2004.

CMMSP TUC11
Tuesday 1040–1100 hrs

Conducting Ni Nanoparticles in an Ion-modified Polymer

J.Y. Sze[1], C.I. Pakes[2], S. Prawer[2], B.K. Tay[1] and D.N. Jamieson[2]

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Conductive atomic force microscopy has been used to perform nanoscale current mapping of Ni-implanted polythylene terephthlate films at low temperature. The films were implanted using a filtered cathodic arc with pulse substrate biasing. Our interest is in the study of electrical transport in the implanted surface layer, which demonstrates a reduction in bulk sheet resistance for Ni surface concentration of 14–18%. The local transport properties are found to evolve with increasing Ni content from a near continuous conducting surface to the formation of a quasi-regular array of conducing Ni clusters, about 30 nm in size, consistent with X-ray analysis. We shall discuss temperature dependent electrical measurements, that are indicative of an insulator-metal transition accompanying the formation of Ni crystallites, and the magnetic properties of the films.

CMMSP TUC12
Tuesday 1100–1120 hrs

Investigation of the Growth and Spontaneous Alignment of Lanthanum Gallate Self-Assembled Microdots on Si(111) Surface

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The formation of self-assembled Quantum Dots (QDs) on semiconductor surfaces is well-known. We have used RF sputtering to produce self-assembled islands of doped Lanthanum Gallate on Si(111) substrate that are several orders of magnitude larger than the QDs. These microdots, however, share many features with Quantum Dots, such as the ability for spontaneous alignment. We present our Scanning Electron Microscopy (SEM) and Energy Dispersive Spectrometry (EDS) results, and put forward explanations of the formation and alignment by reference to the Stranski-Krastanov (SK) Growth Mechanism.

CMMSP TUC13
Tuesday 1120–1140 hrs

Nano-assembly of Conjugated Polymer on Carbon Nanotubes: An STM Study

R. Goh[1], E. R. Waclawik[2], N. Motta[1,3], J. M. Bell[1]

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Composites of the conducting polymer poly (alkylthiophene)s and carbon nanotubes have huge potential for a variety of application including organic solar cells and optoelectronic memory device[1,2]. For this potential to be realised, the interactions between nanotube and the polymer and the crystallisation mechanism needs to be first of all clarified. Here, we will report on our latest work on scanning tunnelling microscope (STM) to directly visualise the conformation of poly(3hexylthiophene) (P3HT) on single walled carbon nanotubes (SWNT). Based on high resolution STM observations, the mechanisms for the organisation of monolayer and multilayers of P3HT on SWNT are proposed.

[1] E. Kymakis, PhD thesis, University of Cambridge (2003)

[2] A. Star, Y. Lu, K. Bradley, and G. Gruner, Nano Lett, **4**, 1587 (2004)

CMMSP TUC14
Tuesday 1140–1200 hrs

Nanoporosity in a Self-Assembled Drug Delivery System Detected by Positron Annihilation Lifetime Spectroscopy

Ansgar Bögershausen[1], Steven J. Pas[1,2], Anita J. Hill[2,3*], and Hubert Koller[1]

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We present a new drug carrier system that consists of silica hybrid gels having organic side groups. A major difference to existing formulations is that the matrix is generated in the presence of the drug molecule in a self-assembling process. The critical role of pore architecture (size and accessibility) in the tailored drug release is clearly revealed by positron annihilation lifetime spectroscopy (PALS), while the classical nitrogen adsorption technique (BET method) is not suitable here to indicate the internal void structure.

CMMSP TUC21
Tuesday 1400–1440 hrs

Silicon-based Quantum Computing using Buried Donor Architectures

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Quantum computers have the potential to unveil a new paradigm of information processing via the coherent control of quantum bits (qubits). Solid-state implementations based on superconductors and semiconductors are particularly promising due to the prospect of producing large numbers of qubits via integrated circuit fabrication technology. Of these, the Kane Si:P scheme[1] has generated great interest because of the long coherence times of spins in silicon. This and related Si schemes (such as the Si:P charge qubit[2]) require the positioning of single phosphorus atoms in silicon, registered to surface control gates with high precision, together with an ability to read out a single spin or charge. Important strides in construction of atomically-precise P atom arrays in Si have been demonstrated over the past few years using a bottom-up assembly approach[3], while controlled single ion implantation[4] has recently been used to construct Si:P qubit test devices with a precise number of P atoms using more conventional top-down nanotechnologies. This presentation will discuss the challenges of fabricating, controlling and measuring such single donor qubits, in particular those constructed via single ion implantation. Experimental results showing the gate-controlled transfer of single electrons between two buried Si:P quantum dots, each containing ~ 600 phosphorus atoms, with non-invasive detection using rf single electron transistors (SETs) will be presented[5], together with recent data on devices with only a few (less than ten) phosphorus donors.

[1] B.E. Kane, Nature 393, 133 (1998).

[2] L.C.L. Hollenberg, A.S. Dzurak, C. Wellard, A.R. Hamilton, D.J. Reilly, G.J. Milburn and R.G. Clark, Phys. Rev. B 69, 113301 (2004).

[3] S.R. Schofield, N.J. Curson, M.Y. Simmons, F.J. Ruess, T. Hallam, L. Oberbeck and R.G. Clark, Phys. Rev. Lett. 91, 136104 (2003).

[4] R.P. McKinnon, F.E. Stanley, E. Gauja, L.D. Macks, M. Mitic, V. Chan, K. Peceros, T.M. Buehler, A.S. Dzurak, R.G. Clark, C. Yang, D.N. Jamieson and S.D. Prawer, Smart Mat. and Struct. 11, 735 (2002).

[5] T.M. Buehler, V. Chan, A.G. Ferguson, A.S. Dzurak, F.E. Stanley, D.J. Reilly, A.R. Hamilton, R.G. Clark, D.N. Jamieson, C. Yang, C.I. Pakes and S. Prawer, in preparation.

CMMSP TUC23

Tuesday 1440–1500 hrs

Differentiating Dopant and Resist in Device Fabrication on the Atomic Scale

T.C.G. Reusch[1], N.J. Curson[1], S.R. Schofield[2], T. Hallam[1], and M.Y. Simmons[1]

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STM lithography using a hydrogen resist has been recently demonstrated to achieve atomically precise placements of single phosphorous dopants on Si(001) surfaces[1]. This approach is currently pursued to fabricate nanoscale devices towards the quantum computer architecture proposed by Kane[2].

So far, studying the redistribution of P dopants in the Si(001) surface has been hampered by the fact that the P dopants in the surface and remains of the hydrogen resist have close similarity in STM imaging[3]. We demonstrate that subtle differences in the local electronic structure can be exploited for differentiating the two species in voltage-dependent imaging and Scanning Tunneling Spectroscopy.

[1] S. R. Schofield et al., Phys. Rev. Lett. 91, 136104(2003)

[2] B. E. Kane, Nature 393, 133(1998)

[3] N. J. Curson et al., Phys. Rev. B 69, 195303(2004)

CMMSP TUC24

Tuesday 1500–1520 hrs

Magnetospectroscopy to 18 T of Phosphorous Donor in Silicon

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We report the far-infrared absorption magnetospectroscopy of P donor in Si to higher magnetic fields than those employed previously. Absorption spectroscopy provides additional information to that provided by PTIS for P donor in Si. Anti-crossings between various states have been observed.

CMMSP TUC25
Tuesday 1520–1540 hrs

Kelvin Probe Force Microscopy Study of Ion Implanted Thermal Oxide Thin Films on Silicon

M. D. H. Lay, C. I. Pakes, and J. C. McCallum

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Ion implantation through gate oxides may be used for future device fabrication. However, studies of the damage created have mostly been restricted to optical and magnetic studies with EPR, PL and IR absorption. We have studied the surface potential of keV energy P implanted 15 nm thermal oxides on silicon substrates with Kelvin probe Force Microscopy. Results have shown a surface potential change while there may not be any observed change in the topology. Analytical & numerical modeling has also been used to relate the change in potential to net charge.

CMMSP TUC31
Tuesday 1620–1700 hrs

Liquid Semiconductors: Is Mott or Anderson Localisation Relevant?

J. Enderby

President, Institute of Physics

Emeritus Professor and Senior Research Fellow in Physics, Department of Physics, University of Bristol

Sir Professor John Enderby is the current President of the Institute of Physics (IOP) and his two-year term of office will encompass the Einstein International Year of Physics—the centenary of Einstein's greatest discoveries, and a celebration of physics around the world. He received his knighthood in the 2004 New Year's honours list for services to science and technology and is currently involved in work on molten ceramics and some exotic liquid semiconducting materials. This later work includes studies of the electrical conductivity of liquid silicon obtained from samples that were aerodynamically levitated on an inert argon gas stream. In this case it was shown that the conductivity could be obtained by accurate measurements of the change in the self-inductance and the resistance of a sensing coil in the presence of a conducting sample over a frequency range of 100 kHz to 5 MHz. This and related work on liquid alloy semiconductors has challenged the idea that the apparent metal to non-metal transition observed in liquid alloy semiconductors is related to disorder induced localization. This presentation will highlight aspects of this work.

CMMSP TUC33
Tuesday 1700–1720 hrs

Investigation Of Subsurface Specimen Charging Induced in Buried Oxide Layers by Electron Beam Irradiation

M A. Stevens-Kalceff[1,2] and S. Mickle[1]

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Kelvin Probe Microscopy (KPM) and Cathodoluminescence (CL) microanalysis have been used to investigate electron beam induced localized charging processes and defect generation in technologically important SIMOX-SOI. KPM directly confirms significant localized residual potentials associated with the buried oxide layer. Observed potentials are modelled giving insight into the complex, dynamic and self-regulating irradiation induced processes which involve competition between electron trapping, defect generation and electromigration. CL identifies defects in irradiated SIMOX consistent with oxygen radiolysis and breakdown of the buried oxide layer. CL also provides evidence for the dissociation of passivating species from silicon nanocrystals incorporated within the buried oxide layer.

CMMSP TUC34
Tuesday 1720–1740 hrs

Photo-excitation Induced Processes In Amorphous Semiconductors

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Amorphous semiconductors are used in fabricating many opto-electronic devices such as solar cells, large area thin film transistors (TFT), memory storage discs etc., and hence have immense industrial applications. Most of such devices operate on the principle of first creating excited electron and hole pairs by optical excitations or injections and then their separation and collection or their radiative recombination. On one hand, structures of such semiconductors do not have any long-range orders and hence tend to hinder the motion of charge carriers by offering them some confinements. On the other hand, the lack of long-range periodicity gives rise to several new phenomena, which do not occur in crystalline solids.. Some of these new phenomena are used in new frontier technologies, for example, future DVDs are likely to use the phenomena of photodarkening and volume expansion for storing information in their optical memory.

In this paper, the current understanding of photodarkening, volume expansion and radiative recombination of the excited charge carriers in amorphous semiconductors will be presented.

[1] J. Singh and K. Shimakawa, Advances in Amorphous Semiconductors (Taylor & Francis, London and New York, 2003).

CMMSP TUC35
Tuesday 1740–1800 hrs

Electrical Conduction Mechanism of ZnO Thin Films

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The ZnO thin films deposited by magnetron sputtering were studied by X-ray diffraction and conductivity measurement. We have found that the density of ZnO thin films have some relationships with their conductivity. The conductivity with temperature has been found to follow the Arrhenious equation, revealing two activation energies, one for higher and one for the lower temperature ranges. While the activation energy at higher temperatures is derived from charge transport in the conduction band, the lower energy activation energy is derived from electronic hoping between the nearest neighbours.

POSTERS

CMMSP PTU 45

1-Dimensional P Wires in Si

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Mesoscopic wire fabrication methods were developed for Si wafers containing P “delta-doped layers”. Reactive ion etching through masks written using electron-beam-lithography was used to make 1-D wires that are a few nm thick[1], and 20nm to 1um wide. These permitted exploration of electron quantum transport at 4K in disordered systems, as wire width approaches the electron coherence length. The results exhibit resistivity rising sharply as channel widths reduce. Also, wafers grown at 250C show resistivity two orders less than those at room temperature, agreeing with the notion that higher encapsulation temperatures provider better quality crystals.

[1] ‘Encapsulation of phosphorus dopants in silicon for the fabrication of a quantum computer’, L. Oberbeck, N. J. Curson, M. Y. Simmons, R. Brenner, A. R. Hamilton, S. R. Schofield, and R. G. Clark, Appl. Phys. Lett. 81, 3197 (2002)

CMMSP PTU 46

Ion Beam Lithography of PMMA Using Single Ion Detection

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A high energy ion (>1 MeV) travelling through a resist material leaves a cylindrical latent damage track with a very high aspect ratio. We aim to realise the full potential of ion beam lithography by reaching the ultimate resolution limit of a single ion track using controlled ion implantation. We spin a PMMA resist film onto a PIN photodiodes which functions as an active substrate, counting each ion impact. We have investigated the formation of single ion tracks using ions with a wide range of LETs using non-contact Atomic Force Microscopy (AFM) to image single ion tracks.

CMMSP PTU 47

Charge Transfer in Single-Ion Implanted Silicon Devices

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We present results on gate-controlled charge transfer in silicon devices fabricated using controlled single-ion implantation. Individual phosphorus donors are introduced using integrated p-i-n detectors[1]. Positional accuracy of 20 nm is obtained using a nanopatterned resist mask, and nanocircuitry consisting of surface electrodes and single-electron transistors is used to control and detect charge transfer in the implanted region[2]. Using the cross-correlated signal from two simultaneously operated single-electron transistors, we have observed isolated charge transfer events with occasional coupling to nearby fluctuating charge. These results indicate a possible pathway for charge-based solid state quantum bits.

[1] T. Hopf *et al.*, Submitted to AIP Congress 2005

[2] M. Mitic *et al.*, Submitted to Microelectron. Eng.

CMMSP PTU 48

Dephasing of a Charge Qubit by Charge Fluctions

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In this work, we examine the dephasing effects of charge fluctuations on Si:P donor charge qubits caused by the presence of randomly occupied charge traps. We numerically calculate the evolution of a general two-level system in the presence of these traps, by either solving a deterministic master equation or a stochastic Schroedinger equation, depending on the trap rate. The induced dephasing rate is calculated as a function of both the strength and the rate of the fluctuation as well as the position of the trap with respect to the qubit. This general formalism is applied to the specific case of a phosphorus in silicon based charge qubit.

CMMSP PTU 49

Development of a Silicon-based Single Electron Transistor

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Single electron transistors (SETs) are able to perform fast and sensitive charge measurements. The silicon SET described here is designed for controllable and reproducible low temperature operation, suitable for integration with Si-based quantum bit devices. It comprises a novel dual gate structure on a silicon-on-insulator substrate. A silicon quantum wire is formed in a high-resistivity superficial silicon layer. Carriers are induced in the silicon wire by a back gate in the degenerately-doped silicon substrate. The tunnel barriers are created electrostatically, using lithographically defined metallic electrodes. This architecture enables independent control of tunnel barrier height and island occupancy.

CMMSP PTU 50

Stress Formation in Continuous and Multiple Layer Depositions of SiO_2 by Helicon-activated Reactive Evaporation

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Multiple layers of SiO_2 films have been deposited by helicon-activated reactive evaporation which show dramatic differences in the stress profiles compared to a single continuous deposition. A new in-situ method of measuring curvature due to stress in the film shows promising results for a non-destructive and direct method of stress measurement. The presence of a post-growth relaxation mechanism, which serves to redistribute the stress formed during film growth, is suggested following a comparison of results obtained by in-situ stress measurements and by profilometry after etching back the film. This may have implications for optoelectronic applications, e.g. through stress-induced birefringence.

CMMSP PTU 51

Effects of As/P Exchange on InAs/InP (100) Quantum Dots Formation by Metalorganic Chemical Vapor Deposition

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Self-assembled InAs/InP quantum dots (QDs) are very promising active materials for QD lasers and semiconductor amplifiers for optical fiber communications (1.3–1.55 mm). However the main challenge associated with this material system is the As/P exchange reaction which degrades the structural and optical properties of the QDs. In this talk, we will show the effect of growing a thin spacer layer of GaAs or InGaAs prior to the deposition of the InAs QDs by metalorganic chemical vapor deposition. Not only the effect of As/P exchange is suppressed or minimized but the bandgap of the QDs could be tuned too.

CMMSP PTU 52

Fast Simulation of a Quantum Phase Transitions in a Ion-Trap Realisable Unitary Map

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We demonstrate a method of experimentally exploring the quantum critical point of the Ising universality class using unitary maps that have recently been demonstrated in ion trap quantum gates. We reverse the idea with which Feynman conceived quantum computing, and ask whether a realisable simulation corresponds to a physical system. Using renormalisation group theory, we show that a specific unitary map may be identified with the time evolution of an effective Hamiltonian, which belongs to the same universality class as the transverse Ising Hamiltonian. We suggest experimental signatures, and present numerical simulations for these in the six-qubit case.

CMMSP PTU 53

RVB Theory of Cs_2CuCl_4 in a Magnetic Field

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The Resonance Valence Bond (RVB) state was (incorrectly) suggested as the solution to the ground state of the Hubbard model on the square and isotropic triangular lattices[1]. Recently deconfined spinons, a natural feature of an RVB state, have been observed by neutron scattering in the frustrated antiferromagnetic Cs_2CuCl_4[2]. Exact diagonalisation shows that the RVB state strongly overlaps with the exact ground state for some frustrated Heisenberg models[3]. We develop the

RVB theory of the Heisenberg model on the anisotropic triangular lattice (appropriate for Cs2CuCl4) in a magnetic field and compare the results with the aforementioned neutron scattering experiments.

[1] P.W. Anderson, Science **235**, 1196 (1987)

[2] R. Coldea *et al.*, Phys. Rev. B **68**, 134424 (2003)

[3] L. Capriotti *et al.*, Phys. Rev. Lett. **87**, 097201 (2001)

CMMSP PTU 54

Phase Evolution in Aluminium Alloys as Studied by Nuclear Magnetic Resonance and Positron Annihilation Lifetime Spectroscopy

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The structural evolution of aluminum alloys Al(Cu), Al(Cu, Mg), and Al(Cu, Cd) is studied by combining the chemical specificity of ^{63}Cu nuclear magnetic resonance (NMR) with the defect sensitivity of positron annihilation lifetime spectroscopy (PALS). The early stages of decomposition including solute clustering and Guinier-Preston (GP) or Guinier-Preston-Bagaryatski (GPB) zone formation are followed and the effects of micro alloying are examined. Structural evolution is encouraged via a sequence of thermal treatments as well as mechanical deformation, or light cold-work, of the alloys.

[1] Bastow, T. J. and Celotto, *Acta Materialia*, Vol 51 (15): 4621–4630 (2003).

[2] Bastow, T. J. and Celotto, S., *Materials Scienece and Engineering C*, Vol 23 (6–8): 757–762 (2003).

[3] Bastow, T. J., ^{63}Cu *Phil. Mag.* in press.

CMMSP PTU 55

Analysis of Intermetallic Phases in Aerospace Aluminium Alloys Using a Nuclear Microprobe and Phase Correlation Mapping

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In this work we investigate the use of correlation maps produced using PIXE analysis performed on a nuclear microprobe for studying different intermetallic phases in the important aerospace alloy AA2024-T3. The aim of this work is to develop a method for the rapid identification of intermetallic particles and their association with the onset of pitting corrosion in this alloy. We show that Cu-Fe-Mn-Al intermetallic particles in conjunction with S-phase intermetallics have a high correlation with pit nucleation. We also show that Al-Cu correlation diagrams can be used to show dealloying of S-phase particles ($CuMgAl_2$) following corrosion.

CMMSP PTU 56

Electron Paramagnetic Resonance of Defects and Fe^{3+} in Kimberley Zebra Rock

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The unusual red-brown and white bands in Zebra rock from the Kimberley region of Western Australia have been proposed as originating from a ferronematic Precambrian liquid crystal phase[1]. This is supported by the linewidth variations and orientation dependence of the EPR spectra of defects and substitutional Fe^{3+} in the kaolinite constituent. The temperature dependence of the EPR spectra of superparamagnetic particles of ferrihydrite, observed in both red and white regions, suggest particle uniformity and a mechanism for the aggregation and segregation of the haematite in the red bands.

[1] E. Mattievich, J. Chadwick, J.D. Cashion, J.F. Boas, M. J. Clark and R.D. Mackie (2003). Proceedings of the 27th Annual Condensed Matter and Materials Meeting, Wagga 2003. www.aip.org.au/wagga2003

CMMSP PTU 57

Determining Structural Information from Powders using Small Angle X-ray Scattering (SAXS).

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Small angle X-ray scattering (SAXS) is an excellent technique to characterise the morphology of inhomogeneities in the bulk in the size range from 1 nm—several hundred nm's. SAXS is due to the electron density difference between the matrix and the inhomogeneity. It is an indirect imaging technique where information on the morphology of the inhomogeneity is determined by a transformation from reciprocal space to real space. I will introduce the fundamentals of SAXS and describe how SAXS can determine information from powder samples such as specific surface area, pore size and volume fraction.

CMMSP PTU 58

Plasma Engineering of Multilayered Carbon Coatings

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Thin film coatings consisting of alternating layers of different materials or phases (multilayers) with structural features in the nanometer scale can exhibit exceptional mechanical properties. For demanding applications such as cutting tools and biomedical devices, this new and novel method for producing coatings may prove to be superior compared to traditional single-layer coatings. However, the relationship between microstructure and properties in multilayers is not well understood. We investigate the possibility of producing multilayers consisting of different forms of amorphous carbon. We show that these types of multilayered structures can be synthesised using plasma deposition and processing.

CMMSP PTU 59

Magnetic Structures and Valence Transitions in $RMn_2(Si,Ge)_2$ (R=Yb, Eu)

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Rare-earth (R) intermetallic compounds containing Yb and Eu are of continuing interest—they exhibit a wide range of unusual physical and magnetic properties as well as intermediate valences associated with the transition from the divalent state to the trivalent state. Ternary $RMn_2(Si,Ge)_2$ compounds (R= Yb, Eu) have attracted particular attention as the 1-2-2 compounds form readily, allowing details of the magnetic interactions for the Mn and R sublattices and the valence transitions to be investigated. Here we present the findings of a comprehensive investigation of $YbMn_2(Si,Ge)_2$ and $EuMn_2(Si,Ge)_2$ using neutron diffraction (~1.8–723 K; p ~ 0–2.7 GPa) and related techniques. We have determined the magnetic structures over the range of (Yb,Eu)-2–2 compounds and propose a magnetic phase diagram for $YbMn_2Si_{2-x}Ge_x$.

CMMSP PTU 60

Using Single-Electron Transistors to Investigate Charge Transport in Ion Implanted Si:P Nanostructures

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By capactively coupling sensitive charge detectors (i.e. single-electron transistors SETs) to nanostructures such as quantum dots and two-dimensional systems, it is possible to investigate charge transport properties in extremely low conduction regimes where direct transport measurements are increasingly difficult[1,2]. Ion implanted Si:P nanostructures, nano-MOSFETs and metallic dots with source-drain leads, that are also capacitively coupled to aluminium SETs have been constructed in order to study charge transport between locally doped regions in Si at mK temperatures via direct source-drain measurement as well as charge detection. Of particular interest are the effects of material defects and gate control on charge transport, which is of relevance to Si-based quantum computing[3,4].

[1] Y.Y. Wei, K.v. Klitzing, K. Eberl, Phys. Rev. Lett. **81**, 1674 (1998).

[2] W. Lu, Z. Ji, L. Pfeiffer, K.W. West, A.J. Rimberg, Nature **423**, 422 (2003).

[3] B.E. Kane, Nature **393**, 133 (1998).

[4] L.C.L. Hollenburg, A.S. Dzurak, C. Wellard, A.R. Hamilton, D.J. Reilly, G.J. Milburn, R.G. Clark, Phys. Rev. B. **69**, 113301 (2004).

CMMSP PTU 61

The Effect of Vapor Concentration on the Formation of Nanowires

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During the synthesis of MgO, Si-SiO_x (x=1–2) nanowires using chemical vapor deposition (CVD) method in the presence of catalysts, we found that the concentration of vapor can significantly affect the morphology and formation of final products. When Mg vapor concentration was low, MgO nanowires and nanoribbons formed via vapor-liquid-solid (VLS) or vapor-solid (VS) mechanisms; when Mg vapor concentration was very high, only micro-sized MgO whiskers and ribbons were obtained, which usually grow via VS mechanism. Similarly, different concentrations of Si and SiO_x vapor lead to the products of Si and SiOx nanoswires and growth mechanisms of VLS and VS, respectively.

[1] Y.J. Chen, J.B. Li, Y.S. Han et al., J. Cryst. Growth, **245**, 163 (2002)

[2] Y.J. Chen, J.B. Li, J.H. Dai, Chem. Phys. Lett., **344**, 450 (2001)

CMMSP PTU 62

Structures, Properties and Applications of Three-terminal Carbon Nanotube Junctions

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We present an overview of *structures, formation mechanisms, properties* and applications of multy-terminal junctions of carbon nanotubes. We cosider different types of these junctions consisted of solely sp^2 C-atoms and topological defects. Further we present effect arising under force influence upon ends of “fork”- and “bough”-junctions: processes of branch sticking together and opening of closed branches. Various forms of the spacer region, the latter formed by one or more pairs of covalent bonds that include sp^3 C-atoms are considered. The effects of the spacer-symmetry on the transmission function and the I-V characteristics of the different tube junctions are investigated.

CMMSP PTU 63

Thermal and Electrical Currents in Double Quantum Dot Interferometers

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We theoretically consider thermal transport in an electronic interferometer comprising a parallel circuit of two quantum dots. As a result of quantum interference, the heat current through one of the dots is in the opposite direction to the temperature gradient. An excess heat current flows through the other dot. Although locally, heat flows from cold to hot, globally the second law of thermodynamics is not violated because the entropy current associated with heat transfer through the whole device is still positive. We discuss the second law of thermodynamics in relation to the two unique thermal transport processes in the interferometer.

[1] S. Y. Cho, R. H. McKenzie, K. Kang, and C. K. Kim, J. Phys. Cond. Matt. **15**, 1147 (2003)

[2] S. Y. Cho and R. H. McKenzie, cond-mat/0403414 (2004)

CMMSP PTU 64

Spin-Charge Conductance in Nanoscale Electronic Devices

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A fundamental issue is how to characterize spin currents associated with a given charge currents which is well understood in conventional electronics, such as that described by the Landauer-Büttiker formula. We introduce a matrix representation of conductance in electron spin space and show a unifying concept underlying charge and spin conductance in mesoscopic systems. We consider an experimental setup to measure the spin conductance associated with tunneling from a scanning tunneling microscope tip through a magnetic atom and discuss how to observe the spin conductance.

[1] H.-Q. Zhou, S. Y. Cho, and R. H. McKenzie, Phys. Rev. Lett. **91**, 186803 (2003)

CMMSP PTU 65

Fabrication and Metallic Behaviour of Induced 2D Hole Systems in Novel GaAs Heterostructures

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We have demonstrated a novel method for fabricating induced p-type field effect transistors (FETs). This method is a hybrid of previous techniques[1–3] but offers simpler device fabrication, lower threshold voltage and high mobility (μ_{peak} = 6 x 10^5 $cm^2V^{-1}s^{-1}$). Low temperature transport measurements in lower mobility induced 2D hole samples (μ_{peak} = 1.5 x 10^5 $cm^2V^{-1}s^{-1}$), show very strong metallic behaviour when traditionally, it is higher mobility 2D systems that produce the strongest metallic behaviour. Modelling of the scattering mechanisms in these devices suggests that particle interactions must also be considered to obtain a complete explanation of the metallic behaviour in 2D systems.

[1] B.E. Kane *et al., Appl. Phys. Lett.* **63**, 2132 (1993).

[2] Y. Hanein, H. Shtrikman and U. Meirav, *Appl. Phys. Lett.* **70**, 1426 (1997).

[3] R.H. Harrell *et al., Appl. Phys. Lett.* **74**, 2328 (1999).

CMMSP PTU 66

Systematic Hamiltonian Identification of Two-Level Systems

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The problem of characterising the evolution of a two-level system accurately has received much attention recently as this is essential to the operation of a so called “quantum computer”. This characterisation is usually performed using state and process tomography where the full density matrix is measured for a range of different input states. We suggest another technique where the parameters in the system Hamiltonian can be determined directly to arbitrary accuracy. For situations where the system is effectively *closed* such as those required for quantum computing, this may provide a more efficient method of characterisation than conventional tomography.

CMMSP PTU 67

Porous Alumina as a Template for the Design of Novel Semiconductor Nanostructures

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Porous alumina is an attractive material for the design of nanostructured materials. Produced by a simple electrochemical anodization process, it is characterised by a hexagonally close-packed ordered array of pores, the properties of which can be controlled by changing the anodising conditions[1]. Recently, porous alumina has been used to make a wide variety of diverse nanostructures[2]. Here, we report on the formation of porous alumina by pulsed anodic oxidation, and the ways in which this porous template could be used to form a number of semiconductor nanostructures by metal-organic chemical vapour deposition and ion implantation.

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CMMSP PTU 68

Mechanical Behaviour of a- and c-axis Epitaxial ZnO Grown on Sapphire

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The mechanical behaviour of ~500 nm-thick epitaxial ZnO layers grown on a- and c-axis sapphire have been studied using nanoindentation, atomic force microscopy, cross-sectional transmission electron microscopy (XTEM), and scanning cathodoluminescence monochromatic imaging. XTEM results suggest that the presence of as-grown dislocations strongly influence the deformation processes of the epi-layers. Comparison of the epi-layers with single crystal bulk ZnO reveals significant differences in the mechanical behaviour of the two systems, with the eip-layers showing both increased hardness and a suppression of “pop-in” events. The results of this study have implications for the fabrication and processing of ZnO based optoelectronic devices.

CMMSP PTU 69

Correlations in Inelastic Scattering

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It is often assumed that inelastic electron scattering from the plasmon is incoherent and confined to small angles. However it can be seen that this is not the case in elements and compounds that share the ‘simple’ metal form of electron correlation. A continuous electron density distribution results in a characteristic ‘bare’ plasmon spectrum. In this case, an image filter can be used to test a simple model describing the dynamical scattering of electrons that have suffered multiple interactions with plasmons.

CMMSP PTU 70

Specific Mechanical Behaviour of DLC Coatings at High Temperature

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Diamond-like carbon (DLC) coatings are used in numerous industrial applications including tribology, optics, electronics and biomedical. However, the extensive scientific work devoted to DLC gives little information on the influence of temperature on its mechanical behaviour.

In order to obtain information more relevant to real-world situations, we propose to explore the elastic and plastic properties of DLC samples using nanoindentation at temperatures ranging between 20°C and 500°C. Performing the tests at high temperature allows assessment of the reversible phenomena induced by temperature increments as well as irreversible transformations for instance the sp^3/sp^2 transitions.

CMMSP PTU 71

Geometric Analysis and Optimisation of the Single Electron Transistor for Solid-State Quantum Computer

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The single electron transistor (SET) offers unparalled performance as a nano-scale electrometer. Due to this they are attractive devices for performing quantum computer read-out in the solid state, as this generally involves the detection of the location of a single electron in the substrate. Through the use of finite element modelling with the ISE-TCAD semiconductor simulation package, we investigate various SET geometries to optimize sensitivity to sub-surface charge motion. We reproduce the expected IV curve for a SET using mesoscopic circuitry arguments and relate the currents to read-out events for both the Kane and charge-qubit solid-state quantum computer architectures. The techniques used to describe the read-out procedure are quite general and as such are applicable to most devices acting in the mesoscopic realm in the steady-state.

CMMSP PTU 72

Molecular Simulation of Colloidal Fluid Flow in a Microchannel

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We have used molecular dynamics simulations to study the flow of a colloidal fluid through a narrow channel, with width ranging from a few up to several tens of colloidal particle diameters, as a function of the external force that pulls the fluid through the channel. Our results show that the classical Navier-Stokes-Fourier description fails for small channel widths and large external fields. We show how a modified hydrodynamic description can be used to model the velocity, temperature and concentration profiles.

CMMSP PTU 73

Lattice Dynamics of Hydrogenated Austenitic Steels

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We investigated hydrogen vibrations in of Fe-18Cr-10Ni and Fe-25Cr-20Ni austenitic steels doped in H gas atmosphere at pressures up to 7 GPa. Measurements were performed with neutron spectrometers FANS at NIST and TOSCA at ISIS.

Experiments show that vibrational energy of H atoms in studied steels decreases from 132 meV at H/Me=0.0033 to 111 meV at H/Me=0.9 due to lattice dilatation. The hydrogen peaks are broadened. At H contents from 0.003 to 0.4—where the single broad peak is observed—the broadening is most probably connected with the Me-H force constant disorder. At H/Me>0.4–0.5—where H-peak has the two-component structure—the H-H interaction becomes important resulting in the dispersion of the optical phonon branches.

CMMSP PTU 74

What Causes Dissipation in a Ballistic Quantum Point Contact?

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The defining signature of transport in quantum point contacts is the discretization of conductance into “Landauer steps”, in units of $2e^2/h$=0.078mS. They can be explained via collisionless quantum transmission of individual electrons through a one-dimensional, lossless barrier. However, simple quantum scattering cannot tackle the central issue of conduction: *What causes dissipation in a ballistic quantum point contact*? The answer—given uniquely by many-body quantum theory—leads not only to conductance quantization, while fully accounting for inelastic energy loss, but also resolves a long-standing experimental enigma in the noise of a quantum point contact.

CMMSP PTU 75

Practicality of Fault-Tolerant Quantum Computation

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The theoretical power of large scale quantum algorithms has driven the race to build a practical quantum computer. However, large scale algorithms such as Shor algorithm have been shown to be quite sensitive to error effects within quantum computers. Quantum error correction (QEC) and Fault-tolerant quantum computation (FTQC) provide a platform for correcting errors to arbitrary accuracy, however suitable Fault-tolerant circuits are generally far more complex than their non-Fault-tolerant versions. We will provide a brief introductory analysis to the stability of preparing a logical 0 state using the 7-qubit Steane code both

Fault-tolerantly and non-Fault-tolerantly for linear nearest neighbour (LNN) circuits and circuits employing arbitrary coupling between qubits. We will show that the increased complexity of fault-tolerant circuits cause them to be unreliable compared with their non-fault-tolerant counterparts at all but extremely low error rates.

CMMSP PTU 76

TDPAC Study of Implantation Induced Amorphization in GaAs and InAs

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The III-V compound semiconductors have generated a considerable interest because of their technological importance. In order to exploit the full potential of these materials, doping with different ions is required. Ion implantation is the most attractive method of dopant incorporation for device fabrication because concentration of the dopants can be controlled precisely and almost all the elements can be implanted. The process of ion implantation is always accompanied by the radiation damage of the lattice and for higher doses, it leads to amorphization. The perturbed angular correlation technique in time differential mode has been utilized to characterize the implantation induced crystalline to amorphous transformation in GaAs and InAs. The radioactive probe nuclei ^{111}In were first introduced in the crystal lattice followed by implantation with stable Ge ions. The crystalline, disordered and amorphous probe environments were identified from the measurement. Besides, Rutherford backscattering measurements were performed to infer the morphology of implantation induced damage.

CMMSP PTU 77

Characterizations of MgO Substrates and Epitaxial YBCO Thin Films

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YBCO films were grown on MgO substrates for fabricating step-edge junction SQUIDs and other devices. In-plane 45˚ grain misalignment was frequently observed in the films grown on the degraded or contaminated MgO substrates. We investigated the chemical properties of the MgO substrates of varied surface conditions that are due to different substrate preparation methods and environmental degradation by using XPS. The in-plane grain orientation of the YBCO films was studied by means of XRD phi-scan. A final cleaning step of MgO substrates using an ion beam etching (IBE) prior to the thin film deposition was found to be effective in removing the in-plane grain misalignment and promoting the growth of perfectly aligned c-axis YBCO films.

CMMSP PTU 78

UV and Raman Spectroscopic Study of Diamond-Like Carbon

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UV and Raman spectra of thin films of partially graphitised DLC reveal spectroscopic structures that can be associated with excitations localised within fused-ring aromatic molecular groups. We compare theoretical and experimental spectra and show that a primary contributor to UV absorption in these materials involves π electron excitations in structures similar to de-hydrogenated coronene. This information is being used in the development of a quasi-molecular model to describe the properties of DLC films.

CMMSP PTU 79

Silicon Nanocrystals as an Optical Gain Medium?

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There has been enormous interest in the possibility of using silicon nanocrystals as an optical gain medium since initial reports by Pavesi et al. However, despite considerable research effort there is little widespread

acceptance of the original, or subsequent, measurements. One of the key reasons for this being the fact that the measurements rely heavily on the variable stripe length (VSL) technique, the results of which have been shown to suffer from possible misinterpretation. To avoid these experimental difficulties we have undertaken optical pump-probe measurements with planar waveguide structures containing silicon nanocrystals. This paper reports the results of these measurements.

CMMSP PTU 80

Mechanical Properties of Nanoscale Si

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This paper examines the effect of mechanical deformation on nanoscale silicon structures. Direct mechanical indentation of nanometer thick Si films, produced by the oxidation of silicon-on-insulator (SOI) wafers, is examined to determine the dynamics of deformation and associated phase changes. The resulting deformed region is characterized by photoluminescence, cathodoluminescence, transmission electron microscopy, and Raman microspectroscopy. The effect of mechanical deformation due to differential expansion and contraction rates is also explored. In this case by studying the luminescence from silicon nanocrystals embedded in SiO_2 during different heating and cooling cycles.

CMMSP PTU 81

Effect of Material Structure on Photoluminescence Spectra from Silicon Nanocrystals

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A broad range of material structures have been employed by researchers studying light emission from Si nanocrystals. What is often not often appreciated, however, is that such structures can have a significant impact on measured emission spectra. Indeed, the spectral distortions due to even simple material structures can be very significant and lead to misinterpretation of measured data. These effects are illustrated in the present study by studying the photoluminescence spectra from an identical layer of luminescencet silicon nanocrystals produced by ion-implantation (30 keV Si; $2.5x10^{16}$ $Si.cm^{-2}$) into SiO_2/Si structures with different oxide thicknesses.

CMMSP PTU 82

Modication of Mechanical Properties of Silicon Cantilevers by Self Ion Implantation

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Nano-scale silicon structures are employed for a broad range of micro-electro-mechanical (MEMS) devices and structures. The ability to tailor the mechanical properties of such structures, or components of these structures, is highly desirable. This paper examines the use of self-ion irradiation as a means of modifying the Young's modulus of 3D silicon nanostructures, namely, silicon cantilevers. The mechanical properties of such structures were measured using an atomic force microscope and demonstrate that significant changes in Young's modulii (> 20%) can be effected. Modeling shows that the changes can be predicted from the mechanical properties of crystalline and amorphous silicon.

CMMSP PTU 83

Leaky Mode Emission from a Planar Optical Waveguide Made of Luminescent Silicon Nanocrystals

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The propagation of light emitted from silicon nanocrystals forming planar waveguides buried in SiO_2 is studied both experimentally and theoretically. Experiments reveal that photoluminescence spectra detected from the sample facet contains narrow, (10–20 nm full-with-at-half-maximum) polarisation-resolved transverse electric and transverse magnetic modes instead of the usual broad nanocrystal emission band peaked at 700–800 nm. A theoretical model developed in the framework of wave optics identifies these modes as leaky substrate modes propagating along the waveguide boundary (*not* the usual modes guided inside the nanocrystal plane due to its graded index profile).

CMMSP PTU 84

Photonic Band-Gap Effects on Photoluminescence of Silicon Nanocrystals Embedded in Artificial Opals

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This study explores the optical emission from a regular array of light emitting silicon nanocrystals as a means of controlling the spectral distribution of emitted light. Nnaocrystals were formed in synthetic opals by Si-ion implantation and their optical properties studied using micro-photoluminescence and reflection techniques. The photoluminescence spectra from Si nanocrystals embedded in silica spheres is narrowed by the inhibition of emission at wavelengths corresponding to the opal photonic pseudo-band-gap (~690 nm). Measurements of photoluminescence spectra from individual implanted silica spheres is also demonstrated.

CMMSP PTU 85

Luttinger Liquid versus Charge Density Wave Behaviour in the Spinless Fermion Holstein Model

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In order to clarify the physics of the crossover from a Luttinger liquid to a Peierls insulator, we investigate ground-state and spectral properties of the one-dimensional spinless fermion Holstein model at half-filling. In the metallic regime we determine the renormalized effective coupling constant and the velocity of the charge excitations via a density-matrix renormalization group finite-size scaling approach. At the transition to the charge-ordered Peierls-distorted state, which occurs only above a finite critical electron-phonon coupling if the phonon dynamics is taken into account, the staggered charge structure factor starts to increase from zero. At the same time a gap in the (inverse) photoemission spectra evolves, which is calculated in good accordance by exact diagonalization and projector-based renormalization (PRM) techniques. Moreover the PRM approach reveals the softening of the Brillouin zone boundary phonon mode. Effects of an additional Hubbard interaction are discussed in the framework of the Holstein-Hubbard model, in particular with respect to a Peierls-Mott insulator-insulator transition.

CMMSP PTU 86

Neutron Diffraction Studies of the Ferroelectric/paraelectric Transition in Triglycine Sulphate

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This research is a preliminary study in preparation for relaxation measurements using the stroboscopic neutron diffraction technique being presented at this congress[1]. Triglycine sulphate, TGS, is a ferroelectric material with important potential for its pyroelectric applications. However, despite a number of structural studies of TGS in the literature, many have been done using x-ray diffraction and so uncertainty remains in regards to the precise hydrogen atom positions and the role of hydrogen bonding in the transition to the ferroelectric state. In this paper, structural studies using single-crystal neutron diffraction at temperatures in the vicinity of the Curie temperature, will be presented.

[1] J.E. Daniels, A.J. Studer, T.R. Finlayson and M.E. Hagen, "Time-resolved studies of neutron diffraction intensities in association with phase transitions", (Presentation at this Congress)

CMMSP PTU 88

Simulation of Gold Nanoparticles and Surface Absorption

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We will present the results of two of our computational themes: the structure and dynamics of small gold clusters, and absorption of molecules onto gold surfaces. The motivation for this work is two-fold. Gold nanoparticles are known to have important optical and catalytic properties[1], and gold surfaces are good substrates for self-assembling molecular devices. We use density functional and empirical techniques to simulate these systems and understand the underlying atomistic mechanisms. Ultimately the two themes are linked since control of nanoparticle growth and functionality can be achieved through selective absorption.

[1] M.M. Schubert *et. al.*, J. Catalysis, **197**, 113 (2001)

[2] Wagner, F.E. *et al*, Nature, **407**, 691 (2000)

CMMSP PTU 89

Single Molecules on Gold Surfaces and Molecular Conduction

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The conduction of electric current through single molecules is the subject of considerable research interest. Experimental studies have concentrated on scanned probe measurements of current voltage characteristics[1], with the results for some molecules demonstrating, for example, diodic behaviour or negative differential resistance[2]. Agreement is yet to be reached between these measured currents and calculated values[3], and a unified picture of the transport process is still pending. Here we present our simulations of single molecules adsorbed on gold surfaces to understand how factors such as absorption site and applied bias can affect the calculated tunnelling current.

[1] R.P. Andres *et al.*, Science **272**, 1323 (1996)

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CMMSP PTU 90

Optimal Construction of Arbitrary Fault-tolerant Gates

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In this work, we perform a detailed study of the properties of optimal fault-tolerant approximations of arbitrary gates using the gate set directly applicable to the 7-qubit Steane code. Given a unitary matrix distance measure that we define, we find that for a given number of gates n the optimal distance that can be achieved is approximately d = 0.3 10^(–0.05 n). Full details of the method used to construct these optimal approximations are given.

CMMSP PTU 91

Towards Exciton Condensation in Quantum Semiconductor Structures

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The phenomena of exciton condensation, analogous to Bose-Einstein Condensation (BEC) of bosonic atoms is a rapidly advancing field with recent observations of macroscopically ordered states in a two-dimensional system[1,2]. The basic requirements of an exciton system include long radiative lifetime, repulsive interactions and low potential disorder.

In this paper we present measurements of the luminescence properties of cold excitons in a range of systems including coupled quantum wells[1,2], quantum ring-like topologies in the optical Aharonov-Bohm regime[3] and selectively patterned 2D geometries and comment on their applicability to the observation of exciton condensation.

[1] D. Snoke, S. Denev, Y. Liu, L. Pfeiffer and K. West, *Nature* **418**, 754 (2002)

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[3] A. O. Govorov, S. E. Ulloa, K. Karrai, and R. J. Warburton, *Phys. Rev. B* **66**, 081309(R) (2002).

CMMSP PTU 92

Self-consistent Linear Response Approximation for Longitudinal and Transverse Plasmons

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We present a unified treatment of the dispersion relations for the longitudinal and transverse plasmons in an electron gas on the basis of the self-consistent linear response approximation (SCLRA). For the longitudinal plasmon, it turns out that our result is equivalent to random phase approximation (RPA) result. The advantages of the SCLRA are its universality to allow a unified treatment of both longitudinal and transverse plasmons on the same theoretical footing, and also its clear physical meaning.

CMMSP PTU 93

Atomic Intermixing of $In_xGa_{1-x}As$/InP Quantum Well Structures

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Intermixing in quantum-confined structures has drawn considerable interest in recent year due to its potential for the fabrication of photonic integrated circuit of differing functionalities. Intermixing of these structures leads to modification of the band gap, optical and electrical properties. In this work the atomic intermixing by both ion irradiation and impurity free vacancy disordering of $In_xGa_{1-x}As$/InP QWs is investigated for lattice-matched (x=0.53), tensile strained (x=0.38) and compressive strained (x=0.68) QWs. Various optical techniques such as photoluminescence, time-resolved photoluminescence and photoreflectance are used to investigate the properties of the QWs and the carrier dynamics after intermixing.

CMMSP PTU 94

Charge Transport in Melanin, a Disordered Bio-Organic Conductor

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Melanins are organic macromolecules with many roles in the biosphere including as pigments and photoprotectants in humans. They possess several unique physical and chemical properties. However, these properties are, in general, poorly understood. In our paper, we will present solid state measurements showing that the electrical conductivity of melanin is strongly dependent on relative humidity. These results suggest that charge transport in melanin may be dominated by ionic rather than electronic processes. The remarkably strong RH dependence is an unusual feature, and it may be critical to understanding and exploiting the properties of melanins.

CMMSP PTU 96

Adiabatic Passage Techniques in Solid-state Quantum Devices

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We describe recent work towards understanding charge transfer mechanisms based on adiabatic passage techniques with all-electrical controls through two-dot systems (rapid-adiabatic passage), three-dot systems (Coherent Tunneling Adiabatic Passage—CTAP) and multi-dot systems (Straddling CTAP). Adiabatic passage minimizes adiabatic evolution times through the use of optimized control pulses, maintaining the robustness of adiabatic methods. We show that these schemes may be implemented in present day and soon to be realized technologies developed for quantum computing and their role in the transportation of quantum information within a quantum network.

CMMSP PTU 97

Interplay between Tm^{3+} and Cr^{5+} Magnetic Sublattices in $TmCrO_4$

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The tetragonal compound $TmCrO_4$ allows us to study the effect of the magnetic interaction between the S = 1/2 Cr^{5+} and the Tm^{3+} sublattices. The magnetic structure of $TmCrO_4$ at T = 2K determined with neutron diffraction shows two ferromagnetic Tm and Cr sublattices parallel to the *c* axis. ^{169}Tm Mössbauer and μSR spectra of $TmCrO_4$ were measured between T = 4.2 and 300 K. The results show that the Cr sublattice orders at T = 18.75 K with a second order transition at T_c = 18.75 K and the Tm sublattice with a first order transition below 17 K. Analysis of inelastic neutron scattering measurements on $TmCrO_4$ is in progress.

CMMSP PTU 98

Magnon Dispersion and Structure Factors for Heisenberg Antiferromagnets

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The dispersion relations and structure factors for single-magnon states are computed for the Heisenberg antiferromagnet on square and cubic lattices, using high-order series expansions.

The dispersion relation is in almost perfect agreement with second-order spin-wave theory for the cubic lattice. For square lattice, the spin-wave theory predicts a flat dispersion from (π, 0) to (π/2, π/2), but the series gives the excitation energy at (π/2, π/2) about 9.3% higher than that at (π, 0). This is in agreement with experimental data for $Cu(DCOO)_2{\cdot}4D_2O$ (CFTD)[1] and $Sr_2Cu_3O_4Cl_2$[2], but opposite to La_2CuO_4[3]. The predictions for the structure factors can also be tested against experimental data from neutron scattering experiments.

[1] H.M. Ronnow, *et al.* Phys. Rev. Lett. **87**, 037202(2001).

[2] Y.J. Kim, *et al.*, Phys. Rev. B**64**, 024435(2001).

[3] R. Coldea, *et al.*, Phys. Rev. Lett. **86**, 5377(2001).

CMMSP PTU 99

Finite Size Effects and Superconducting Correlations

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The role of finite size and its effect on the superconducting correlations in one dimensional Hubbard systems with correlated hopping[1] has been investigated. The study has been performed using both exact diagonalization and density matrix renormalization group methods. Various quantum measurements have been used to probe the underlying microscopic mechanisms responsible for modulating the superconducting signatures. The role of topological transitions has also been determined by measuring the spin and charge Berry Phases.

[1] L. Arrachea, A.A. Aligia and E. Gagliano, Phys. Rev. Lett., **76**, 4396 (1996)

CMMSP PTU 100

Fast Solid-state Donor Electron Spin Quantum Computing

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We present an alternate scheme for quantum computing based on the Kane[1] architecture. This scheme will based on donor electron spins in semiconductors. The proposed scheme will take advantage of the long decoherence times recently measured for donor electron spins in similar systems[2]. It also takes advatage of the comparitively fast electron spin time scales. We show how quantum gates may be performed on fast timescales in comparison to typical decoherence timescales for this architecture.

[1] B.E. Kane, Nature 393, 133 (1998).

[2] A. M. Tyryshkin, S. A. Lyon, A. V. Astashkin, and A. M. Raitsimring, Phy. Rev. B68 193207 (2003).

CMMSP PTU 101

Electron Trapping and de-Trapping in Ion-Beam-Damaged Diamond Surfaces

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Ion beam damaged diamond surfaces subjected to electron irradiation are observed to develop a pronounced negative surface charge, the origin of which has remained a mystery. We show that this effect is associated with the capture of electrons into traps created by the ion irradiation process. The trapped charge increases with ion dose and incident electron current, and decreases with increasing sample temperature and laser illumination as the traps are depleted of charge. An activation energy for detrapping of about 1.5 eV is deduced from the temperature dependence of the charging. These results have important implications for the use of diamond in electron multipliers and cold cathode devices.

CMMSP PTU 102

Coherent Spin Transport and Two-dimensional Architectures for Scalable Donor Quantum Computing

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Although it has been shown that linear qubit arrays can in principle implement Shor's quantum factoring algorithm without significant extra gate overheads[1], for the realistic case of logical encoded qubits intra-qubit information flow bottlenecks become a serious and probably insurmountable problem. A second direction of quantum information flow is required to define a scalable architecture for fault-tolerant quantum computing. For the case of donor based quantum computing we consider means of implementing coherent spin transport in order to break free of the 1D constraint of the Kane design[2], and address some of the outstanding architecture issues in the process.

[1] A. Fowler, S. Devitt and L. Hollenberg, Quant. Inf. and Comp., **4**, 237 (2004)

[2] B. Kane , Nature, 393, 133 (1998)

CMMSP PTU 103

Fabrication of Two Donor Quantum Computer Devices by Controlled Single Ion Implantation

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Fabrication of a quantum computer in silicon requires the ability to embed individual donors at precise positions. We present a novel method for the implantation of single ions, which we use to fabricate prototype devices, allowing us to test important parameters including charge transfer and decoherence[1]. Here we present numerical models and experimental results demonstrating the unequivocal detection, for the first time, of single sub-20 keV ions with

100% efficiency, using the ion impact ionization signal to register the individual ions. This technique has applications not only in quantum computing, but also for suppressing statistical fluctuations in dopant numbers for conventional microelectronics devices.

[1] Los Alamos Science, **Information, Science and Technology in a Quantum World**, Number 27, 284–301 (2002)

CMMSP PTU 104

Towards Stark Shift Tuning of Phosphorous Doped Silicon Qubits

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The Kane[1] model for a silicon based quantum computer proposes that the nuclear spins of individual phosphorus dopant atoms be the qubits. An external voltage would control the phosphorus hyperfine field and hence the nuclear magnetic resonance frequency of the qubits. Here electron spin resonance is used to probe for changes in the phosphorus hyperfine field. Initial measurements on (bulk) P:Si wafers as a function of applied DC voltage at 5 K show no Stark shift. However, DC current measurements at 4.2 K show that this observation is not a fundamental problem but the result of slow time scale charge migration in the 10^{17} cm^{-3} doped silicon.

[1] B. Kane, *Nature* **393**, 133 (1998).

CMMSP PTU 105

NMRON Measurements of Nano-Crystalline Cobalt

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A nuclear magnetic resonance on oriented nuclei study of nanocrystalline cobalt metal via the ^{60}Co nuclear probe is reported. In particular, modulated adiabatic passage on oriented nuclei (MAPON)[1] is used to investigate the electric quadrupole interaction (EQI) at the cobalt nuclei. These MAPON data show the presence of hexagonal and cubic crystalline sites plus an additional EQI peak with a mode value of –28(2) kHz for ^{60}Co tentatively assigned as a uniquely valued relativistic quadrupole interaction existing in the nanocrystalline interfacials. NMR of ^{59}Co in the nanocrystalline powder, thermally detected via the ^{60}Co nuclear orientation is also presented.

[1] P.T. Callaghan, P.J. Back and D.H. Chaplin, *Phys. Rev. B.* **37** 4900–4910 (1988).

CMMSP PTU 106

The Rheology of Melt-free Polycrystalline Olivine

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Several very pure olivine polycrystals have been prepared from sol-gel precursors by hot-isostatic pressing. Compressive creep tests at progressively increasing stress have been performed on each of these specimens in a Paterson apparatus at a confining pressure of 300 MPa and temperatures of1150–1350°C. Grain growth during the deformation tests is minor: mean grain sizes varying with hot-pressing temperature from 3 to 6 micron. The transition from diffusion to dislocation creep occurs at stresses of 100 to 150 MPa and strain rates are systematically much lower than expected from previous work on mildly impure olivine of larger grain size.

CMMSP PTU 107

InAs/GaAs Quantum Dot Layers Grown by MOCVD

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Theoretical predictions have been made that suggest quantum dot nanostructures can be used in the fabrication of semiconductor devices with superior performance characteristics. The synthesis of high quality self assembled quantum dot layers remains to be an enormous experimental challenge. Our research focuses on the deposition of quantum dot layers by the commercially viable technique of metal-organic vapor-phase epitaxy (MOVPE). The results of our latest efforts to produce device quality InAs quantum dot layers on a GaAs substrate are presented. We address the key issues related to the formation of InAs QDs in particular the stacking multiple dot layers suitable for device application.

CMMSP PTU 108

Dielectric Properties and Photoluminescence of Diatomaceous Silicas

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Silica shells produced by diatoms have been studied to investigate their potential for applications in electronic and photonic devices due to their dielectric and photoluminescent properties.

Dielectric measurements for low (1k–1MHz) and high (~1GHz) frequencies were performed on processed diatomaceous earth samples and compared with measurements for artificial porous silica samples.

Photoluminescence spectra for a sample of freshwater benthic diatoms were obtained and compared with silica spectra.

The ratio of the 3.2eV photoluminescence peak compared to a peak at ~2.20eV is smaller than for pure fused silica, and there is evidence of extra shoulder peak near 2.2eV for diatogenic silica.

CMMSP PTU 109

Qubit Control and Crosstalk Characterization in the Kane Quantum Computer

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The Kane proposal[1] for implementing a quantum computer on an array of ^{31}P atoms in silicon, requires the placement of closely spaced control gates. This theoretical study investigates gate bias and architectural implications with a view to achieve realistic control of qubits. The control of an individual qubit (donor nuclear or electron spin) may be problematic due to interactions (crosstalk) between the gates and the donors neighbouring the qubit being addressed. We use analytical and TCAD modelling, to determine the nature and extent of crosstalk propagation, methods to eliminate them viz. adaptive correction and consider incorporation in a scalable implementation.

[1] B.E. Kane, Nature, **393**, 133 (1998)

CMMSP PTU 110

Heterostructure Field Effect Transistors in InAlN/GaN

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Heterostructure field effect transistors (HFET's) in AlGaN/GaN have achieved record breaking output power levels at high frequencies. This heterostructure suffers from current collapse, persistent photo current and RF compression. Here, we study the alternative way in which the *AlGaN* layer is replaced by an $Al_xIn_{1-x}N$ barrier for HFET implementation[1]. The $In_xAl_{1-x}N$ layer composition can be adjusted to be lattice matched or polarization matched to *GaN*. The InAlN/GaN structure shows high values of 2DEG concentration, up to $4x10^{13}cm^{-2}$. Both DC and RF characteristics of the InAlN/GaN HFETs were measured, showing potential for improvement over the performance of state of the art AlGaN/GaN transistors.

[1] O. Katz, D. Mistele, B. Meyler, G. Bahir, and J. Salzman, "InAlN/GaN Heterostructure Field-Effect Transistor DC and Small Signal Characteristics", to be published in Electronics Letters (2004)

CMMSP PTU 111

Glass Transition in Colloidal Hard Spheres

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The glass transition remains a poorly understood aspect of condensed matter physics. A better understanding of this transition is important not only from a fundamental viewpoint, but for the potential industrial applications. Hard-sphere colloidal suspensions provide an excellent model system for studying phase transitions, and the glass transition in particular. This poster will present the results of investigations, using a range of dynamic light scattering (DLS) techniques, to probe the dynamics of hard-sphere colloidal suspensions as they undergo a phase transition from a metastable fluid to an amorphous glassy phase, as a function of elapsed time since the quench.

CMMSP PTU 112

A New THz Facility for Condensed Matter Physics

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This paper describes a new THz facility for condensed matter physics that complements the existing infrastructure at the University of Wollongong (UoW). The THz regime is of immense importance in condensed matter physics as many energies of interest fall in this region—phonon energies, cyclotron energies in laboratory magnetic fields, energies of shallow impurities in semiconductors, bound levels in heterostructures, to name a few.

CMMSP PTU 113

Spectroscopy of Acceptor States in ZnSe

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We report the infrared absorption spectrum of nominally undoped bulk crystalline ZnSe prepared by the solid-growth method, and expected to contain Li as the chief unintentional impurity. Our data resolves features more clearly than does previous work. On the basis of the data and analysis presented we discuss earlier interpretations of the myriad absorption features and suggest a new explanation: that the origin of the complex structure in the absorption spectrum of ZnSe is the presence of more than one acceptor.

CMMSP PTU 114

Precipitation, Recovery, Phase Transition and Recrystallization Processes of Massively Transformed TiAl Scrutinized by ex- and in-situ High-energy X-ray Diffraction

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High-energy synchrotron radiation above 100 keV is a novel and sophisticated probe to access the volume properties of materials. A Debye-Scherrer method is shortly presented for the measurements of textures, strain and composition.

Low density, high specific yield strength, good oxidation resistance and good creep properties at elevated temperatures make intermetallic γ-TiAl-based alloys top candidates as structural materials for advanced jet and automotive engines as well as for future hypersonic vehicles. The mechanical properties depend strongly on composition, thermo mechanical processing and subsequent heat treatments. The present study examines the recrystallization processes of a massively transformed specimen of $Ti_{45}Al_{46}Nb_9$ upon a heat ramp from room temperature to 1400°C. The registered Debye-Scherrer rings are rich of features relating to thermal expansion, phase changes, domain and phase coherences, chemical separation and much more which will be regarded in detail.

CMMSP PTU 115

An RF-GD-OES Calibration for Surface Analysis on Aluminium Alloys

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Glow-Discharge Optical Emission Spectrometry (GD-OES) is a powerful technique for the rapid analysis of elements in a solid surface as a function of depth. DC-GD-OES allows depth profiling on electrically conductive surfaces only, and has proven to be difficult for the analysis of insulating layers, such as oxides. However, the technique of radio-frequency (RF) GD-OES has the advantage of being able to depth profile through multiple layers, both conducting and insulating. In this work, a LECO GDS-850A spectrometer was calibrated for aluminium, oxygen, and other elements, with the RF source installed. A quantitative depth profile for a sample of tempered aluminium alloy 7475 is presented and compared with earlier work[1,2].

[1] S.K. Toh, D.G. McCulloch, J. Duplessis, P.J.K. Paterson, A.E. Hughes, D. Jamieson, B. Rout, J.M. Long, and A. Stoneham, Surface Review and Letters **10**, 365–371 (2003).

[2] J.M. Long (2003), in Proceedings of the 27th Annual A&NZIP Condensed Matter and Materials Meeting (Wagga Wagga, Australia), 4–7 February, editors. J. Cashion, T. Finlayson, D. Paganin, A. Smith, and G. Troup (Australian Institute of Physics, http://www.aip.org.au/wagga2003/Hubpage.pdf).

CMMSP PTU 116

Ion Scattering Simulations of Misfit Dislocations at the Fe_2O_3/Al_2O_3 interface

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Recent studies of buried interface a-Fe_2O_3(0001)/ a-Al_2O_3(0001) using high resolution transmission electron microscopy (HRTEM) and ion scattering techniques reveal the existence of disordering at the interface due to the misfit dislocations[1]. Molecular dynamics (MD) calculations were carried out to understand the formation of misfit dislocations and the interface structural features[2]. The misfit dislocations are formed because of the lattice mismatch between the substrate and the film. Ion scattering simulations were carried out using VEGAS code, in which the atomic positions generated by the MD calculations were used. The hitting probabilities determined from these simulations were compared with the experimental surface and interface peaks obtained from the aligned RBS spectrum.

[1] C.M. Wang, S. Thevuthasan, F. Gao, D.E. McCready and S.A. Chambers, Thin Solid Films, **414**, 31 (2002)

[2] F. Gao, C.M. Wang, S. Thevuthasan, S. Maheswaran, and A. El-Azab, submitted to Phys. Rev. B.

CMMSP PTU 117

Nano-scale Superconducting Photon/Particle Detector

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With the advent of sub-micrometre fabrication technology, superconducting devices have entered a new regime of applications. In the example to be described[1], the quantum limits of energy sensitivity, response time and spectral bandwidth of a SQUID-based nano-bolometer are explored. Experimental proof-of-principle data are presented and prospects for the ultimate goal of single-particle detection and spectroscopy are discussed.

[1] L. Hao, J. C. Macfarlane, P. Josephs-Franks and J. C. Gallop, 'Inductive Superconducting Transition-edge Photon and Particle Detector', IEEE Trans. Appl. Supercond, vol.13, no. 2, pp. 622–625, Jun 2003.

CMMSP PTU 118

Ab Intio Modelling of Energetics in ta-C Films

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Amorphous carbon (a-C) films can be deposited using a variety of techniques to produce films with a range of properties. At low densities, the material is soft due to graphite-like bonding, while at high densities the material is hard and contains predominantly diamond-like bonding. In this paper we study the bonding and energetics of structures formed at different densities and bonding configurations using *ab initio* Car-Parrinello molecular dynamics. The results are used to help understand why high density a-C films can be readily synthesised and how films of different densities behave following annealing.

CMMSP PTU 119

The Melanins: Robust Functionality through Structural Disorder

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The melanins are a class of functional macromolecule found throughout the biosphere. In humans they are mainly responsible for photo-protection and pigmentation. They have a remarkable set of physio-chemical properties; for example, in the condensed solid state they are electrical conductors and photoconductors. In my talk I will discuss the structure-property-function relationships of these unique bio-macromolecules. I will present spectroscopic evidence, quantum chemical simulations and solid state measurements which all show that melanins may be a unique example of a biological system where function is derived from chemical and structural disorder.

CMMSP PTU 120

Characterization of π-SQUIDs Fabricated Using Orthogonal $YBa_2Cu_3O_{7-d}$ Step Edge Junctions

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The predominately *d*-wave nature of the order parameter of high-T_c superconductors offers the possibility to fabricate Josephson junctions (JJ) with a phase shift of π[1]. A dc superconducting quantum interference device (SQUID) in which one JJ is "normal" and the other is a π-JJ (called a π-SQUID) is expected to demonstrate spontaneous flux generation and a spontaneous persistent current at zero applied field[2,3]. Under these conditions a π-SQUID needs no external bias and has an intrinsic double-well potential, making it a possible candidate for a qubit in quantum computing.

For symmetric π-SQUIDs with a small inductance, the phase shift across the π-junctions causes a *minimum* in the $I_c(B)$ pattern at zero applied field, in contrast to the maximum observed in normal SQUIDs. We outline the design and fabrication of π-SQUIDs using orthogonal step-edge junctions and characterize the devices in terms of expected π-SQUID behaviour. We will also discuss issues relating to experiments performed in a true zero-field environment and overcoming remanent fields that cause trapped flux during the cool down of the device past its critical temperature.

[1] D.A. Wollman et al., *Phys.Rev. Lett.* **71**, 2134 (1993).

[2] R.R. Schulz, B. Chesca, B. Goetz, C.W. Schneider, A. Schmehl, H. Bielefeldt, H. Hilgenkamp and J. Mannhart, *Appl. Phys. Lett.* **76**(7), 912–915 (2000).

[3] B. Chesca, R.R. Schulz, B. Goetz, C.W. Schneider, H. Hilgenkamp and J. Mannhart, *Phys. Rev. Lett.* **88**(17), 177003–1–4 (2002).

CMMSP PTU 121

Efficiency of Ideally Filtered Thermionic Devices

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The efficiency of ideally filtered one-dimensional and three-dimensional k_x thermionic refrigerators and power generators are compared. Whilst it has been shown that the one-dimensional device may theoretically achieve Carnot efficiency in the limit of ideal filtering[1], it is shown here that the k_x filtered thermionic device does not for arbitrary electrochemical potentials. However, with non-arbitrary electrochemical potentials the efficiency may

approach the Carnot value. It is shown that, as the energy position of the ideal k_x filter changes, the efficiency of the system varies and a value exists for both refrigeration and power generation where peak efficiencies occur.

[1] T. E. Humphrey, R. Newbury, R. P. Taylor, and H. Linke, Phys. Rev. Lett, **89**, 116801 (2002)

CMMSP PTU 122

Low Energy Spin-Polarized (e,2e) Coincidence Spectroscopy of Fe Layer on W(110).

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Spin-polarized (e,2e) spectroscopy was applied to study ferromagnetic layers of iron deposited on nonmagnetic substrate. Normal incidence and 26 eV primary electrons were used to record energy—and momentum distributions of correlated electron pairs. Polarization of incident beam was chosen to be perpendicular to the scattering plane. Experimental results confirm, that the Fe film changes the easy magnetization axis when the film thickness reaches the critical value of about 50 ML. Spin-dependent total energy distribution and spin-dependent parallel-to-the-surface momentum distribution reflect mostly spin-dependent distributions of electronic states in energy-momentum space.

CMMSP PTU 123

Spin-Orbit Coupling Studied by Low Energy Spin-Polarized (e,2e) Coincidence Spectroscopy

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We present experimental results showing spin-orbit coupling in W(110) collected through the use of novel two-electron coincidence spectroscopy (e,2e) in reflection mode with a low-energy spin-polarized incident electron beam. Time-of-flight energy analysis and position sensitive detection allows the collection of both angular and energy distributions of correlated electron pairs. Analysis of energy sharing and momentum conservation provide detailed insight into the scattering dynamics of this and other systems. Using this technique we were able to analyze how two correlated electrons share energy within 2 eV total (binding) energy just below the Fermi level. We have observed spin-orbit coupling in the inelastic scattering of low energy electrons from W(110).

CMMSP WEC11

Wednesday 1040–1100 hrs

Prediction of Surface Free Energy and Surface Phonon Modes in Nanodiamond Clusters

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A Monte-Carlo/Molecular Dynamics study of the vibrational density of states (VDOS) in relaxed nanodiamond clusters of cubic, octahedral and cubo-octahedral morphology has been preformed. The clusters ranged in size from 1700 to 102,000 atoms. The density of states was decomposed into contributions from the bulk and surface atoms and also according to the bonding coordination of the surface atoms. From the VDOS, an estimate of the Gibbs surface free energy of the various clusters was calculated and the relative stability of each of the cluster morphologies is predicted as a function of cluster size.

CMMSP WEC12

Wednesday 1100–1120 hrs

Ion-irradiation-induced Porosity in GaSb and InSb

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Ion irradiation of crystalline GaSb and InSb can yield not only amorphisation, as commonly observed in semiconductors, but also porosity. Extended x-ray absorption fine structure spectroscopy, electron microscopy and Rutherford backscattering spectrometry have been used to determine the exact nature of and relationship between these two transformations. In both materials, low dose, room temperature implantation produces spherical voids yet the material remains crystalline. With increasing implant dose, the porous layer eventually evolves into a network of straight rods 15nm in diameter. We suggest the porosity arises from preferential clustering of interstitials into extended defects and vacancies agglomerating to form voids.

CMMSP WEC13
Wednesday 1120–1140 hrs

On the Structure of Self-assembled Biomimetic Precipitates

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Astonishingly life-like microscopic precipitates, biomorphs, can self-assemble in barium containing alkaline silicate solutions and this has prompted debate as to weather they might have been mistaken for early fossils[1–3]. In this contribution we present electron microscopy and diffraction studies of the detailed tectonics of such biomorphs all with a curved global morphology reminiscent of biogenic forms. They consist of amorphous silica and microcrystalline barium carbonate particles elongated along the witherite c-axis. The carbonate particles always display an extraordinary orientational order particularly evident in helical filaments where they form a twisted rodpacking.

[1] J. M. García Ruiz, S. T. Hyde, A. M. Carnerup, A. G. Christy, M. J. Van Kranendonk, N. J. Welham Science 302, 1194–1197 (2003)

[2] J. M. García Ruiz, A. M. Carnerup, A. G. Christy, N. J. Welham, S. T. Hyde, Astrobiology, 2, 353–369 (2002)

[3] S. T. Hyde, A. M. Carnerup, A.-K Larsson, A. G. Christy, J. M. García Ruiz, Physica A 339, 24–33 (2004)

CMMSP WEC14
Wednesday 1140–1220 hrs

Magnetic Carbon Nanofoam

A.V. Rode[1], E.G. Gamaly[1], N.R. Madsen[1], B. Luther-Davies[1], S.T. Hyde[1], A.G. Christy[2], R.G. Elliman[1] and J. Giapintzakis[3]

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New and rich physical phenomena observed in complex nanostructures are related to a broad variety of possibilities for the microscopic atomic arrangements. Carbon owes its versatility to the different ways carbon atoms can bond to each other, making a nearly endless number of forms, taking many different appearances, properties, and morphologies.

We have recently synthesised a hierarchically nanostructured magnetic carbon foam by a high-repetition-rate laser ablation of glassy carbon in Ar[1,2]. The material contains graphite-like sheets with hyperbolic curvature, as proposed for “schwarzite”. The all-carbon nanofoam exhibits para- and even ferromagnetic behavior up to 90 K, showing a narrow hysteresis curve with a coercive force H_c = 420 Oe and remnant magnetisation of 5x10^{-3} emu/g at low temperatures, susceptibility of the order of 10^{-5} emu/gOe and a high saturation magnetization up to 0.8 emu/g at 1.8 K. We postulate that localized unpaired spins occur because of topological and bonding defects associated with the sheet curvature, and that these spins are stabilized for > 1 year due to the steric protection offered by the convoluted sheets.

This work underscores how nanotechnology can change long-held understanding of which materials can be magnetic. It shows that we need to re-visit the magnetic prejudice of the periodic table.

[1] A.V. Rode, E.G. Gamaly, A.G. Christy, J.D. Fitz Gerald, S.T. Hyde, R.G. Elliman, B. Luther-Davies, A.I. Veinger, J. Androulakis, J. Giapintzakis, Phys. Rev. B, **70**, 054407 (2004).

[2] A.V. Rode, R. G. Elliman, E.G. Gamaly, A.I. Veinger, A.G. Christy, S.T. Hyde, B. Luther-Davies, Appl. Surf. Science **197–198**, 644–649 (2002).

POSTERS

CMMSP PWE 45

Enhanced Sensitivity of Electron Spin Resonance Using Absorption-Free Measurement

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The method of absorption-free measurement allows the detection of quantum or classical objects without a change in the energy or momentum of the object. Although counterintuitive, the phenomenon has been demonstrated experimentally in numerous formats. It is shown that the method can be applied to electron spin resonance spectroscopy to enhance the sensitivity to samples which have a long spin-lattice relaxation time and hence exhibit saturation due to the absorption of microwave energy. By re-designing the spectrometer to use absorption-free measurement, saturation can be avoided because the sample can be measured with reduced absorption of microwave energy.

CMMSP PWE 46

Influence of Adsorbed/condensed Cyclohexane between Mica Surfaces on Stick-slip Frictional Behavior

Satomi Ohnishi, Dasikaku Kaneko, Andrew M. Stewart, Vassili V. Yaminsky

The stick-slip frictional behavior observed between mica surfaces under cyclohexane vapor was investigated with the Surface Force Apparatus. The dynamic shear stress decreased with increasing the relative vapor pressure. When the relative vapor pressure reached 25%, the stick-slip pattern was observed during sliding while the stick-slip pattern was not observed between the surfaces exposed to the saturated cyclohexane vapor. The dependence on relative vapor pressure of shear stress and pull-off force suggests that the stick-slip is caused by

nonequilibrium condition of cyclohexane adsorption inside and condensation outside of the contact area.

CMMSP PWE 47

Phase Diagram for a Triangular Lattice *t-J-V* Model for the Novel Superconductor Na_xCoO_2

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We study a lattice model for the recently discovered material Na_xCoO_2–yH_2O which exhibits superconductivity[1] as well as other propertics indicative of strong electron correlations. The host material ($x=0$) contains triangular lattice planes of $S=1/2$ Co^{4+} ions. Electron doping with Na changes a fraction of them to Co^{3+} ($S=0$), and leads to superconductivity for $0.25<x<0.35$. Our model is a *t-J-V* model with filling factor $n=2/3$. Series expansion methods at zero temperature are used to study aspects of the phase diagram[2], in particular spin and/or charge ordered states and corresponding phase transitions.

[1] K. Takada *et al.*, Nature **422**, 53(2003).

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CMMSP PWE 48

Deformation Mechanisms in Germanium Under Nanoindentation

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Nanoindentation extends conventional hardness indentation tests to characterise sub-micrometer structures. It is known that during the indentation of silicon, a high-pressure phase transition to a metallic state occurs. However, although Ge is similar to Si in many respects (both elemental cubic semiconductors), its behaviour under nanoindentation is quite different. We have explored the conditions under which Ge undergoes a phase transformation under indentation, examing the effect of doping level, crystallographic orientation, spatial constraint (thin-film vs bulk material), and temperature. A range of techniques including nanoindentation, transmission electron microscopy, atomic force microscopy and Raman microspectroscopy were used to characterise deformation mechanisms.

CMMSP PWE 49

Investigation of Periodically Modified Thin Silver Films Displaying Enhanced Transmission Spectra

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In 1998, Ebbesen *et al*[1] first reported greatly enhanced zero order transmission spectra from thin metal films patterned with a two dimensional array of sub-wavelength apertures. Such devices have applications in the fields of photonics, biotechnology and photolithography.

Here, we report on the fabrication of periodically structured silver films using a 20nm focused ion beam driven by an Elphy Quantum lithography system. The expected transmission through these structures in the visible and near-infrared as well as the near-zone electromagnetic fields calculated using the finite difference time domain technique will also be presented.

[1] T. Ebbesen, H. Lezec, H. Ghaemi, T. Thio and P. Wolff. Nature, 667, 391, 1998.

CMMSP PWE 50

Realistic Monitoring of a Charge Qubit by a Quantum Tunnelling Device—a Quantum Trajectory Approach

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Recently[1], we presented a model for continuous DC-biased measurement of a coupled quantum dot (CQD) charge qubit by realistic measurement devices. Modelling realistic measurement devices as ideal detectors embedded in an equivalent measurement circuit (see figure), our aim was to describe the evolution of the qubit state *conditioned* on the macroscopic output of the external circuit, i.e. the measured current.

We generalised a recently developed quantum trajectory theory for realistic photodetectors[2] to treat solid-state detectors—primarily a single electron transistor (SET). This method yields stochastic equations whose (numerical) solutions are the “realistic quantum trajectories” of the conditioned qubit state.

Here we present numerical solutions and analysis for the SET equations. The solutions elucidate the regimes in which (Rabi) electron tunnelling between the CQDs can be detected in a realistic measurement. Further to this, the solutions reveal the conditions under which electron tunnelling events through the SET can be observed, which is related to the question of the nature of the back-action noise of the SET.

[1] N.P. Oxtoby, P. Warszawski, H.M. Wiseman, R.E.S. Polkinghorne and He-Bi Sun, cond-mat/0401204

[2] P. Warszawski, H.M. Wiseman and H. Mabuchi, Phys. Rev. A **65** 023802 (2002)

CMMSP PWE 51

Nanoscale Electrical Characterisation of Trap-assisted Oxide Electrostatics

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Conductive atomic force microscopy has been used to electrically image quasibreakdown sites in thin, native SiO_2 films. Local current-voltage spectroscopy reveals, at individual sites, fluctuations in the breakdown current between well defined conductivity states. Modelling has been performed to show that conduction through the film is governed by local trap-assisted tunneling involving typically one or two charge traps. Our study provides a semiquantitative analysis to characterise the effective trap states that give rise to local random telegraph signals in the oxide film, which is of importance in quantum device applications where charge trapping at defect sites can influence the local electrostatic properties. The onset of irreversible, catastrophic breakdown arising from hot electron injection is examined, providing insight into the mechanism of trap creation and lateral propagation of the breakdown site.

CMMSP PWE 52

Insight into the Conductivity Mechanism of Polymer Electrolytes Provided by Positron Annihilation Lifetime Spectroscopy

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DC conductivity measured from polymer electrolytes is typically non-Arrhenius and is most often described by free volume (FV) theory[1]. To determine if polymer FV can be used exclusively to describe the solvated mobile ions, the pressure and temperature dependence of both the conductivity and FV of a polymer electrolyte have been measured and evaluated for the first time.

FV theory was supported by the observation of:

- a linear dependence of conductivity on hole volume (V_h) as measured by PALS[2];
- zero V_h occurring at a temperature very close to the zero mobility temperature (T_0) obtained from a VTF fit to the temperature dependence of the DC conductivity[3].

Conductivity measured as a function of pressure allowed the calculation of V_A, which can be considered as an increase in volume required for ionic motion to occur[4]. Critical volumes calculated from two current FV models[5,6] were found to be unrealistic. Combining V_A with V_h at the same temperature resulted in a more realistic and 'model-free' figure for the critical volume. A comparison of the isothermal and isobaric dependence of conductivity on V_h^{-1} illustrates that FV cannot be considered the sole factor responsible for conductivity in polymer electrolytes.

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CMMSP PWE 53

Fast and Slow Positrons as Probes of Polyolefin UV Degradation

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The degradation of polyolefins by absorption of ultra-violet (UV) radiation is usually minimised by the incorporation of organic UV screeners that absorb UV light or quench the chemical degradation process early on[1]. These are subject to migration and degradation necessitating high loading levels which ultimately leads to unwanted changes in the appearance of the final polymer composite. Recently we reported that the incorporation of 2 wt % nanoparticulate ZnO gives superior UV resistance compared to organic screeners without changing the absorption spectrum of the polymer in the visible region[2].

Here we use conventional (fast) positron annihilation lifetime spectroscopy (PALS) as a method for the early detection of polymer degradation. In conjunction with PALS, optical microscopy, UV-Vis and FTIR spectroscopy we show that a synergy exists between nanoparticulate ZnO and an organic screener. The equivalent UV protection of 2 wt% ZnO at reduced loadings of both ZnO (1 wt %) and organic screener (0.15 wt %) was achieved. This is most likely due to the combined effect of the organic screener migrating to the surface with ZnO (which does not migrate) protecting below. Variable energy Doppler broadening of (slow) positron annihilation radiation (DBPAR) showed that samples containing 1 wt % ZnO and 0.15 wt % organic screener show degradation to a depth of *ca.* 1.5 μm.

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[2] A. Ammala, A.J. Hill, P. Meakin, S. J. Pas, and T.W. Turney. Transparent nanoparticulate zinc oxide UV stabilizers for polyolefins. *Journal of Nanoparticle Research*., **4**, 167–174 (2002)

CMMSP PWE 54

The Frequency Factor for Homogeneously Broadened Lines in Field Swept Electron Paramagnetic Resonance Spectroscopy

John Pilbrow

Monash University

The detected signal in Continuous Wave Electron Paramagnetic Resonance, usually carried out at a fixed microwave frequency by sweeping the applied magnetic field, is given by the product of a frequency factor and a lineshape function. For inhomogeneously broadened lines consisting of many overlapping spin packets, the frequency factor is equal to the applied (fixed) microwave frequency. The situation for homogeneously broadened lines is unresolved and requires that an experimental solution should first be sought. Possible samples, that must show an absence of electron spin echoes, will be identified and preliminary results reported.

CMMSP PWE 55

Domain Structure Effects in the Relaxor Ferroelectric PZN-PT

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PZN-PT ($Pb(Zn_{1/3}Nb_{2/3})O_3$-x%$PbTiO_3$) exhibits a maximum strain versus electric field exceeding 1% if it is poled along <001>. Two suggestions exist for the origin of this exceptional strain: the domain structure created during poling[1]; “polarisation rotation”[2] due to the existence of a monoclinic phase reported[3] for PZN-8%PT.

Neutron diffraction data will be presented that shows the monoclinic phase is in fact a distortion of the ambient phase resulting from intersecting domain structures. This interpretation also reconciles PZN-4.5%PT which shows similar properties to PZN-8%PT yet does not exist in the monoclinic structure.

[1] S-E.Park & T.R.Shrout, J. Appl. Phys. **82**, 1804 (1997)

[2] D.Vanderbuilt & M.H.Cohen, Phys. Rev. B **63**, 094108 (2001)

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CMMSP PWE 56

Spatially Periodic Director Reorientation in Planar Nematic Cell with Finite Director Anchoring

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Spatially periodic structure of a director can arise in nematic liquid crystal cell undergoing electric field. To study the influence of the strength of director anchoring with the cell surface on this effect one has to minimize the free energy of nematic cell to get the system of differential equations, which define the director orientation in the cell bulk and corresponding boundary conditions. The solution gives us the dependence of the threshold electric field value and the director structure period on the strength of director anchoring and determines the area of the parameters where the periodic structure exists.

CMMSP PWE 57

Comparison of the Experimental Phase Diagram of the Half-filled Layered Organic Superconductors with the Theoretical Phase Diagram of the RVB Theory of the Hubbard—Heisenberg Model

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We present RVB, BCS and Ginzberg-Landau theories of superconductivity for the Hubbard-Heisenberg model on an anisotropic triangular lattice. Our calculations are consistent with the observed phase diagram of the half-filled layered organic superconductors, β, β', κ and λ phases of $(BEDT\text{-}TTF)_2X$ and $(BETS)_2X$. We find a first order transition from a Mott insulator to a $d_{x^2-y^2}$ superconductor. For highly frustrated lattices we find that the symmetry of the superconducting phase changes to a phase that breaks time reversal symmetry. We discuss moun spin relaxation experiments to detect this new phase in κ-$(BEDT\text{-}TTF)_2Cu(CN)_3$.

CMMSP PWE 58

Diamond for Quantum Communications, Spintronics and Quantum Computing

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Optically emitting defect centres in diamond display a range of unique quantum properties that offer exciting possibilities for the construction of quantum devices which employ optical read-out. In this talk I will review these remarkable properties and explain why diamond is an ideal material for use in the fabrication of (i) single photon sources for quantum communications, (ii) optical fibre-based single spin read out systems and (iii) platforms for the investigation of quantum entanglement in solid state systems. The toolkit of available fabrication strategies will be presented. Our most recent results on the fabrication of fibre based single photon sources and all-diamond waveguides and cavities will be reviewed.

CMMSP PWE 59

The Ageless Aerospace Vehicle: A Complex Multi-Agent Structural Health Management System

A. Batten[1], G. C. Edwards[1], A. J. D. Farmer[1], V. Gerasimov[2], M. Hedley[2], N. Hoschke[1], M. E. Johnson[2], C. J. Lewis[1], A. Murdoch[2], D.C. Price[1], M. Prokopenko[2], D. A. Scott[1], P. Valencia[2] and P. Wang[2]

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Structural health monitoring and management of complex, safety-critical structures such as aerospace vehicles will ultimately require the development of intelligent systems to process the data from large numbers of sensors, to evaluate and diagnose detected damage, to form a prognosis for the damaged structure, and to make decisions regarding remediation or repair of the damage. A complex multi-agent systems approach to the development of such intelligent systems is being investigated, in order to satisfy the requirements of robustness and scalability. This paper reports the current state of development of a laboratory-scale test-bed built to facilitate the development and demonstration of the sensors, sensing strategies and algorithms that will produce the required functionality. This work involves a wide range of physics-related issues in materials science, sensing and complex systems science.

CMMSP PWE 60

Segregation & Refinement of Hydrogen at a Moving Amorphous/ Crystalline Interface within Silicon

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Segregation and refinement of hydrogen at a crystallising amorphous/crystalline interface in silicon is interesting for the possibility of producing silicon-on-insulator wafers for high performance microelectronic devices. The possibility of refining hydrogen into a narrow band may facilitate delamination of the overlying crystalline layer similar to the SmartCut^{TM} process. Hydrogen infiltration into amorphous silicon surface layers from the native oxide and refinement of the H during solid phase epitaxy has previously been investigated by Olson and Roth[1]. However, the refinement of high concentrations of hydrogen ion implanted into surface and buried amorphous silicon has not been studied. We present results of the crystalline kinetics via time-resolved reflectivity studies and of the hydrogen profiles and crystalline structure of the regrown layers respectively via elastic recoil detection and Rutherford backscattering analysis.

[1] G.L. Olson, J.A. Roth. *Handbook of Crystal Growth 3: Thin Films and Epitaxy, Part A: Basic Techniques*, chapter 7: Solid Phase Epitaxy, pages 255–312. Hughes Research Laboratories, 1994.

CMMSP PWE 61

Electrochemical Measurements of Siloxane Polymers for Anticorrosion Coatings

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We report on the ability of various coatings, prepared from model organofunctional silanes of form $(C_3H_7)Si(CH_3)_n(OH)_{3-n}$, where n = 1,2 or 3, to provide a barrier to corrosion. These coatings have been characterised with electrochemical impedance spectroscopy (EIS) and X-ray Photoelectron Spectroscopy (XPS) measurements. Surface coatings from pH 2 and 4 aqueous solutions of these materials have been formed on the native oxide of aluminium, and studied with XPS at Flinders and EIS at LaTrobe. Our results show an interesting correlation between the number of active silanol species and the corrosion performance of the respective coating.

CMMSP PWE 62

The Surface Attachment of Cut Single-walled Carbon Nanotubes

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Single-walled nanotubes (SWNT) possess low solubilities in most media. At Flinders, we have cut and functionalised SWNTs to enhance solubility attach other species. We have successfully illustrated the merit of this method, through the chemical mounting of cut nanotubes on gold and aluminium surfaces. These systems have been characterised by X-ray photoelectron spectroscopy (XPS), atomic force microscopy (AFM) as well as acid-base chemistry. The successful attachment of various species to nanotubes in future will enable smarter chemical devices, where only the unique properties of carbon nanotubes, such as superior electron transport properties, will be required for their optimisation.

CMMSP PWE 63

Fabrication of Single Nickel-nitrogen Defects in Diamond

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We present the first demonstration of controlled fabrication of the NE8 centre in diamond which occurs at ~800 nm and is 1.2 nm wide at room temperature. Using chemical vapour deposition (CVD) we have fabricated isolated NE8 centres in diamond thin films grown on fused silica substrates. The films were characterised using confocal microscopy and spectra from single centres were collected using photoluminescence spectroscopy. Under continuous laser excitation, the photoluminescence was measured using a Hanbury-Brown and Twiss interferometer. Individual defect centres measured in this way were shown to be antibunched, meaning single photon pulses were produced. These advancements in fabrication techniques have enormous implications in the area of quantum communications.

CMMSP PWE 64

Small Radius Clean and Metal-doped Boron-carbide Nanotubes: A Density Functional Study

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Recent work has suggested that hole doping of LiBC might produce superconductivity in this material[1]. In this paper we present the results of fully spin polarized *ab initio* Density Functional Theory calculations using the VASP code[2] of the properties of small radius, clean and metal doped Boron-carbide (BC) nanotubes. Undoped single-walled BC tubes were found to be more energetically favorable than the corresponding BC strips. While the effect of doping small radius BC nanotubes with Li and Cu was found to depend on the type of dopant and the nanotubular radius, significant changes in the structural and electronic properties can be obtained.

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CMMSP PWE 65

Shockley and Rydberg Surface States and Quantum Wells on the Cu (111) Surface

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Adsorbed alkali metals such as Na on (111) noble (and near noble) metal surfaces form quantum well systems. It has been suggested that these systems could be used as metal-based nanostructured quantum electronic devices which would operate at room temperature.

As a preliminary to the study of the surface states of these systems we have calculated the band structure of surface states and resonances for the clean Cu (111) surface from just below the Fermi level to 30 eV above it using our layer-by-layer KKR method.

An exponentially saturated image barrier with truncation in the region of the jellium discontinuity is found to reproduce experimental results. We have found excited surface features which could elicit the variation of the self-energy of the electron with energy and momentum as well as higher energy variation of the image potential.

CMMSP PWE 66

Hydrogen Distribution of Ferromagnetic Microstructures in Carbon created by Proton Microbeam Irradiation

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Ferromagnetic microstructures can be produced in highly orientated pyrolytic graphite (HOPG) by MeV proton microbeam irradiation[1]. The origin of the strong ferromagnetism is not yet understood. New theoretical models[2] as well as negative results of MeV alpha irradiation indicate that the implanted hydrogen plays a major role. Necessary information for this are the stability of the hydrogen atoms at different implanted doses as well as the virgin hydrogen content. Therefore, the microscopic distribution of the implanted hydrogen was investigated using sensitive three dimensional hydrogen microscopy by coincident proton-proton-scattering[3,4].

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CMMSP PWE 67

Preferential Amorphisation of Ge Nanocrystals in a Silica Matrix

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Relative to bulk crystalline material, Ge nanocrystals in a silica matrix exhibit subtle structural perturbations including a non-Gaussian inter-atomic distance distribution. We now demonstrate such nanocrystals are extremely sensitive to ion irradiation. Using transmission electron microscopy, Raman spectroscopy and extended x-ray absorption fine structure spectroscopy, the crystalline-to-amorphous phase transformation in ~8 nm diameter nanocrystals and bulk crystalline material has been compared. Amorphisation of Ge nanocrytals in a silica matrix was achieved at an ion dose ~100 times less than that required for bulk crystalline standards. This rapid amorphisation of Ge nanocrystals is attributed to the preferential nucleation of the amorphous phase at the nanocrystal/matrix interface, the pre-irradiation, higher-energy structural state of the nanocrystals themselves and an enhanced nanocrystal vacancy concentration due to the more effective trapping of irradiation-induced interstitials at the nanocrystal/matrix interface and inhibited Frenkel pair recombination when Ge interstitials are recoiled into the matrix. To demonstrate the significance of the latter, we show ion irradiation of ~2 nm diameter nanocrystals yields their dissolution when the range of recoiled Ge atoms exceeds the nanocrystal bounds.

CMMSP PWE 68

Density Functional *ab initio* Calculations of Bulk Wurtzite CdSe

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We present a study of structural, electronic and vibrational properties of wurtzite CdSe under the Kohn-Sham formalism of Density Functional Theory (DFT) using the recently developed hybrid functionals B3LYP and B3PW. We use an (total-energy optimized) all-electron gaussian basis-set to calculate lattice parameters, bulk moduli and elastic constants. The B3PW functional was found to predict bulk properties to reasonable agreement with experiment. We present a comparison of the electronic density of states predicted by the aforementioned hybrid functionals and examine how varying the amount of non-local Hatree-Fock exchange potential in the functional effects the electronic structure (predicted band gap energy). We also make pseudo-potential *ab initio* derived calculations of the phonon dispersion curve and vibrational density of states (VDOS), which are in reasonable agreement with experiment.

CMMSP PWE 69

Modelling Structural Morphology and Free Energies of Gold Nanoclusters

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Due to the promising electronic, biological, catalytic and even magnetic properties, both experimental and theoretical studies have been focusing on the stability of gold nanoclusters with different motifs and sizes, at different chemical and physical environments. In this paper, we present the result of molecular dynamics (MD) simulation of gold nanoclusters with different motifs and sizes[1]. The glue potential[2–7], which is a well-tested potential for gold in bulk and nano-scale, was used in our study. The structures and vibrational properties at room temperatures were analyzed. The potential energy and also the vibrational entropy were determined for different motifs and sizes. Finally, the total free energy of gold nanocluster was determined as an indication of occurrence possibility, in terms of statistical thermodynamics.

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CMMSP PWE 70

Persistent Photosignals in Non-ideal Semiconductor Devices

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Persistent photoinduced effects (PPE) are relaxation phenomena that exhibit non-exponential decay. We present an explicit model for PPE for the case of semiconductors with defects. The relaxation rate is shown to be *time dependent, parallel relaxation channels are not invoked*. We present experimental evidence of PPE in GaN-based Schottky detectors, and in GaN-GaAlN Transistors. The experimental data is well described by the suggested mechanism. We extract physical properties, such as surface state trap density at the semiconductor-metal interface and their trapping lifetime. This model has general validity and provides the underlying mechanism for the ubiquitous persistent effect in non-ideal semiconductors.

CMMSP PWE 71

Theoretical Study of the Adsorption of the 6-trifluoracetoxy-norbornadiene Molecule on the Si (001) Surface

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There is currently considerable interest in the chemisorption of organic molecules on silicon surfaces. Here we report the results of theoretical studies using the Gaussian03[1] and VASP[2] software packages of the interaction of the 6-trifluoracetoxy-norbornadiene molecule ($C_6H_6CHOCOCF_3$) with the Si(001) surface. The lowest energy structure corresponds to the carbon atoms of the norbornadiene base (C_6H_6CH) bonding directly to the silicon dimer dangling bonds with the C=C bonds of the molecule oriented perpendicular to the silicon dimer bonds. The energetics and bonding characteristics associated with the chemisorption of this molecule on the Si(001) surface will be compared with those of other similar molecules reported in the literature[3,4].

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CMMSP PWE 72

Near-Field Optical Properties of Thin Randomly Nanostructured Silver Films

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We will present AFM-SNOM measurements for randomly structured thin silver films, prepared by inverse nanosphere lithography to create circular holes in the metal film. Care is taken to create continuous films, which show none of the “worm”-like structures of semi-continuous metal films. Two sphere/hole concentrations are studied. The higher hole concentration samples show a strong similarity between the near-field intensity and topology, while the low hole concentration samples show almost no correlation between intensity and topology, but rather wave-like patterns which originate from surface protrusions or holes. Possible mechanisms and reasons for the differences will be discussed.

CMMSP PWE 73

Correlating Morphology and the Spectroscopy of Colour Centres in Diamond using a Combined Near-Field Scanning Optical Microscope and Raman Spectrometer

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The correlation of the morphology of isolated diamond nanocrystals and thin film Chemical Vapour Deposited (CVD) diamond with fluorescence, photoluminescence and Raman spectroscopy of colour centres is studied using a combined Near-Field Scanning Optical Microscope (NSOM) and Raman spectrometer. The location, concentration and spectra of defects such as the Nitrogen-Vacancy (NV) and Nickle centres in diamond, which are of interest as single photon sources and in quantum computing applications, are reported.

CMMSP PWE 74

Nonlinear Left-handed Metamaterials

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Left-handed metamaterials (LHMs), also known as materials with negative refraction, were first described theoretically by Veselago in 1960-s as materials with both negative dielectric permittivity and negative magnetic permeability. We develop the concepts of *nonlinear* LHMs and show that their properties can be dynamically controlled using electromagnetic field intensity[1]. The nonlinearity of such materials is dramatically enhanced due to the presence of metallic resonators in the structure. Moreover, we demonstrate that LHMs with quadratic nonlinear response[2] can be used for creation of *opaque lens*, which can form an image of the second harmonic field being opaque at the fundamental frequency.

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CMMSP PWE 75

Preliminary Investigations of Hydrogen Adsoprtion in Mesoporous Silica

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Hydrogen storage is currently an intense area of research. Numerous materials are being investigated for this including: metal hydrides, various forms of carbon, zeolites and metal-organic frameworks. We have done preliminary work on hydrogen adsorption in the mesoporous silica MCM-41. This material consists of a regular array of cylindrical pores in amorphous silica and has been characterised by SAXS, N_2 adsorption and TEM. It has been shown to reversibly absorb hydrogen at 77 K. Modelling of SAXS data determines the pore morphology independent of N_2 adsorption. A minimum pore size, wall thickness and distance between pores are determined via modelling.

CMMSP PWE 76

Diffusion between Interstitial Sites in the C15 AB_2 Structure

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H is readily absorbed by a number of intermetallic AB_2 compounds with the cubic C15 structure. The H occupy interstitial sites of types e and g and can diffuse rapidly between them. An aim of measuring the diffusivity *D* of the (tracer) diffusion of H in these compounds is to deduce information about the jump rates between the interstitial sites. An analytic expression for *D* is derived in terms of the four relevant jump rates between the sites in the low concentration limit. The method uses a general approach for diffusion in complex systems[1] and a computer algebra package.

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CMMSP PWE 77

Perturbed Angular Correlation Spectroscopy of Implantation-damaged Indium Nitride

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Indium nitride is predicted to have technological applications such as in high frequency transistors[1]. However, information on implantation-induced damage and annealing is limited[2]. In this work the radioisotope probe ^{111}In/Cd has been implanted[3] into indium nitride films as ^{111}InO- ions at 125 keV and 10^{14} ions/cm^2. Perturbed angular correlation spectroscopy on the as-implanted films shows the quadrupole interaction frequency of indium metal indicating that severe damage and nitrogen effusion occurs for such a fluence. Following annealing an additional frequency of 156 MHz is observed, which may be associated with diffusion of some of the ^{111}In/Cd probes into the unimplanted region of InN or formation of polycrystalline or amorphous indium oxides.

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CMMSP PWE 78

Formation of Organic Monolayers on Hydrogen-Terminated Silicon Surfaces via Silicon-Carbon Bond: Effect of Terminal Groups on Stability

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Functionalization of hydrogen-terminated silicon surfaces with stable and dense aryl-terminated alkyl self-assembled monolayers (SAMs) provides opportunities for the development of low cost organic field effect transistors. In this paper we present results for one such σ–π SAMs, 3-phenylpropyl ($C_6H_5(CH_2)_3$–) SAMs on porous silicon, and compare its stability with octyl ($CH_3(CH_2)_7$–) SAMs on Si(100). The SAMs were prepared using the Grignard reagent method and characterized using X-ray photoelectron and FT-infrared spectroscopies and contact angle measurements. Our results show the 3-phenylpropyl SAMs are not as susceptible to oxidation as the octyl SAMs, and we attribute the increased stability in the former to be due to its more dense structure arising from the π–π stacking of the phenyl rings.

CMMSP PWE 79

The Apparent Optical Indices of Spongy Nanoporous Gold

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Thin spongy nanoporous gold films containing nano-size pores (5–20 nm) on glass substrates were fabricated by the sputtering of $AuAl_2$ precursor films followed by a de-alloying etch in acid or base. Optical constants of the layers were determined from beam intensities (spectroscopic) and polarization states (ellipsometric Ψ and Δ) recorded as a function of the wavelength and angle of incidence of the light beam. Changing the angle of incidence influenced the real part of the effective refractive index (n*) but not the imaginary part (k*). The complex refractive indices of spongy nanoporous gold films satisfy Kramers-Kronig self-consistency and have unusual dispersion relations. These gold films exhibit unique optical constants, which are completely different from those of typical 20nm gold films. They are not metal like, especially at IR wavelengths.

CMMSP PWE 80

Interaction Correction to the Longitudinal Conductivity and Hall Resistivity in High Quality Two-Dimensional GaAs Electron and Hole Systems

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The origin of the anomalous metallic behaviour in high quality two-dimensional (2D) systems at low temperature remains controversial, as theory suggests that 2D metallic Fermi liquids should not exist. We have performed a systematic study of the quantum mechanical corrections to the longitudinal conductivity and Hall resistivity in high quality GaAs electron and hole systems[1]. We demonstrate that both corrections are consistent with a recent finite-temperature Fermi-liquid based theory by Zala *et al.*[2]. Our results suggest that the observed metallic behaviour is due to electron-electron interactions and screening of ionised impurity scattering, ruling out some of the more exotic explanations.

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CMMSP PWE 81

Elastic Modulus of Silicon Nitride Thin Films from Nanoindentation

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A CSIRO UMIS II nanoindenter was used to measure the elastic modulus of plasma-enhanced-chemical-vapour-deposition silicon nitride thin films deposited on germanium and silicon substrates. The plane-strain modulus calculated from the compliance data is observed to depend on the thin film residual strain. Atomic force microscope imaging of the residual impressions indicated sink-in and the consequent overestimation of the projected contact area. Subsequent adjustment of the modulus data indicates no deposition temperature (150–300˚C) dependence, despite the differences in bonding configuration and mass density of the thin films.

CMMSP PWE 82

Electronic Raman Spectroscopy (ERS) of Donors in Silicon for Quantum Computing: Getting at the Exhange Coupling Constant (J)

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When fabricating a solid-state quantum computer (QC) based on phosphorous donor atoms in silicon[1], establishing that controlled electronic wavefunction overlap has been achieved is a prerequisite to donor entanglement. Recently, an optical method capable of estimating the strength of wavefunction overlap between neighbouring phosphorous donors and the distribution of donors in an ensemble has been proposed[2]. Based on electronic Raman scattering (ERS)[3], the technique promises to provide a direct measure of the exchange coupling constant (J). In this work, we report on the observation of the ERS signal from donors in an engineered substrate. Using various donor placement strategies including ion implantation, we report on our progress towards measuring J.

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CMMSP PWE 83

Properties of an Optical Microcavity Containing Silicon Nanocrystals

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The photoluminescence from nanocrystalline Si formed by plasma enhanced chemical vapour deposition (PECVD) followed by high temperature annealing, generally have a broad spectral distribution due to the nanocrystal size distribution. For many applications, it is desirable to reduce the spectral width and increase the emission intensity at a particular wavelength. In this study, two distributed Bragg mirrors made from PECVD SiO_2 and Si_3N_4 are used to define a microcavity in order to alter the nanocrystal emission. The optical properties of these microcavities and their impact on the nanocrystal emission are reported.

CMMSP PWE 84

Magnon Specific Heat in Ferromagnetic Nanoparticles of Iron Group

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Nanoparticles have assumed great importance in science and technology. Nanoparticles of iron, cobalt and their alloys are useful for data storage on tapes/disks. Cobalt-alloys are being used for 15–20 nm thin films and smaller grains can store more megabits of information. But spin and lattice waves can limit their grain-size. Magnetic properties on a very small scale are not the same as on a large scale because of domain problem. Whereas a big permanent magnet is made of millions of domains, a tiny magnet can only be made with one domain. Its energy is made of exchange and anisotropy terms and so the magnon spectrum is different from the bulk material. Theoretically, magnon specific heat $C_m = aT^{3/2} - bT^{1/2}$ where a and b depend on the grain size at a given temperature.

CMMSP PWE 85

Gaussian Wavefunction Simulation of Solid State Systems for Quantum Computation

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Quantum mechanical modelling of isolated ^{31}P donor impurities in a silicon lattice is an important component in the modelling of a Kane-type solid state quantum computer. Previous studies have used Heitler-London or Hartree-Fock self-consistent field modelling, but the accuracy of these methods is largely unknown, and they are difficult to extend to more complex systems due to lengthy numerical integration. We adapted techniques from quantum chemistry to address this problem. In a basis of spherical Gaussian type functions, many of the relevant integrals become analytic, allowing the use of very large basis sets. We used such a basis for the simulation of systems relevant to the Kane architecture.

CMMSP PWE 86

Raman Spectroscopy and Estimating the Temperature of Silicon <100˚ K

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Micro-Raman spectroscopy is one of the few techniques that can be used to perform a reliable, non-contact determination of temperature in solid-state systems. It is particularly well suited to applications where a probe laser

can cause localised heating. One of three methodologies are usually employed[1,2,3] whereby measurement of the:

(i) ratio of stokes to antistokes line intensities

(ii) peak linewidth (Γ) or

(iii) peak shift (Ω)

of the first order Raman optical phonon is correlated with sample temperature. At low temperatures (i.e. < 100˚K) in silicon, we report that changes in the Raman peak position provide the best approach for temperature estimation. We also report on the anomalous temperature dependence of the silicon peak shift which can be explained by the negative thermal expansion coefficient and Grüneisen parameter[4].

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CMMSP PWE 87

Microcharacterisation of the Effects of Focused Ion Beam Irradiation on Wide Bandgap Materials

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Focussed ion irradiation of wide bandgap materials is of great importance to fundamental physics (scattering, impurity effects) and practical applications (nano-modification, analysis, TEM sample preparation)[1]. Atomic Force and Kelvin Probe Microscopy and electron microprobe techniques were used in the systematic, high-resolution microcharacterisation of focussed keV ion beam irradiated n-Silicon and p-SIMOX (SOI). Variation with ion fluence of properties including surface topography, induced localised electrostatic potential and spatial elemental composition were investigated and qualitative correlations found. The resultant potential distributions were modelled successfully using finite-element techniques. Explanations for the distributions have been proposed based on ion neutralisation, ion emission and charge trapping.

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CMMSP PWE 88

An Alternative Interpretation of Mössbauer Spectra for ^{57}Fe-doped Lanthanum Calcium Manganite

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$La_{2/3}Ca_{1/3}MnO_3$ is the generic colossal magnetoresistance material with an insulator-metallic transition temperature of about 273 K. In this work, Mössbauer spectroscopy is used to probe its Mn sub-lattice magnetisation via a 0.5 at. % substitution of Mn atoms with enriched ^{57}Fe. Relaxation effects are successfully interpreted in terms of slowly fluctuating magnetic clusters according to a model devised elsewhere for the analysis of iron oxide spectra. Smaller, faster relaxing clusters are represented as a paramagnetic component of the spectra. The derived temperature dependence of the Mn sub-lattice magnetisation is compared with results obtained using other interpretations and other measurement techniques.

CMMSP PWE 89

Mnemonics Nurture Expert Memory Of Noteworthy Ideas & Concepts

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In a short story in honour of Isaac Asimov[1], a congressman is concerned to overhear a student's comment that *many voters earn money just showing up near polls*. However, it proved to be a device to help remember the planets in order of their distance from the Sun. In my student days it was *many Victorians eat marmalade jam, some use Nice plum*. I'm certain that there are a lot of devilishly clever mnemonics out there for remembering other lists and sets of concepts in physics. I'd like to collect them and will offer prizes for the best one in Condensed Matter and Materials and the best one in all other areas of physics at the Congress. Please visit this poster and contribute to the collection!

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CMMSP PWE 90

Crystal Field Interaction in RFe_2Si_2 (R = Er, Tm)

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New ^{169}Tm Mössbauer effect (ME) data for $TmFe_2Si_2$ and inelastic neutron scattering (INS) data for $ErFe_2Si_2$ have been recorded and analysed in terms of the crystal field interaction at the rare earth site. The local point symmetry is tetragonal, requiring five crystal field parameters. There is now an almost complete set of ^{155}Gd and ^{169}Tm ME data and Er INS data for the intermetallic series RT_2Si_2 (R = rare earth, T = Fe, Co, Ni, Cu)[1] and the improved crystal field systematics will be presented and discussed. AINSE (grant 2003/109) is acknowledged for funding neutron activations of the short-lived ^{169}Tm Mössbauer source.

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CMMSP PWE 91

The Néel Temperature for $YbMnO_3$

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As for other members of this hexagonal rare earth series, $YbMnO_3$ undergoes both a ferroelectric transition (TC ≈ 1000 K) and an antiferromagnetic transition. The magnetic phase involves a spin system with strong geometrical frustration and the Néel temperature is difficult to determine experimentally. Most recently, it has been reported as either 82 K[1] or 88 K[2]. We present here a temperature-dependent Mössbauer spectroscopy investigation of $Yb^{57}Fe_xMn_{1-x}O_3$ (x = 0.005, 0.01) that supports the higher value. Comparison of spectra recorded for the paramagnetic and magnetic phases confirms that the triangulated Mn sub-lattice magnetisation lies in the basal plane.

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[2] K. Yoshii and H. Abe, J. Solid State Chem., **165**, 131 (2002)

CMMSP PWE 92

Influence of Growth Parameters on InAs/GaAs Quantum Dot Nucleation and Defect Formation

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Semiconductor quantum dots (QDs) offer many advantages for opto-electronic devices due to their zero dimensional nature and discrete energy states. In this work we discuss the self-assembled growth of InAs/GaAs quantum dots by Metal-Organic Chemical Vapour Deposition (MOCVD). A systematic study of the various growth parameters was performed and atomic force microscopy, plan-view and cross-sectional TEM, and photoluminescence measurements used to characterise the samples. The QD samples were found to be susceptible to the formation of three main types of defects. This work will discuss the nature of these defects and the growth conditions under which they can be avoided, leading to device quality QDs.

CMMSP PWE 93

Magnetic-field Influence on Rashba Spin-precession

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We propose relieving the strict prerequisite of the narrow width of the quantum well or the strong transverse confining potential for the operation of the Datta-Das Spin-Field-Effect transistor[1] by applying an external magnetic field perpendicular to the 2D-electron-gas. We investigate the ballistic transport of a quasi-one dimensional system considering the Rashba Spin-Obit (RSO) interaction[2] under the external magnetic field. Our results show the perfect spin modulation of the conductance due to the RSO coupling under new conditions and our proposal is therefore a proper alternative to the prerequisite for the function of Spin-Field-Effect transistors.

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CMMSP PWE 94

Direct and Indirect Transitions at the Ordered and Disordered Fermi surface of Cu3Au

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The compositionally random Cu-Au system displays a variety of unusual phases which, together with other properties such as the incommensurate long-period superlattice in CuAu, are believed to be related to Fermi Surface topology[1,2]. The intermetallic compound Cu_3Au has an order disorder transition at 377˚C which with the change in structure shows changes in the Fermi Surface(FS).

The FS of Cu_3Au has previously been studied by Angle resolved Photoemission (ARPES) in the Constant Initial State mode[3]. With the change in the structure from the disordered to the ordered state the Brillouin Zone contracts and band backfolding occurs resulting in a Fermi surface with a more intricate topology. A new generation toroidal angle resolving electron energy analyzer, developed at La Trobe University, has been used to map the changes that occur to the Fermi Surface across the disorder-order transition using both the constant initial state mode and the Azimuthal Scan technique. Comparison of the results from both techniques permit the identification of the direct transitions from the Brillouin Zones and transitions which occur due to the effects of broadening in the final states and due to Umklapp transitions.

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[3] Con Foo, J.A., et al., *The Fermi Surface Dimensions Of Disordered Cu_3Au As Determined By Angle Resolved Photoemission Spectroscopy.* Solid State Communications, 1998. **107**(8): p. 385–390.

CMMSP PWE 95

Ion Implantation Facility for Precision Doping of Semiconductor Devices

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We have developed an ion implantation system for application to: the nano-fabrication of p-type and n-type silicon devices; the fabrication of silicon nano-resistors; single phosphorus doping of silicon-based quantum computer devices; the doping of diamond-based devices; the study of ion beam physics of low energy ion interactions with solids. The system reliably delivers a wide range of ion spices, including B^+, Te^+, P^+, C^+, N^+ and H^+ with an energy up to 15 keV. The ion implanter operates in the mode of beam-on-demand control triggered by signals from the substrate and the beam current is adjustable in a wide range from ~mA to a few ions per-second. The beam purity of each ion species is routinely monitored and analysed using micro-ERDA/PIXE/RBS.

CMMSP PWE 96

High Resolution Depth Analysis of Multilayer Structures by SNMS

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Secondary Neutral Mass Spectroscopy (SNMS) is a surface analysis technique in which neutrals sputtered from a sample are ionised by electron gas prior to analysis by a mass spectrometer. The elemental sensitivity factors are nearly independent of the bombarding energy, simplifying the quantification of spectra[1]. The instrument (a SPECS INA-X) has a detection limit in the ppm range and nanometre depth resolution. Sample preparation is minimal. We have used the SNMS to seamlessly depth-profile composite multilayer structures of Al (metal conductor) on Si thermal oxide (insulator) on Si wafer (semiconductor), Ti /TiN multilayers on Si and Cr/Au on glass.

[1] J. Jorzick et al, Appl. Phys. A, **78**, 255 (2004)

CMMSP PWE 97

Synthesis and Characterisation of Titanium Vanadium Nitride Thin Films

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Ternary alloys involving titanium, vanadium and nitrogen have shown desirable properties including high hardness and attractive colours. In this work we investigated the effect of varying the ratio of Ti:V on the hardness and optical properties of $Ti_{(1-x)}V_xN$ alloys produced using a dual source pulsed cathodic arc. A maximum in indentation hardness was found at a ratio of $Ti_{0.77}V_{0.23}N$ and this alloy has a substantially higher hardness than TiN. The complex refractive index at 633 nm was measured by ellipsometry and found to vary markedly with composition in the region of the hardness peak.

CMMSP PWE 98

Optical Readout of Single-spins for Solid-state Quantum Computing

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We propose readout of spin qubits, using a far infrared (FIR) laser to resonantly transfer a single electron to a donor beneath a single electron transistor (SET). This is an optical based implementation of work in ref.[2] on spin-dependent resonant transfer. This method offers the advantage of working at significantly reduced electric field strengths as compared to the existing adiabatic technique proposed by Kane[3], hence the preservation of the D-readout state. We also propose a method to perform spin initialisation using the same resonant technique. We thus provide an alternative method for spin readout and initialisation in donor based solid-state quantum computing.

[1] L. C. L Hollenberg *et al*., Phys. Rev. B **69**, 233301 (2004)

[2] B. E. Kane, Nature **393**, 133 (1998)

CMMSP PWE 99

Atomistic Simulation of Cation Ordering and Radiation Damage in $Sr_{1-3x/2}La_xTiO_3$ Defect Perovskites

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$Sr_{1-3x/2}La_xTiO_3$ perovskites are known to contain charge-compensating cation vacancies, which display one-dimensional ordering at high La concentrations. Recently, the radiation resistance of these perovskites has been measured, revealing an anomalously high radiation resistance at around $x = 0.2$. We use atomistic computer simulation techniques to study short-range cation and vacancy ordering as a function of La concentration and thermal history. Long-range electrostatic effects dominate the interactions, and ordering in one- and two-dimensions is observed. We also give preliminary results on the effects of La concentration and ordering on radiation resistance, including both primary damage creation and defect annealing.

CMMSP PWE 100

The Ni $2p_{3/2}$ Auger-photoelectron Coincidence Spectrum

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The photoelectron and Auger electron spectra of the transition metals can be complicated by many-body processes. Auger Photoelectron Coincidence Spectroscopy (APECS) provides and opportunity to explore a number of these effects.

We present Ni $2p_{3/2}$ photoelectron spectra measured in coincidence with components of the Ni L_3-$M_{4,5}M_{4,5}$ Auger spectrum. The coincidence-photoelectron spectrum is similar to the XPS photoelectron spectrum when measured in coincidence with electrons with the energy of the L_3-$M_{4,5}M_{4,5}$ ^{1}G component. The coincidence-photoelectron lineshape changes when measured in coincidence with electrons 1.0 and 2.0 eV below the energy of the L_3-$M_{4,5}M_{4,5}$ ^{1}G component where the relative contribution from L_3-$M_{4,5}$-$M_{4,5}M_{4,5}M_{4,5}$ processes is greater.

The lineshapes are interpreted using the many-body theory previously applied to the analysis of the coincidence-photoelectron lines of Cu and Ag[1]. In particular, we consider effects of the initial- and final-state lifetimes, and many-body effects involving shake-up/down excitations.

1. M. Ohno, J. Electron Spectrosc. Relat. Phenom. 124 (2002) 39

CMMSP PWE 101

Zeeman Spectra of Boron in Germanium at High Fields

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Zeeman spectra of boron in germanium have been examined for B||<110> in the Faraday configuration with fields up to 18T. Previous studies[1] have been confined to 0–7T, for the Voigt arrangement with linearly polarised radiation. All spectral lines yield detailed Zeeman patterns; that of the G line will be presented for the range 0–18T along with a comparison with theory from 1–10T[2].

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[2] W. O. G. Schmitt, *et. al., J. Phys.: Condens. Matter* **3**, 6789 (1991).

CMMSP PWE 102

Study of Bulk Traps and Interface States in P_implanted Si MOS Capacitors Using Constant Capacitance Deep Level Transient Spectroscopy

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Ion implantation doping of Si through an SiO_2 overlayer is of interest for fabrication of a solid-state quantum computer based on the Kane proposal of P qubits in a Si matrix. The areal density of P atoms estimated to be required is 10^{11} cm^{-2}. To obtain quantitative information about the bulk charge traps and interface traps introduced during implantation and to monitor their annealing characteristics during subsequent thermal treatment of implanted samples we are using constant capacitance deep level transient spectroscopy (CCDLTS). Of particular importance to the solid-state quantum computer fabrication program is the fact that CCDLTS allows the near-oxide interface region to be probed and that it has more than adequate sensitivity to detect defects in the ion fluence regime 10^{11} cm^{-2} of interest. Here, we present results from a CCDLTS study of P-implanted MOS capacitors where a range of bulk traps are identified and their annealing behaviour analysed.

CMMSP PWE 103

A Comparison of Electronic Structure Determination by Electron Momentum Spectroscopy and by Angular Resolved Photoemission

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Angular-resolved photoelectron spectroscopy is currently the most widely-used technique to determine the band structure of single crystals. Recently new measurements have become available using a scattering technique: Electron Momentum Spectroscopy (EMS). In particular the electronic structure of single crystals copper and silicon[1] was measured by EMS. Here we compare both techniques, and indicate under what conditions one technique is superior over the other. Specifically the band selectivity is different between the techniques, as is energy and momentum resolution and surface sensitivity. Conceivably a greater understanding of electronic structure may be achieved by a combination of these two techniques.

[1] A. S. Kheifets, V. A. Sashin, M. Vos, E. Weigold, Phys. Rev. B, **68**, 233205 (2003).

CMMSP PWE 104

Magnetic Behaviour of $ErFe_{12-x}Nb_x$ (x = 0.6–0.8)

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The magnetic behaviour of ferrimagnetic $ErFe_{12-x}Nb_x$ compounds has been investigated over the temperature range 4.2–300 K using ac and dc magnetic techniques and Mössbauer spectroscopy. The spin reorientation temperatures T_{sr} in $ErFe_{12-x}Nb_x$ compounds remain essentially unchanged with increasing x (T_{sr} ~ 42 K) compared with a significant decrease in $DyFe_{12-x}Nb_x$ (T_{sr1} ~ 236–204 K; T_{sr2} ~154–94 K). This can be understood by taking the different crystal field terms responsible for the spin reorientations into account. The site magnetic moments derived for $ErFe_{11.4}Nb_{0.6}$ at 4.2 K are 2.19 $_B$, 1.98 $_B$ and 1.69 $_B$ for the 8i, 8j and 8f sites respectively.

CMMSP PWE 105

Characterisation of Vacuum (Physical Vapour) Deposited Lumogen Optical Films

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The material and surface characterisation of Lumogen Yellow S optical thin films vacuum deposited on silicon dioxide surfaces is made using a range of analytical techniques. Differential scanning calorimetry (DSC) and thermo-gravimetric analysis (TGA) have been applied to determine the degree of crystallinity in the films. Ultraviolet-visible spectroscopy (UV-vis), x-ray diffraction (XRD) and scanning electron microscopy (SEM) are utilised to study the change in film structure with respect to deposition conditions.

UV-vis and DSC/TGA results yield basic data on the melting point, absorption and emission spectra for the material while x-ray scattering is used to calibrate film thickness. XRD provides a more reliable probe of crystallinity and results show changes in crystal structure and growth after post-deposition treatment at elevated temperatures. Size quantification and the degree of crystallinity in the films is confirmed by direct SEM imaging showing the crystal formation on the film surface.

CMMSP PWE 106

A Study of Stress Development during Thermal Cycling of PECVD-Deposited Materials Used for the Synthesis of Silicon Nanocrystals and Associated Optical Structures

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PECVD-deposited materials used for the synthesis of Si nanocrystals and devices designed to tailor their emission undergo severe thermal cycling with temperatures exceeding 1100°C. The different thermal expansion coefficients of the materials, as well as the release of copious amounts of H during annealing (up to 30 atomic-%), results in significant stress and often cracking of the final structures. A simple sample curvature measurement technique has been developed to study the development of stress during thermal cycling. When correlated with complementary measurements, a better understanding of the failure mechanisms, and how to best avoid them, is obtained.

CMMSP PWE 107

Heavy Ion Elastic Recoil Detection Analysis of Silicon-rich Silica Films Used for the Synthesis of Silicon Nanocrystals

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In recent years, nanocrystalline silicon has sparked considerable interest, since its light emitting properties provides the potential for integrating electronic and photonic functionality in a single circuit using a common material system. This paper presents the heavy ion elastic recoil detection (HI-ERD) analysis of PECVD-deposited silicon-rich silica films used for the synthesis of silicon nanocrystals and shows that, due to its sensitivity to light elements and H in particular, HI-ERD analysis is a useful tool in unraveling experimental issues related to their deposition and processing.

CMMSP PWE 108

Advanced Chebyshev Expansion Methods for Finite-temperature Dynamical Correlation Functions

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The numerical calculation of dynamical correlation functions, like optical conductivities, structure factors, spectral functions etc. is one of the typical tasks in condensed matter physics. With the effort scaling only linearly in the problem dimension, Chebyshev expansion and kernel polynomial methods[1] belong to the most efficient and stable approaches to such problems. In this contribution we give an overview of these methods and propose extensions to *finite temperature*[2]. To illustrate their performance we present a comprehensive study of the optical conductivity of non-interacting electrons in a random potential (Anderson model), calculated for large finite clusters. In addition, we apply the new method to explore transport properties and correlation effects of interacting quantum systems, e.g., spin chains.

[1] R. N. Silver, H. Roeder, Phys. Rev. E **56**, 4822 (1997).

[2] A. Weisse, Eur. Phys. J. B **40**, 125 (2004).

CMMSP PWE 109

Electron Excited Auger Electron Spectroscopy of Cu

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The inner core KLL Auger lines for Cu has been measured using high energy electron excitation of thin free standing membranes. The thin free standing metallic samples were prepared by evaporation on to amorphous carbon films. The spectra have been treated to background correction using the Shirley method and have been analyzed assuming the satellite structure observed in copper[1] is caused by d-band spectator vacancy shake-up from the $^1S_0$, $^1D_2$ and $^3P_2$ peaks. The results have been compared to available experimental measurements and theoretical predictions.

[1] L. Köver, I. Cserny, J. Tóth, D. Varga, T. Mukoyama, J. Elecron Spectros. Relat. Phenom., **114–116**, 55 (2001)

CMMSP PWE 110

The Effect of Annealing Environment on the Luminescence of Silicon Nanocrystals in Silica

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There is considerable interest in the properties of Si nanocrystals embedded in SiO_2, with a particular emphasis on the strong room-temperature luminescence exhibited by such material. However, what has not been appreciated is that apparently subtle changes in the choice of annealing ambient (e.g. Ar instead of N_2) has a significant effect on nanocrystal luminescence. In this study, we show that the choice of ambient affects both the nanocrystal size distribution and the concentration of non-radiative defects present at the nanocrystal surface. Nitrogen is shown to play an important role in this respect.

CMMSP PWE 111

Optimizing Luminescence Efficiency from Si Nanocrystals through the Control and Passivation of Defects

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Silicon nanocrystals embedded in SiO_2 exhibit strong room-temperature luminescence as a direct consequence of their small size. The quality of surface passivation dramatically affects both the luminescence intensity and lifetime, and can be affected by such things as the thermal annealing cycle, the annealing environment, and impurities. In this work, the effect of hydrogen passivation on the luminescence is investigated. Continuous and time-resolved photoluminescence measurements are used as a relative measure of defect densities, which are monitored as a function of passivation temperature and duration. Models are presented for the reaction kinetics of passivation in atomic and molecular hydrogen, based on models for passivation of defects at planar Si/SiO_2 interfaces.

CMMSP PWE 112

Magnetic Properties of $Gd_{1-x}Sr_xCoO_{3-\delta}$ (x = 0.67, 0.90 and 0.95)

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We have examined the magnetic properties of $Gd_{1-x}Sr_xCoO_{3-\delta}$ from 17 to 320 K for a range of samples, x = 0.67, 0.90 and 0.95. The materials are found to show peaks in the real and imaginary parts of the ac susceptibility and the positions of these peaks show frequency dependence, indicative of spinglass behaviour. At x = 0.67, it appears that at temperatures between T_f (~154 K) and 320 K the curve cannot be fitted by a Curie-Weiss law, suggesting that the material is ordered to some extent. Based on the behaviour of related materials, we suggest a state with an antiferromagnetic matrix containing ferromagnetic clusters.

CMMSP PWE 113

Martensitic Transformation under Magnetic Field in a NiMnGa Single Crystal

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NiMnGa is an interesting ferromagnetic shape memory alloy. In the present paper, the martensitic transformation of a NiMnGa single crystal under different magnetic fields is studied by using SQUID. An abnormal jump is found in the magnetization curves when the sample is cooled under magnetic fields of several thousand Gauss. The range of the magnetic field under which this abnormal jump is observed varies with the orientation of the single crystal. The mechanism associated with this phenomenon is discussed.

CMMSP PWE 114

Quantum and Transport Lifetimes of a Spin-split Two-dimensional Electron Gas

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A theoretical study is presented for transport properties of a two-dimensional electron gas in the presence of spin-orbit interaction induced by the Rashba effect. The quantum and transport lifetimes in different spin-orbits are evaluated by including electron scattering with remote and background impurities in an InAlAs/InGaAs heterojunction. The results have been compared with those obtained experimentally.

CMMSP PWE 115

Dynamic Properties of the Sulfur Contaminated Fe(110) Surface

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Sulfur contamination of Fe produces undesirable attributes, affecting the metal's adhesion and wear behaviour. We previously examined S/Fe(110)[1,2] at different coverages and adsorption sites, using density functional theory at 0K. This study examines the dynamics of a 1/4 monolayer coverage of S/Fe(110) at 298, 500, 800

and 1808K. A combination of vibrational frequency and ab initio molecular dynamics calculations showed that S moves from the high energy atop site (2nd order saddle-point) to the minimum (4-fold hollow) via the transition state (bridge). At 1808K, surface melting can be seen but S does not desorb, nor diffuse into the bulk.

[1] M.J.S. Spencer, I.K. Snook, I. Yarovsky, to be submitted, J.Phys.Chem.B (2004)

[2] M.J.S. Spencer, A. Hung, I. Snook, I. Yarovsky, Surface Science, **540**, 420 (2003)

CMMSP PWE 116

Electronic and Magnetic Properties of Thin Fe Films on Pd(001)

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We have studied the electronic and magnetic properties of thin Fe film on Pd(001) with the techniques of Angle-Resolved Photoemission and Magnetic Linear Dichroism in Angular Distributions of the photoelectrons. The angle-resolved photoemission spectra of thin Fe films (1–3 ML) on Pd (001) substrate were measured with incident photon energy of 22 eV to 70 eV. The asymmetry function with respect to the magnetisation directions of the sample was also measured with linear polarised light. The 3d-4d hybridisation was studied through the induced polarisation observed in the angular distribution of photoelectrons from Pd.

CMMSP PWE 117

Thin Boron Nitride Nanotubes Formed during Annealing in Ammonia Gas

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We present a mechano-thermal process to synthesis thin boron nitride nanotubes of diameter around 7 nanometers. They were produced by mechanical milling of amorphous boron powder at ambient temperature, followed by thermal annealing in ammonia gas. High energy ball milling creates a precursor containing a high density of nanocrystalline BN seeds and fine particles of metal catalyst. Nanotubes grow out from the milled boron powder during subsequent annealing. The novelty of this approach lies in the formation of the thin BN nanotubes by annealing in ammonia gas instead of nitrogen gas. The boron nitride nanotubes produced have a well-defined crystalline structure and there is no iron within them. If nitrogen gas is used, thicker nanotubes of diameter in the range of 20–100 nm were obtained and iron was more likely to be found inside the nanotubes.

CMMSP PWE 118

Magnetism of Isolated Atoms at Surfaces and in Vacancy-Related Complexes

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Experiments with radioactive tracer atoms have opened up a new approach to examining the surfaces of magnetic materials[1,2]. The Perturbed Angular Correlation (PAC) spectroscopy, which is applied, allows the precise position and the magnetic field at the specific site to be determined. By careful annealing the atoms can be moved to different sites on surfaces or imbedded in vacancy-related complexes in the bulk.

For sp-elements, like selenium or cadmium, the field on nickel surfaces correlate with the number of neighbouring atoms. These results initiated a reiteration of the investigations on vacancy-related impurity complexes in the bulk.

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[2] H. Granzer, H.H. Bertschat, H. Haas, W.-D. Zeitz, J. Lohmüller, G. Schatz and the ISOLDE-Coll., Phys. Rev. Lett 77 (1996) 4261

CMMSP PWE 119

Characterization of Carbon Boron Nitride Graphitic Nanostructures Synthesized by RF-magnetron Co-sputtering

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Carbon boron nitride (CBN) thin films were deposited on molybdenum substrates by RF-magnetron co-sputtering using pure graphite and boron nitride targets. As-deposited and post-annealed films were characterized by high resolution transmission electron microscopy. A precursor film which possesses regions of a disordered and turbostratic graphitic structure was formed over a relatively low and wide substrate temperature range (130–500˚C). After subsequent annealing up to 900˚C, the precursor structure transformed to various locally well-graphitised polyhedral nanoparticles, including multi-walled tubes, boxes, onions, etc. However, regions of untransformed nanoporous particles were also visible, suggesting higher annealing temperatures are required for activating graphitic CBN nanostructured growth.

CMMSP THC11
Thursday 1040–1100 hrs

Helium Vapour-Pressure Thermometry by Ultrasound Attenuation

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The temperature of a liquid helium bath or cryostat can be controlled in the range 1K–4.2K by maintaining a reduced He vapour pressure (~1 mbar–1000 mbar) above the liquid[1] . The technique is employed, for example, to provide an intermediate temperature stage during the cooling of an adiabatic demagnetisation refrigerator. Conventional thermal-conductivity vacuum gauges do not operate reliably with helium in this pressure range, and the alternative capacitance-manometer gauges are quite expensive (>$2000). A novel, inexpensive technique based on the transmission of ultrasound through the He gas has been developed. Using readily-available components (costing <$10) and a relatively simple electronic read-out, the desired pressure range can be reliably established (+/–0.01mbar

[1] see e.g., G.K. White, Experimental Techniques in Low-Temperature Physics, Oxford University Press, 1989.

CMMSP THC12
Thursday 1100–1120 hrs

Crystallinity in Lumogen Optical Thin Films

A. Deslandes[1], A.B. Wedding[2] and J.S. Quinton[1]

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Lumogen Yellow S is a commercial pigment with properties that facilitates use for wavelength-converting optical coatings. A common application is in UV downconversion, absorbing radiation in the ultraviolet and re-emitting at visible wavelengths. Due to its very high conversion efficiency, lumogen films are used to increase the quantum efficiency of silicon-based photon detectors such as CCD's.

Lumogen coatings are considered stable, however reports show that as-deposited amorphous films exhibit non-uniformity and crystalline growth within the film if left standing at room temperature for a length of time. We are interested in harnessing this behaviour to produce nanocrystalline coatings with controlled optical properties.

The film structure has been studied using a range of techniques such as XRD, SEM and UV-vis absorption spectroscopy and show evidence for crystalline structures within the film. We aim to demonstrate the formation of crystalline structures and a significant influence of the storage temperature upon the nucleation and growth rate of crystals within the film.

CMMSP THC13
Thursday 1120–1140 hrs

Application of Optical Near-fields for Dry Etching

V. Polonski, B. Martin, R. Netterfield, P.J. Martin

CSIRO Industrial Physics, Lindfield NSW Australia

The dry etching of materials, conventionally thought of as plasma-assisted processing, is shown to also occur as a nanophotonics-based phenomenon. In our experiments, we have utilised periodic structures with quarter-micron features in the capacity of test structures placed in a gas-etchant environment. The unambiguous demonstration of dry etching for the chosen planar configuration can be attributed to the interplay of concurrent optical near-field effects acting on the material surface. Such size-dependent phenomena are presently little understood but offer effectively non-linear interactions without the usual power requirements and have enormous potential, especially if applied to sub-diffraction surface engineering problems and in nanoscale emerging science applications.

CMMSP THC14
Thursday 1140–1220 hrs

Acoustic Reflectivity of Liquid Saturated Porous Materials

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A great deal of information can be obtained by observing the angle of incidence behavior of acoustic and seismic waves reflected from the interface between differing materials. The reflectivity from liquid saturated porous materials is studied experimentally using a unique acoustic goniometer. Past the first critical angle, corrections for the bounded beam used must be considered and the modeling and calibration on well-known elastic materials was described. The experiments on liquid saturated sintered glass beads that carry a second 'slow' compressional wave are in good agreement with the predictions of existing theories.

CMMSP THC21
Thursday 1400–1440 hrs

Superconducting Quantum Engineering at the CSIRO

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Superconductivity is an extremely fruitful and exciting field of research, which has been awarded five Nobel prizes in since 1911. One unique property of superconducting systems, their macroscopic quantum behaviour, makes them ideal candidates to engineer quantum states for various applications. CSIRO Industrial Physics has a strong background in both low (LTS) and high (HTS)

temperature superconductivity developed over the past 30 years. Having researched Josephson junctions and superconducting quantum interference devices (SQUIDs) for a range of applications, new devices have been fabricated including nanoSQUIDs, absolute value detectors and HTS axial gradiometers for a diverse range of applications. Recent work has also considered two-state quantum systems for operation at milli-kelvin temperatures. This talk will describe some of the history of superconductivity, the related work at CSIRO and recent our research in quantum engineering.

CMMSP THC23
Thursday 1440–1500 hrs

Competing Types of Long-range 3D Magnetic Order in the Layered Molecular Network Compounds $M(NCO)_2(pyz)$, M = Mn, Fe or Co

C.D. Ling[1,2] and J.L. Manson[3]

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We have synthesised $M(NCO)_2(pyz)$ compounds where M is Mn, Fe or Co. We present the results of a neutron powder diffraction investigation into the crystal and magnetic structures of these compounds as a function of temperature. We find that the structures of all three compounds are isomorphic and related to that of $Mn(N_3)_2(pyz)$[1], and yet exhibit two distinct magnetic structures at low temperature. The relationship between these two magnetic structures, and the finely balanced magnetic exchange interactions that lead to the adoption of one over the other, are discussed.

[1] J.L. Manson, A.M. Arif and J.S. Miller, Chem. Commun., 123, 1497 (1999).

CMMSP THC24
Thursday 1500–1520 hrs

Studying Antiferromagnets Using an Exchange Bias Bilayer Thin Film

N. Ross, M.J. Lwin, R.C. Woodward, D.C. Crew and R.L. Stamps

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We have measured the resonance frequency of a Ni/NiO exchange bias bilayer using a Pulsed Inductive Microwave Magnetometer (PIMM) technique. Measuring the dependence of resonance frequency on both the magnitude and direction of external applied field allows us to unambiguously determine the various contributions to the anisotropy of the system, including the exchange bias. We relate changes in this exchange bias with time to changes in the domain state of the antiferromagnetic NiO. This gives us a window into the state of the antiferromagnet which is difficult to obtain with conventional hysteretic techniques that grossly perturb the antiferromagnetic NiO, by reversing the Ni layer during each measurement.

CMMSP THC25
Thursday 1520–1540 hrs

Surface Studies of Horse-spleen Ferritin

C.I. Pakes, G.C. Tettamanzi, A. Dowler, A. Cimmino, P. Olivero, S. Prawer and D.N. Jamieson

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Ferritin is an iron storage protein containing an antiferromagnetic core of up to 4500 Fe^{3+} ions. From low temperature bulk magnetisation measurements, it is known that these systems demonstrate macroscopic quantum tunneling of the Néel vector[1], arising from the non-compensated spin. Our interest is in developing techniques to allow the spin of individual proteins to be probed. We present a study of the Raman signature of surface-deposited ferritin, which demonstrates that exposure to UV laser pulses gives rise to the development of sp^2 bonded carbon in the protein, arranged in a polycrystalline graphite structure, with crystallite dimension equal to the protein size. Prospects for protein-based spintronics, using probe-based techniques to incorporate the proteins into nanoscale electronic circuits will be discussed.

[1] D.D. Awschalom et al, Phys. Rev. Lett, 68, 3092 (1992)

CMMSP THC31
Thursday 1620–1700 hrs

Tidbits about Qubits: Spin Computation in Nanostructures

Sankar Das Sarma

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I will provide an introduction to the emerging field of spintronics and spin qubits in this talk. Active control of carrier spin in nanostructures of semiconductors and other electronic materials is projected to lead to new device functionalities in the future. In particular, it may be possible to envision memory and logic operations being carried out on the same ‘spintronic’ chip. I will discuss various aspects of fundamental physics related to this new research area of spin electronics with the particular emphasis on localized electron spins in semiconductor nanostructures, such as GaAs quantum dots and P donors in Si. A revolutionary possibility in the (perhaps, far) future is using the natural two-level quantum dynamics of electron spin to create robust quantum bits (‘qubits’) which could be used to carry out solid state quantum information processing or quantum computation. I will discuss in details the questions of entanglement, decoherence, quantum error correction, and quantum gates in semiconductor nanostructure-based solid state spin quantum computer architectures, critically discussing from a theoretical perspective the current status of the field and

the prospects for carrying out large-scale quantum computation using solid state spin qubits.

This research has been supported by LPS, ARDA, ARO, DARPA, ONR, and NSF.

Please see http://www.physics.umd.edu/cmtc for the relevant publications.

CMMSP THC33
Thursday 1700–1720 hrs

Fabrication of Nano-Devices in Silicon Using Scanning Tunneling Microscopy

F.J. Rueß, M.J. Butcher, L. Oberbeck, M.Y. Simmons, K.E.J. Goh, A.R. Hamilton, T. Hallam, T. C. G. Reusch, N.J. Curson and R.G. Clark

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Recently our group has demonstrated, using a scanning tunneling microscope, the ability to place individual phosphorus atoms in silicon at precise locations[1]. These dopants can then be encapsulated in epitaxial silicon with minimal diffusion and segregation[2]. We have extended the scheme to fabricate and electrically characterize 2D and 1D nano-devices[3] by the use of an elegant registration technique, involving an in-situ scanning electron microscope etched registration markers on the samples and optical lithography. Here we will discuss this fabrication strategy and present electrical transport measurements from a number of devices.

[1] S.R. Schofield, N.J. Curson, M.Y. Simmons, F.J. Rueß, T. Hallam, L. Oberbeck and R. G.Clark, Phys Rev Lett 91, 136104 (2003).

[2] L. Oberbeck, N.J. Curson, T. Hallam, M.Y. Simmons and R.G. Clark, Thin Solid Films, 464–465 23 (2004).

[3] F.J. Rueß, L. Oberbeck, M.Y. Simmons, KEJ Goh, A.R. Hamilton, T. Hallam, S.R. Schofield, N.J. Curson and R. G.Clark, To be published in Nanoletters, Oct 2004.

CMMSP THC34
Thursday 1720–1740 hrs

Quantum Electro-Mechanical System (QEMS)

D. Wahyu Utami[1], H.S. Goan[2] and G.J. Milburn[1]

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Recent development in Nano Electro-Mechanical Systems (NEMS) has yield oscillators with resonant frequencies above Giga Hertz with quality factors above 100,000. At this scale a NEMS oscillator becomes a quantum device capable of operating at the atomic level with extraordinary sensitivity to small forces or molecular masses. With this motivation, we study the phonon-electron interaction in several quantum electromechanical systems (QEMS). First, a system comprising a single quantum dot harmonically bound between two electrodes which facilitates a tunneling current between them[1] and secondly the electron shuttle system firstly introduced by Gorelik[2]. We describe the system via quantum master equation for the density operator of the electronic and vibrational degrees of freedom and thus incorporates the dynamics of both diagonal (population) and off diagonal (coherence) terms. We derive coupled equations of motion for the electron occupation number of the dot and the vibrational degrees of freedom, including damping of the vibration and thermo-mechanical noise. This dynamical description is related to observable features of the system including the stationary current as a function of bias voltage. A number of possible applications are explored for feasibility including molecular QEMS devices as quantum limited nanoscale detectors and as elements in quantum computer architectures.

[1] H. Park, et al., Nature, 407, 57 (2000)

[2] L.Y. Gorelik, et al., Phys. Rev. Lett. 80, 4526–4529, (1998)

CMMSP THC35
Thursday 1740–1800 hrs

Electron Momentum Spectroscopy of Some Simple Condensed Materials

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In this paper we present our experimental measurements of the valence band structures for the lightest three group I and II oxides[1]. Electron momentum spectroscopy[2] has been used to map the energy and momentum resolved electronic structure. The purpose of these measurements is to provide data against which first principles calculations can be tested. In particular, this comprehensive data set allows us to test how well calculations predict trends across these 6 simple ionic solids. The measurements are compared with atomic basis calculations using both Hartree-Fock (HF) and density functional theory (DFT) implemented in the CRYSTAL98 package[3].

[1] V. A. Sashin, H. E. Dorsett, M. Bolorizadeh, and M. J. Ford, J. Chem. Phys. 113, 8175 (2000); Elisabeth A Mikajlo, Helen E Dorsett and Michael J Ford J. Chem. Phys., 120 10799 (2004)

[2] M. A. Coplan, Moore, J. H., and Doering, J. P., Reviews of Modern Physics 66 (3), 985 (1994); J. R. Dennison and A. L. Ritter, J. Electron Spectrosc. Relat. Phenom. 77, 99 (1996); I. E. McCarthy and E. Weigold, Rep. Prog. Phys. 54 (6), 789 (1991).

[3] V. R. Saunders, R. Dovesi, C. Roetti, M. Causà, N. M. Harrison, R. Orlando, and C. M. Zicovich-Wilson, CRYSTAL98 User's Manual. (University of Torino, Torino, 1998).

CMMSP FRC11
Friday 0820–0900 hrs

Scanning Tunnelling Microscopy of Real Time Defect Motion on Surfaces

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The Interface Physics group uses various types of Scanning Probe Microscopy to investigate the structure and dynamic behaviour of surfaces and interfaces. Topics that they are working on at present include surface diffusion, surface phase transitions, gas-surface interactions, nanotribology, and nanobiology. For example, from accurate measurements of the statistics of the observed jump lengths and of the waiting times between successive jumps, it has been deduced that the mobility of indium atoms on a copper surface is caused by the rapid, two-dimensional diffusion of a very low density of monatomic vacancies (missing copper atoms), through the first copper layer. Due to their ultrahigh diffusion rate, these vacancies remain “invisible” for the STM at room temperature. It is important to realize that the slide-puzzle diffusion mechanism is also active when there is no embedded indium in the copper surface. The indium merely serves as a low density of “tracer” particles, which enable us to follow the rearrangements continually taking place in the surface. What we learn from these observations is that not only adatoms, but also the atoms in a close-packed terrace of a metal surface are mobile at relatively low temperatures, e.g. room temperature.

CMMSP FRC13
Friday 0900–0920 hrs

Analysis of Peptides Desorbed from Silicon by a Free Electron Laser

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We have used intense tunable light from a vacuum ultraviolet (VUV) free electron laser (FEL) as well as a F_2 laser to photoionise biomolecules desorbed from flat and porous silicon surfaces. The photoion mass spectrum was measured in a time-of-flight spectrometer. The biomolecules tested were the amino acids valine (Val) and tyrosine (Tyr) as well as di- and tripeptides Val-Val, Val-Tyr and Val-Tyr-Val. The surface structure and laser wavelength were optimised to minimise fragmentation of molecular photoions and hence the sensitivity of this already extremely sensitive[1] surface analysis technique.

[1] I.V. Veryovkin, W.F. Calaway , J.F. Moore, M.J. Pellin, J.W. Lewellen, Y-L Li, S.V. Milton, B.V. King, M. Petravic, Applied Surface Science 231–232 (2004) 962

CMMSP FRC14
Friday 0920–0940 hrs

Photoelectron Diffraction from Cu(111) Surfaces

L. Broekman[1], A. Tadich[1], J.Riley[1], R.Leckey[1], S.Homolya[2], A.Smith[2], T. Seyller[3], K.Emtsev[3], L Ley[3]

1. School Of Physics, Latrobe University , Victoria, Australia; 2. School of Physics and Materials Engineering, Monash University, Victoria Australia; 3. Institut fur Tech Physik II, Universität Erlangen Nürnberg, Germany

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A new generation toroidal angle resolving electron energy analyzer, developed at La Trobe University, has been used to obtain photoelectron diffraction data over a complete hemisphere from Cu and Cu_3Au(111) ordered and disordered surface 3p levels.

The data shows previously reported intensity due to in-plane scattering from low index planes and forward scattering along principle directions[1]. The increased angular resolution of this instrument has provided data which includes dark bands usually ascribed to Kikuchi cancellations[2].

This paper compares this high resolution data with whole hemisphere simulations of the diffraction patterns using the multiple scattering calculations[3] and Kikutchi-band theory.

[1] Osterwalder J, Greber T, Stuck A and Schlapbach L. Phys. Rev. B 44, 13 764 (1991)

[2] A. Winkelmann, B. Schröter, and W. Richter. Phys. Rev. B 69, 245417 (2004)

[3] F. J. Garcí´a de Abajo, M. A. Van Hove, and C. S. Fadley. Phys. Rev. B, 63, 75404 (2001)

CMMSP FRC15
Friday 0940–1000 hrs

Bio-molecule Adsorption Studied Using Micro-beam Photoemission Spectroscopy

A.P.J Stampfl[1], C.-H. Chen[2] , S.-C. Wang[2], M.-L. Huang[2], R. Klauser[2]

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The idea that some functioning bio-surfaces may be built-up using dry (in-vacuum) techniques is interesting because of the compatibility with existing dry-fabrication technologies and that completely novel bio-surfaces not seen in nature may be created. Adsorption chemistry and surface bonding of simple bio-molecules at metal and semiconductor surfaces is probed using synchrotron-based photo-emission techniques. Cysteine, for example, appears to adsorb intact onto Pt{111} in its zwitterionic form. Other examples of in-situ amino-acid and peptide deposition onto metal surfaces are given with a discussion on surface damage due to radiation exposure.

CMMSP FRC21
Friday 1040–1100 hrs

Micromachining of Single Crystal Diamond Using a Novel Lift-off Technique

P. Olivero, S. Rubanov, P. Reichart, S. Huntington, B. Gibson, A. D. Greentree, J. Rabeau, J. Salzman, S. Prawer and D. N. Jamieson

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Diamond has extreme properties, such as high mechanical hardness, chemical inertness, high thermal conductivity, high refractive index, optical transparency, and a series of well-characterized photoluminescent centers. We demonstrate the pioneering fabrication of cantilever, waveguide and optical cavity three-dimensional microstructures in bulk single-crystal diamond, using a novel lift-off technique. The method involves MeV ion implantation to produce a buried sacrificial layer, followed by pattern milling with a focused keV ion beam and chemical etching of the patterned regions. Three-dimensional structures are thus obtained with well-defined micrometric features, which have remarkable potential applications in nano opto-electronics and quantum computing.

CMMSP FRC22
Friday 1100–1120 hrs

Observation of Track Formation and Track Annealing in Swift Heavy Ion irradiated InP

A. S. Khalil, A. M. Stewart, M. C. Ridgway, D. J. Llewellyn, A. P. Byrne and L. T. Chadderton

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The process of track formation in semiconductor materials is not yet well understood. Track registration in 200 MeV Au ion bombarded InP, was investigated using transmission electron microscopy to follow track registration, in-situ TEM, AFM and thermal and electron beam-induced recovery of tracks.

Track cores revealed by HRTEM are found to be around 5 nm in diameter and do not appear to be amorphous. Observations reveal a morphology comprising regular intermittency of bead-like defects along the tracks, suggesting a new fundamental mechanism underlying the formation of these features. Regular intermittency was also observed in other similarly irradiated materials e.g. monazite and apatite.

CMMSP FRC23
Friday 1120–1140 hrs

Modification of Surface and Barrier Properties of Polyethylene Terepthalate and Polycarbonate Plastics by Ion Implantation

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Surface properties of two commercial plastics, SKYPET-BB polyethylene terephthalate (PET) film and Lexan (Polycarbonate) sheet, have been modified by implanting aluminium, silicon, nitrogen and hydrogen ions into samples of the plastics. Aluminium and silicon ions were implanted into the PET and Lexan samples at three different dose levels using a Metal Vapour Vacuum Arc Ion Source implantation system. Hydrogen and nitrogen ions were implanted at two different dose levels in a Plasma Immersion Ion Implantation Facility. Diffusion rates of Helium through the PET samples were determined at 19˚C for pressures of He from 0.5 to 2.5atm. The diffusion rates of helium through the aluminium and silicon implanted samples were much lower than the diffusion rate through the unimplanted PET; nitrogen implantation had little effect.

Lexan samples were characterised by wear testing using a CSEM Tribometer. Hydrogen implanted samples exhibited a dramatic reduction in wear rate.

CMMSP FRC24
Friday 1140–1220 hrs

Nanoelectronics for Quantum Information Processing

C. M. Marcus[1], J. R. Petta[1], A. C. Johnson[1], D. M. Zumbühl[1], J. M. Taylor[1], M. J. Biercuk[1], N. Mason[1], M. D. Lukin[1], A. Yacoby[2], M. P. Hanson[3], A. C. Gossard[3]

1. Department of Physics, Harvard University, Cambridge, MA 02138; 2. Department of Condensed Matter Physics, Weizmann Institute of Science, Rehovot, Israel 76100; 3. Materials Department, University of California, Santa Barbara, CA 93106

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New paradigms for information processing that take advantage of quantum coherence appear capable of providing highly efficient computation and secure communication. However, the requirements for building such systems pose considerable challenges for all of the approaches currently being considered. In this talk, we address the prospects for using electron spin as a holder of quantum information, focusing on two realizations: few electron quantum dots fabricated in GaAs[1,2], and gate-defined quantum dots in carbon nanotubes[3,4]. Recent experimental results, as well as what they suggest about the feasibility of this approach, will be discussed.

[1] J.R.Petta, A. C. Johnson, A. Yacoby, C. M.Marcus, M. P. Hanson, A. C. Gossard, cond-mat/0412048 (2004).

[2] D. M. Zumbuhl, C. M. Marcus, M. P. Hanson, A. C. Gossard, cond-mat/0408276 (2004).

[3] J. Nygard, W.F. Koehl, N. Mason, L. Dicarlo, C. M. Marcus, cond-mat/0410467 (2004).

[4] M. J. Biercuk, N. Mason, C. M. Marcus, Nano Letters **4**, 1 (2004).

Complex Systems, Computational and Mathematical Physics (CSCMP)

CSCMP THD31
Thursday 1620–1700 hrs

Econophysics: From Statistical Physics to Economics

Tiziana Di Matteo

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The relationship between physics and economics has a long and interesting history. Outstanding economists of the past were explicitly inspired by the principles of physics and statistical mechanics, being attracted by the success of these theories. However, the interaction between physicists and economists has never been strong. The situation changed only in the late nineties, when a new interdisciplinary research field emerged: Econophysics. The new field of Econophysics applies the powerful methods of statistical physics and non linear dynamics to macroeconomic modeling and financial market analysis using the physical point of view in dealing with financial problems[1–3]. Financial markets represent a typical example of complex system where the price changes, apparently random, are the result of interactions among a high number of agents (the market operators)[4]. Therefore, financial markets can be studied using the same paradigms and techniques developed in statistical physics for the study of complex systems. There are various research activities and different approaches in the field of Econophysics and this contribution will review some of the work done in this rapidly developing area.

[1] R. N. Mantegna and H. E. Stanley, An introduction to Econophysics (Cambridge University Press, Cambridge, 2000).

[2] J. P. Bouchaud, and M. Potters, Theory of Financial Risks (Cambridge University Press, Cambridge, 2000).

[3] M. M. Dacorogna, R. Gençay, U. A. Müller, R. B. Olsen and O. V. Pictet, An Introduction to High Frequency Finance (Academic Press, San Diego, CA, 2001).

[4] T. Lux and M. Marchesi, Scaling and criticality in a stochastic multi-agent model of a financial market, Nature 397 (1999) 498–500.

CSCMP THD33
Thursday 1700–1720 hrs

Asymmetry of Returns in the Australian Stock Exchange

Susan M. Gunner[1], Louise Brooks[2] and Robin G. Storer[3]

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We use econophysics techniques to investigate the characteristics of the distribution of returns from individual stocks on the Australian Stock Exchange, from optimal portfolios constructed from these stocks and from the All Ordinaries Index. We find in general that the tails of the distributions are asymmetric and that the negative tail favours a power-law behaviour while the positive tail is more Gaussian.

CSCMP THD34
Thursday 1720–1740 hrs

From Hyperbolic Patterns to Euclidean Structures

S.T. Hyde, S.J. Ramsden, and V. Robins

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Networks are widely used models of three-dimensional material structure, e.g., the covalent bonding between atoms in a crystalline mineral. What network structures are possible, and how geometry and topology effect physical properties are questions that are fundamental to the design of new materials. Our technique for generating 3-periodic nets reduces the 3D Euclidean problem to a 2D hyperbolic one. Regular hyperbolic networks can be wrapped onto minimal surfaces to obtain 3-periodic nets, provided their symmetries are compatible. This technique extends to generate sphere packings, rod and helical packings, and interpenetrating networks. By systematically exploring the symmetries commensurate with various minimal surfaces, we generate many known and novel crystalline structures.

CSCMP THD35
Thursday 1740–1800 hrs

Renormalization, Regularization and the Statistical Mechanics of Topographic Wave-Turbulence

J.S. Frederiksen and T.J. O'Kane

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In turbulent flows a continuous range of length scales are simultaneously excited requiring that perturbative expansions be made in terms of the complexity of the interactions. In geophysical flows the coexistence of fluctuations and macroscopic space-time structures arise due to the nonlinear coupling across many scales of motion and through inhomogeneities such as those introduced by topography, wave effects and land-sea contrasts in heating. The rapid spatial and temporal variation in the solutions makes turbulent flows resistant to direct numerical simulation at high Reynolds number and high resolution. In contrast statistical closure theory[1] provides descriptions of the average behavior of an ensemble of turbulent realizations, but requires closing an infinite hierarchy of moment equations. In this presentation we discuss the first tractable statistical mechanical model of inhomogeneous turbulent flow over topography with

Rossby waves. The model is based on renormalized perturbation theory and employs regularization to accurately represent the higher order vertex terms.

[1] T. O'Kane, & J. Frederiksen, J. Fluid Mech., 504, 133 (2004)

POSTERS

CSCMP PTH 41

Spacing Statistics of Model Spectra Related to Farey Sequences

R.L. Dewar[1], B.F. McMillan[1] and B.G. Kenny[1,2]

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Motivated by an attempt to apply quantum chaos theory to the normal mode spectra of a class of waves arising in plasmas and geophysical fluids, in which the frequency at large k depends only on the direction and not the magnitude of the wave vector k, we analyze the probability distribution of nearest neighbours in the spectrum of the model quantum Hamiltonian $H = p_\phi/p_\theta$ and show that it can be understood from the spacing statistics of Farey sequences.

CSCMP PTH 42

A Comparative Study of Truncation Methods in Quasi-2d MHD and Geostrophic Flows

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Recently, Zeitlin (2004) has constructed[1] self-consistent finite mode approximations for 2d magnetohydrodynamics using a Laplacian on the SU(N) group and the idea of sine truncations. This was done for flows with doubly periodic boundary conditions. Also, recently in quasi-geostrophic flows with doubly periodic boundary conditions Frederiksen (1999), has developed[2] a computationally tractable quasi-diagonal DIA (QDIA) closure for flows with general mean and fluctuating components and topography on an f-plane and has generalized the QDIA closure theory to the interaction of Rossby wave turbulence with mean fields and topography on a beta-plane. A comparative study of the two truncation methods will be presented.

[1] V. Zeitlin, On self-consistent finite-mode approximations in (quasi) two-dimensional hydrodynamics and magnetohydrodynamics (not yet published).

[2] J.S. Frederiksen, J. Atmos. Sci, **56**, 1481–1494 (1999).

CSCMP PTH 43

Bushfires as Complex Systems: A Proposed PhD Study

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At its simplest, a bushfire is a series of chemical reactions moving through a fuel bed. However, the behaviour of a free-moving bushfire burning through the landscape is complex and complicated, operating over many temporal and spatial scales, from seconds and millimetres for the combustion physics and chemistry up to hours and kilometres for the convection-atmospheric interactions. A PhD study is proposed that will investigate the behaviour of a bushfire as a complex system, utilising the many tools and techniques that have been developed for analysing complex systems. These tools include cellular automata and statistical mechanics, dynamical systems theory, stability and bifurcation theory, and data assimilation.

CSCMP PTH 44

Some Exact Solutions of Non-Linear Electrodynamics Equations

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In this work we consider spreading of electromagnetic waves in non-linear systems. Some exact solutions in systems of different geometries (in the systems of coaxial cylinders, "cube in cube" and other) and with different dependences of complex dielectric permittivity on electric and the magnetic vectors are obtained. The solutions are expressed by way of the functions determined in terms of the field dependencies of the complex dielectric permittivity. The solutions found arise in the non-linear media only. Methods of mathematical and theoretical physics are used. Some physical peculiarities of the solutions are considered.

CSCMP PTH 46

Inferring the Complex Ginzburg-Landau Equation from Modulus Data

Rotha Yu

In many physical systems the equation of motion of the system is written down in the form of a partial differential equation (PDE). The complex Ginzburg-Landau equation is a very general PDE, special cases of which are used to describe many physical phenomena ranging from Bose-Einstein condensates and superfluids, through to nonlinear optics. Given modulus information on the complex field, we aim to infer the equation of motion of the system. This work has the potential to uncover profound connections between observations and the underlying evolution equations of nature.

CSCMP FRD11
Friday 0820–0840 hrs

Verified Computing in GRworkbench

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GRworkbench enables visual, numerical exploration of the often unintuitive properties of analytically defined space-times. Computing across the coordinate charts covering such space-times presents a challenging numerical problem. We are implementing a number of techniques from the field of verified computing, such as interval arithmetic and automatic differentiation. These advancements permit us to investigate behaviours, such as approaching coordinate and curvature singularities, which are pathological to traditional numerical methods, while guaranteeing that the output encompasses the actual result. We present a range of examples, including the visualisation of all regions of a maximally extended Kerr space-time.

CSCMP FRD12
Friday 0840–0900 hrs

Achieving Scalable Computational Modelling through Frameworks of Interchangable Numerical Methods: StGermain-Snark

S.M. Quenette[1], P.D. Sunter[1], D.A. May[2], L. Moresi[2], B.F. Appelbe[1], L. J. Hodkinson[1], A. Lo[1], R. Hassan[1]

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When developing computational models of phenomena, physicists are concerned with both the general mathematical formulation of the problem, and the detailed physical parameters, and ideally can iteratively refine both over time. However given the difficulty of writing parallel programs for high-performance computer architectures, time constraints often force the use of a pre-existing code and its associated formulation. This initial time saving is often offset by difficulties once the limitations of a given numerical method are reached. In this talk we present StGermain & Snark, parallel solver frameworks with a modular design which allow quickly changing both the mathematical formulation (e.g. incorporating Lagrangian integration points into the Finite Element Method), and the details of the problem being simulated (constitutive relationships, material types etc).

CSCMP FRD13
Friday 0900–0920 hrs

Soliton Resonance and Web Structure in Discrete Integrable Systems

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We present a class of solutions of the two-dimensional Toda lattice equation, its fully discrete analogue and its ultra-discrete limit. These solutions demonstrate the existence of soliton resonance and web structure in discrete integrable systems such as differential-difference equations, difference equations and cellular automata (ultra-discrete equations).

CSCMP FRD14
Friday 0920–0940 hrs

Pathwise Solution of a Class of Quantum Filtering Equations

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This paper considers an alternative formulation of a class of quantum filtering equations that arise in quantum physics for modelling open systems and continuously monitored systems. Specifically, we consider a class of stochastic master equations driven by white noise. The solution is obtained by applying Clark's pathwise reformulation from nonlinear filtering theory. The pathwise versions are defined for all driving paths and depend continuously on them. We also derive robust approximation and illustrate the ideas by applying them to an imperfectly observed two-level atom continuously monitored by homodyne photodetection.

CSCMP FRD15
Friday 0940–1000 hrs

Quantum Teleportation by Measurements on a Large Class of Wavefunctions

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We show that a large class of wavefunctions can be exploited for unit fidelity quantum teleportation with only Bell basis measurements. Using group theory, we show that possible errors close to form a group, and that the ground state of several wavefunctions can be used for unit fidelity teleportation. In particular, there exist systems

which have a finite energy gap to excitations outside this class, reducing the teleportation problem to one of cooling. Finally, we present a way in which we can bound the fidelity of teleportation as a function of a topological order parameter, and some numerical examples.

CSCMP FRD21
Friday 1040–1120 hrs

Experimental Demonstrations of a New Second Law-like Theorem

E.M. Sevick[1], J.C. Reid[1], D.M. Carberry[1], G.M. Wang[1], D.J. Evans[1], D.J. Searles[2]

1. Research School of Chemistry, Australian National University, Canberra ACT; 2. School of Science, Griffith University, Brisbane QLD

The puzzle of how time-reversible microscopic equations of mechanics lead to the time-irreversible macroscopic equations of thermodynamics has existed since the days of Boltzmann. Boltzmann simply side-stepped this paradox, stating “as soon as one looks at bodies of small dimension, the validity of this theorem [the Second Law of Thermodynamics] must cease.” Today we state that the Fluctuation Theorem (FT) is a generalised, Second-Law like theorem that bridges the time-reversible and irreversible descriptions. Here we describe recent experiments where “violations” in the Second Law occur over experimentally realisable time and length scales, consistent with the predictions of the FT.

CSCMP FRD23
Friday 1120–1140 hrs

The Optical Tweezers “Capture” Experiment to Demonstrate the Transient Fluctuation Theorem and the Kawasaki Identity

D.M. Carberry[1], J.C. Reid[1], S.R. Williams[1], G.M. Wang[1], E.M. Sevick[1], D.J. Searles[2], D.J. Evans[1]

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In this presentation I experimentally demonstrate the Kawasaki Identity and the Fluctuation Theorem of Evans and Searles, and show how they are related. The experiment holds a 6.3mm particle in an optical trap of strength k_0 and allows the system to come to equilibrium. After a certain period of time the optical trap strength is suddenly increased to strength k_1. We present results proving the experiments obey both the Fluctuation Theorem and the Kawasaki Identity.

CSCMP FRD24
Friday 1140–1200 hrs

Demonstration of the Steady-State Fluctuation Theorem Using a Colloidal Particle in a Translating Optical Trap

G.M. Wang, J.C. Reid, D.M. Carberry, E.M. Sevick, and Denis J. Evans

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The Steady-State Fluctuation Theorem or SSFT is the application of the Fluctuation Theorem (FT) to a system under a non-equilibrium steady state. According to the literature, the SSFT holds only in the asymptotic limit of long time. In this presentation, we demonstrate experimentally the SSFT using a colloidal particle localised in a translating optical trap. We show that the asymptotic time limit of the SSFT is a result of an approximation in the argument of the theorem. When the argument is expressed exactly, as is possible for our simple colloidal experiment, the FT holds over all times, including short timescales.

CSCMP FRD25
Friday 1200–1220 hrs

Statistical Mechanics Applied to an Undercooled Metastable Liquid

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It is possible to cool a liquid below its freezing temperature, without it crystallising and for it to then enter a long-lived, undercooled, metastable state. Such liquids have been the subject of much study, however the current understanding is largely based on a phenomenological thermodynamic approach. Here we combine modern non-equilibrium statistical mechanics with molecular dynamics simulations of a realistic model at temperatures corresponding to moderate undercooling. We show that an undercooled liquid is fundamentally different to an equilibrium one and elucidate the failure of linear response theory for undercooled liquids.

Environmental Physics (EP)

POSTERS

EP PTH 47

Sensing and Modelling Electric Fields Associated with High Frequency Excitation of Plant Roots

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The growth and water use of forest, crops, plantations and pastures are greatly influenced by the spatial distribution of plant roots within the soil. High frequency (low MHz range) excitation methods show potential in the eventual spatial mapping of plant roots in-situ[1]. The current focus is on determining the electrical properties of roots through impedance spectroscopy. In particular, it is important to completely characterise electrical root-soil coupling in order to determine the best method of modelling the induced electric field. The electric field modelling is also supported through experiments performed with prototype electric field probes.

[1] Ellis T et al. Electrical root mapping, CSIRO/RIRDC Technical report (in press) (2003)

EP PTH 48

Applications of Solid-State 15N NMR Spectroscopy to the Study of Nitrogen Cycling in Hoop Pine Plantations

L.L. George[1], G.S.K. Kannangara[1], Z.H. Xu [2], M.A. Wilson[1], N. Reddy[1], G.R Dennis[1], A.L. McCutcheon[1]

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Solid-state ^{15}N nuclear magnetic resonance spectroscopy (NMR) has been used here to characterise hoop pine samples from forest ecosystems in southeast Queensland, using cross-polarisation magic angle spinning (CPMAS). The effects of cross polarisation were first studied using commercially available ^{15}N enriched and unenriched model compounds, allowing ^{15}N NMR conditions to be optimised. The optimised parameters were then applied to the hoop pine samples. It has been found that different parameters are needed to find different species of nitrogen. Therefore when looking at a hoop pine sample, we cannot expect to see all forms of nitrogen with a single set of parameters. This study has also made use of x-ray photoelectric spectroscopy (XPS), to investigate all forms of nitrogen (both ^{14}N and ^{15}N) containing species. The hoop pine sample results from ^{15}N NMR and XPS both show most of the organic nitrogen to be in the form of amide structures, and are therefore in agreement.

EP PTH 49

Theoretical Analysis of Multiple Thermal Fragmentation of Aerosol Nanoparticles from a Line Source: Evolution of Particle Modes

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The process of multiple fragmentation of nano-particles by means of breaking away smaller particles is considered by means of the exact solution of a set of coupled rate equations. The corresponding particle size distributions are investigated. The mechanism of fragmentation based on weakening bonds between nanoparticles due to evaporative loss of bonding molecules is described. A probabilistic statistical approach is used to justify time delays in the fragmentation processes. Evolution and mutual transformation of particle modes is considered. Comparison with the experimental monitoring of combustion nano-particle aerosols is carried out.

EP PTH 50

Numerical and Experimental Investigation of Thermal Fragmentation of Aerosol Nanoparticles from Vehicle Exhaust

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Recently suggested possibility of intensive thermal fragmentation of nanoparticles from vehicle exhaust may be of a significant importance for the understanding of behaviour of combustion aerosols in the atmosphere. Here, a new evidence is presented for such process to exist. The analysis is based on direct measurements of concentrations of particles with particular diameters at different distances from a source (e.g., a busy road), and their comparison with the result of numerical predictions obtained from the analysis of turbulent diffusion in the atmosphere. Striking differences are shown to be consistent with the existence of particle fragmentation and its physical mechanism.

EP PTH 51

VSF Measurements of Gippsland Lakes' Waters in Two Planes of Polarisation

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Water quality in lakes and rivers is a growing issue in Australia. Regular monitoring of water conditions (for example monitoring recurring blooms of the blue-green algae cyanobacterium *Nodularia*) are an essential component in maintaining and improving water quality. Such broad scale monitoring can potentially be achieved using remote sensing, but these techniques are still in development. One of the important inputs into the models are the volume scattering functions (VSFs) of the water constituents. In this paper we report on the first measurements of VSFs for Australian waters, using the Gippsland lakes system as a case study.

EP FRF11
Friday 0820–0840 hrs

Radar Interrogation of High-flying Insects: What Bug Is That?

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Special-purpose Insect Monitoring Radars (IMRs) have been developed to detect insects undertaking migratory flights at altitudes of more than 1km. The IMR's design incorporates rapid beam variations that "interrogate" targets, allowing retrieval of both trajectory and target-character parameters from the recorded signal. The resulting estimates of the sizes, shapes, and wing-beating patterns provide information about the targets' identities that is potentially valuable to users of IMR information products (e.g. locust controllers). The radar's configuration provides consistent measures of these characters, which potentially allow target types to be resolved along a number of possibly independent identification dimensions.

EP FRF12
Friday 0840–0900 hrs

Ultrasonic Destruction of Contaminants in Soil

A.F.Collings[1,2], A.P. Sosa Pintos[1,2], A.D.Farmer[1], P.B.Gwan[1] and C.J.Leo[2]

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The propagation of high power sound waves through a liquid can initiate the phenomenon of cavitation, the formation, growth and subsequent collapse of gas bubbles arising from the dissolution of air or vaporisation of the liquid during the rarefaction phase of the wave. Bubble collapse produces highly localised temperatures and pressures of some 5000 K and 1000 atmospheres respectively. Solid particles in a slurry act as foci for the nucleation of bubbles, the collapse of which generates a high velocity jet directed towards the solid surface. The extreme conditions generated by the non-linear shock wave resulting from bubble collapse are then localised on the surface of the solid.

Most POPs (persistent organic pollutants) are hydrophobic and are readily adsorbed on the surface of solid particles, so that the cavitation energy generated by high power ultrasound in a slurry of such material is selectively directed towards the contaminants. Because the extreme conditions are localised on the surface of the particles, the bulk solution temperature remains quite low and the decomposition products are immediately quenched, avoiding recombination reactions.

We have exploited this process to achieve very high destruction rates for several of the most notorious contaminants at energy costs far below those of competing technologies. The technique, which is at pilot plant stage, shows great promise with the advantages of in-situ treatment and reduced operating and capital costs compared with conventional technologies.

EP FRF13
Friday 0900–0920 hrs

See RE13

Chrystalline Silicon Thin-film Solar Cells on Glass—Cheap Electricity from the Sun?

Aberle

EP FRF14
Friday 0920–0940 hrs

See RE14

Modifying the Solar Spectrum: Bridging the Gap between First and Third Generation Photovoltaics

Richards

EP FRF15
Friday 0940–1000 hrs

See RE15

Photoelectrochemical Hydrogen Production

Plumb

GeoPhysics (GP)

GP WEF11
Wednesday 1040–1100 hrs

A Most Remarkable Surface

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The Earth's surface is a most remarkable interface forged by interactions between two dynamical systems (the solid Earth beneath and the fluid Earth above) with very distinct timescales. Understanding how the interactions between these systems are imprinted on our landscapes is one of the main challenges of contemporary earth science. Dramatic improvements in our characterisation of landscape, both spatially and temporally, are helping us meet this challenge. This talk will set out some new insights into the evolution of landscape from a modern dynamic perspective using illustrative examples from the Australian continent.

GP WEF12
Wednesday 1100–1120 hrs

Imaging the Earth—the Nature of Seismic Heterogeneity

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Both geophysical and geochemical results point to pervasive 3-D heterogeneity in the Earth's mantle. Geophysical evidence presents a snapshot of current structure, whereas geochemical data contain important information on age. A major source of information on heterogeneity within the Earth comes from seismic tomography, particularly when both P and S wave data can be exploited. A powerful tool for examining the character of heterogeneity comes from the comparison of images of bulk-sound and shear wavespeed extracted in a single inversion, since this isolates the dependencies on the elastic moduli. Such studies are particularly effective when a common path coverage is achieved for P and S as, e.g., when common source and receiver pairs are extracted for arrival times of the phases. The relative behaviour of bulk-sound and shear wavespeed can provide a useful guide to the definition of heterogeneity regimes. For subduction zones a large part of the tomographic signal comes from S wavespeed variations, but in the upper mantle and transition zone there can be significant bulk-sound speed contributions for younger slabs (< 85 Ma), and in stagnant slabs associated with slab roll-back. The narrow segments of fast wavespeeds in the depth range 900–1500 km in the lower mantle are dominated by S variations, with very little bulk-sound contribution, so P images are controlled by shear. Deep in the mantle there are many fast features without obvious association with subduction in the last 100 Ma, which suggests long-lived preservation of components of the geodynamic cycle. Changes in the patterns of heterogeneity occur near 1200 km and 2000 km depth in the lower mantle and indicate the complexity of processes occurring in the current Earth.

GP WEF13
Wednesday 1120–1140 hrs

Imaging Subducting Slabs along the Western Pacific Margin

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Structure of the subducted oceanic lithosphere along the Western Pacific margin has been imaged with unprecedented detail in three dimensions using seismic tomography and earthquake data. The combination of data illustrates the change of slab morphology from dipping at approximately 45° beneath Japan, to lying horizontally under southern Izu-Bonin, to penetrating vertically beneath the Marianas. Using new technology to visualize regional P-wave, bulk sound, and shear wave-speed tomographic inversions even more detail can be depicted, including the presence of tears in the subducting slab beneath the Izu-Bonin and Southern Mariana arcs.

GP WEF14
Wednesday 1140–1200 hrs

Seismological Applications of Laboratory Measurements of Dispersion and Attenuation in Upper-mantle Materials

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Seismic-frequency techniques for the laboratory measurement of dispersion and attenuation will be reviewed. The shear modulus and dissipation, measured at torsional oscillation periods of 1–1000 s and temperatures of 1000–1300°C for four genuinely melt-free olivine polycrystals of mean grain size 3 to 165 micron, have been fitted to a creep-function model. For the conditions of teleseismic wave propagation in the Earth's upper mantle, this model yields calculated shear wave speeds and attenuation for melt-free olivine that reproduce many of the first order features of the seismic structure modelled for the upper mantle beneath both oceanic and continental regions.

GP WEF15
Wednesday 1200–1220 hrs

Finite Element Modeling of Crustal Dynamics with the Imaging Information of the Earth

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The understanding, simulation and prediction of the complex system behaviour of interacting fault systems are very important in both theory and practical applications. This paper presents the recent development of our research activity in finite element modelling of crustal dynamics[1], especially the related efforts on how to integrate with and use the imaging information of the Earth.

[1] H. L. Xing, P. Mora, & A. Makinouchi. Pure Appl. Geophys., 161, no. 9/10, 2091(2004)

POSTERS

GP PWE 120

Minimalising Stress with ABAQUS™ and Nimrod/o

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We use the commercial software ABAQUS™ in conjunction with the program Nimrod/o to optimally inverse model the Australian stress field using data from the Australian Stress Map. Using reconstructed plate boundary configurations and age-area distributions of ocean crust around Australia through time we obtain estimates for ridge push, slab pull and collisional forces acting on the Indo-Australian Plate since the Eocene. Using these constraints we model the orientation of the maximum horizontal compressive stress (SHmax) field for the present, early Miocene and early Eocene with an elastic 2D plane stress finite element model with realistic parameters representing different rock types and geologic provinces for the Australian continent. We show that spatially significant rotations of SHmax directions can be modelled as a consequence of perturbations of SHmax in a heterogeneous plate in areas of juxtaposed rigid and compliant rheologies.

GP PWE 121

Integration Methods for Lagrangian Particle Finite Element Methods

Louis Moresi

In solid earth geodynamics, we often need compute very large deformation of geological structures and track the tensorial material history throughout. A number of unstructured and semi-structured finite element methods have been developed to cope with this requirement. In Lagrangian integration point FEM, material points are used to compute element integrals. The difficulty is in identifying suitable integration schemes for arbitrary distributions of material points in an element. We compare a number of integration methods based upon constructing approximate Voronoi diagrams for robustness and accuracy. The methods are fast enough to be used in 2D and 3D in each of thousands of elements at every timestep.

GP PWE 122

Geophysical Studies in Oil Sands

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The production of conventional light oils will be increasingly difficult to maintain in future years and other previously less economic reserves must be employed. In Canada, much of the reserves are in the form of highly viscous heavy oils that require costly recovery. In this scenario geophysical methods can provide a means to monitor the progress of the reservoir production. Understanding observations, however, requires knowledge of the reservoir materials, typically weakly consolidated sands, under varying conditions. Current studies include carefully controlled field experiments, laboratory rock physics experiments on the rocks and the associated fluids, and linkages to reservoir simulations.

GP PWE 123

Global Scale Mantle Processes of Mars-sized Planets

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Preserved in the Martian crust are several yet-to-be-explained features dating back to the processes operating in a planet during the first billion years: the crustal dichotomy (a global variation of crustal thickness going from thick crust in the south and thin crust in the north), the ancient Martian dynamo (as revealed by remnant magnetism of crustal rocks occuring in both hemispheres), the Tharsis volcanic province (the largest volcanic feature in the solar system superimposed across the crustal dichotomy). Using a 3-D spherical model of mantle convection, we investigate the processes occuring early in a differentiated planet's history. The effect of a

heterogeneous distribution of radiogenically enriched crust overlying a convecting mantle with temperature-dependent viscosity is quantified with spherical harmonic analysis of temperature and velocities fields over time. The planet's time-dependent moment of intertia is also calculated to gain insight on possible length of day variations and changes in orientation with respect to the spin axis (true polar wander) which has implications for the early climate and interpretation of observed paleo-magnetic poles.

GP PWE 124

Sedimentary Basins on Accretionary Crust: Properties and Modelling

C. Heine and R. D. Müller

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Intraplate sedimentary basins show different structural styles and subsidence patterns not conforming to the current understanding of rift basin evolution, likely caused by an interplay between the different rheology, mantle dynamics and far field plate boundary forces. The underlying basement is often referred to as "accretionary crust" and poorly defined in terms of its geophysical parameters and tectonic / structural history. The study investigates the properties of accretionary crust on a global scale, trying to explain the different subsidence behaviour. Parameters obtained from this work will be used for modelling extensional processes utilising the FEM code Ellipsis 2D/3D in an interactive computational environment to further evaluate the role of crustal heterogeneities, and mantle dynamics and as extension driving force.

GP THD11

Thursday 1040–1100 hrs

The Dynamics of Sheared Mantle Plume Tails

R.C. Kerr and C. Meriaux

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We summarize the key results of an extensive series of laboratory experiments[1] that systematically investigate the behaviour of sheared mantle plume tails, as a function of the 5 governing dimensionless numbers. We find 3 distinct convective flow regimes, and determine the transition boundaries between them. We also examine the deflection of a sheared mantle plume tail, and the lateral and upstream spreading of mantle plumes under a moving plate. Our predictions are consistent with geophysical observations of mantle plumes, and geochemical observations from ocean island chains.

[1] R.C. Kerr & C. Meriaux, Geochem. Geophys. Geosys. (in press)

GP THD12

Thursday 1100–1120 hrs

The Effect of Mantle Convection on Surface Topography over the Last 120 Million Years: An Evaluation of Model Predictions Based on the Geological Record

R. Dietmar Müller[1] and B. Steinberger[2]

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We combine a global plate kinematic and mantle convection model with information from the geological record to assess the effect of mantle convection on surface topography over the last 120 million years. The mantle flow field through time is modelled using a spherical harmonic expansion of surface plate velocities and internal mantle density heterogeneities, resulting in a prediction of dynamic topography through time. We use the subsidence history from selected sedimentary basins and evidence for continental uplift through time to show that a combined observational and modelling approach can be used successfully to "ground-truth" models and to differentiate between different mechanisms of basin subsidence.

GP THD13
Thursday 1120–1140 hrs

The Influence of Rheological Structure in the Deformation of the Lithosphere

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We examine the relationship between rheological layering and the response of the deformation of the lithosphere to tectonic deformation in extension (2D/3D) and shear (3D). We are interested in identifying the relationship between localized deformation in the uppermost brittle regions of the lithosphere and diffuse deformation the ductile lower lithosphere. We are particularly interested in identifying the timing and configuration of localized deformation as a function of the extent of total system deformation and lithosphere rheology.

GP THD14
Thursday 1140–1200 hrs

Paradoxical Behavior in a Partially Insulated Thermally Convecting System with Application to the Thermal History of the Earth

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It is generally assumed that continents, acting as thermal insulation above the convecting mantle, inhibit the Earth's internal heat loss. We present a combination of theory, numerical simulations, and laboratory experiments to test the validity of this intuative and commonly used assumption. A scaling theory is developed to predict heat flow from a convecting mantle partially covered by stable continental lithosphere. The theory predicts that parameter regimes exist for which increased continental insulation has no effect on mantle heat flow and can even enhance it. Partial insulation leads to increased internal mantle temperature and decreased mantle viscosity. This, in turn, allows for the more rapid overturn of oceanic lithosphere and increased oceanic heat flux. Depending on the ratio of continental to oceanic surface area, global mantle heat flow can remain constant or even increase as a result. Theoretical scaling analyses are consistent with results from numerical simulations and laboratory experiments. The combination of theory, simulations, and experiments suggests that the effect of continental insulation on mantle cooling is not as great as has often been assumed. The theory also suggests a potential constraint on continental surface area. Increased surface area enhances the subduction rate of oceanic lithosphere. If continents are produced in subduction settings this could enhance continental growth up to a critical point where continental insulation causes convective stress levels to drop to values approaching the lithospheric yield stress. This makes weak plate margins difficult to maintain, which lowers the subduction rate of oceanic lithosphere and limits further growth. The theory is used to predict the critical point as a function of total mantle heat flow. For the Earths rate of mantle heat loss, the predicted continental surface area is, within parameter uncertainty, in accord with the observed value.

GP THD15
Thursday 1200–1220 hrs

Tectonic Drivers

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With some confidence we can identify two thermal boundary layers as drivers of tectonics on terrestrial-type planets. The mechanical behaviour of the top thermal boundary layer of the mantle determines the tectonic mode, which on Earth is plate tectonics. The tectonic modes on Venus and early in Earth history are less clear. The second driver will be a lower thermal boundary layer of the planetary mantle. The form of the resulting flow is more predictable: it is likely to occur as plumes that begin with a large spherical head and continue as a thin cylindrical tail.

GP THD21
Thursday 1400–1420 hrs

The Physics of Imaging Faults in Precious Mineral Reefs

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We have established, experimentally, that the rocks hosting a number of the world's precious mineral reefs are translucent in the VHF-UHF band, that borehole radars can be used to create tactically relevant synthetic aperture images of defects in these reefs. BHR image reconstruction procedures are based on those used in 3D seismology and S.A.R. In this paper we will present images of objects buried in the rocks of the South African Craton and the Canadian shield, and review the use of interactive modelling in coping with sparse spatial sampling

GP THD22
Thursday 1420–1440 hrs

Seismic Imaging of Complex Geological Structures

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Seismic (elastic) waves from small explosions and impact sources can be used to map subsurface geological structure down to depths of several kilometres. The targets in petroleum exploration and development are often quite complex, and have necessitated the use of elaborate 3-D reflection shooting and recording geometries, as well as borehole-based tomographic techniques. In this paper we will examine what is possible using full waveform inversion

of seismic data. The current trend is to exploit vector wavefield processing, so as to incorporate polarisation and other information into the imaging of anisotropic rock units.

GP THD23
Thursday 1440–1500 hrs

Seismic Wave Attenuation and Dispersion in Heterogeneous Porous Rocks

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Many hydrocarbon reservoirs are strongly heterogeneous both vertically and horizontally. Seismic waves propagating in a macroscopic heterogeneous porous rock are attenuated due to the scattering (conversion) of the passing wave's energy into the highly attenuative Biot's slow wave. This is analysed by studying two particular geometrical configurations: (1) a thinly-layered porous medium and (2) porous saturated medium with ellipsoidal inclusions. The frequency dependence of the so-called mode-conversion attenuation has the form of a relaxation peak, with the maximum of the dimensionless attenuation (inverse quality factor) at a frequency at which the wavelength of the Biot's slow wave is approximately equal to the characteristic length of the medium (layer thickness or size of the inclusion). The width and the precise shape of this relaxation peak depend on the particular geometrical configuration. Physically, the mode-conversion attenuation is associated with wave-induced flow of the pore fluid across the interfaces between regions with different properties. The results of this study demonstrate how the local flow (or squirt) attenuation can be effectively modeled within the context of Biot's theory of poroelasticity. Examples of such common reservoir features as fractures (microcracks) and patchy saturation demonstrate the potential significance of this effect.

GP THD24
Thursday 1500–1520 hrs

Thermal Convection with a Water Ice I Rheology: Implications for Icy Satellite Evolution

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Deformation of materials under planetary conditions is a complicated process with transitions in the deformation style occurring as functions of many parameters. The deformation is most realistically described as a sum of contributions from the many available deformation processes. We model stagnant-lid thermal convection for water ice I using three types of multi-component rheological laws combining grain boundary sliding, dislocation and diffusion creep mechanisms. These results suggest deformation in the actively convecting sublayer is likely to be dominated by the mechanism with the largest stress exponent.

GP THD25
Thursday 1520–1540 hrs

Regional Strain Pattern in the Australian Plate Revealed by GPS

S. Zhao, M. Jia, R. Govind, J. Dawson and G. Luton

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We report the strain pattern in the Australian Plate estimated from the GPS observations recorded by the Australian permanent GPS Network. The maximum (compression) principal strain rate averaged in the plate is 0.472 ± 0.057 _ 10–8 /yr with an orientation of 47.9 ± 18.0° (NE), indicating that compression is dominant at the plate-scale of >3000km. The estimated strain field has a complex pattern with extension in Central and Southeast Australia and compression in East and West Australia. The results together with seismic anisotropy suggest that there could be some local/regional deformation mechanisms, which are responsible for the strain anomalies.

Nuclear and Particle Physics (NUPP)

NUPP MOD11
Monday 1040–1120 hrs

Hints of New Physics from Measurements of CP Violation

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The Belle experiment is designed to study CP violation in the B meson system. Due to the record-breaking performance of the KEK-B accelerator, a large data sample of BBar events has been accrued. The latest results on CP-violation are reviewed, including measurements related to each of the three angles of the Unitarity Triangle, and measurements of direct CP asymmetries.

NUPP MOD13
Monday 1120–1140 hrs

Measurement of BR(B $\Rightarrow \rho l \upsilon$) and V_{ub} via Neutrino Reconstruction at Belle

N. Parslow[1], S. Cole[1] and K.E. Varvell[1]

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Semileptonic B decays to light hadrons such as the rho meson occur via b → u quark transitions, allowing measurement of the CKM mixing parameter V_{ub}. The Belle experiment offers two key advantages in making this measurement. Firstly, the clean environment of an $e^+ e^-$ collider means the unseen neutrino can be `reconstructed' by using the missing momentum of the event. Secondly, a large data sample gives us the statistics to minimize the large theoretical uncertainties. We present here preliminary results based on 140 fb^{-1} of data.

NUPP MOD14
Monday 1140–1200 hrs

Unquenched Quark Propagator in Landau Gauge

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We present unquenched calculations of the quark propagator in Landau gauge with 2+1 flavors of dynamical quarks. We use configurations generated with an improved staggered ("Asqtad") action by the MILC collaboration. This quark action has been seen to have excellent rotational symmetry and scaling properties. Quenched and dynamical calculations are performed on a 203x64 lattice with a nominal lattice spacing a = 0.125 fm. The matched quenched and dynamical lattices allow us to investigate the relatively subtle sea quark effects , and even in the quenched case the physical volume of these lattices gives access to lower momentum than our previous study.

NUPP MOD15
Monday 1200–1220 hrs

Pentaquark Interpolating Fields in Lattice QCD

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Claims about the discovery of the theta-plus pentaquark with strangeness = +1 has inspired tremendous interest in the field of high energy physics. As the only ``first principles'' approach for studying nonperturbative QCD, lattice QCD provides a unique insight into the properties of a five quark state. Using the computational power of the APAC national facility's alpha cluster our study is at the leading edge of hadronic physics in lattice QCD. We discuss various pentaquark interpolating fields suitable for lattice QCD simulations. Using a number of interpolating fields we attempt to isolate a signal for a five-quark resonance. Calculations are performed using FLIC fermions in the quenched approximation. We observe that the pentaquark interpolating fields we studied did not give us access to a five quark bound state but rather a Nucleon plus Kaon state.

NUPP MOD21
Monday 1400–1440 hrs

Shell Model Interaction around ^{208}Pb Derived from Experimental Data

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The shell model with a realistic interaction derived from the scattering of free nucleons describes nuclear properties around ^{208}Pb well. Recent studies of γ-decays in nuclei close to ^{208}Pb have added previously missing, crucial information, so that the interaction can now also be derived from measured data, allowing detailed checking of the theory. Measurements and the derivation of detailed wave functions for many states and empirical diagonal and nondiagonal matrix elements of the interaction are presented.

NUPP MOD23
Monday 1440–1500 hrs

Search for "Doorway States" Relevant to the Production and Survival of ^{180}Ta in Stars

G.J. Lane[1], G.D. Dracoulis[1], A.P. Byrne[1,2], P.M. Davidson[1], T. Kibédi[1], K.H. Maier[1], M.A. Lane[1] and A.N. Wilson[1,2]

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The process by which ^{180}Ta is produced in stars is not clear. The problem is especially interesting because ^{180}Ta occurs in nature as an isomeric state with $T_{1/2}$>1.2x10^{15}yr, even though its ground state has a much shorter lifetime ($T_{1/2}$=8.1hr) and photo-induced depopulation of the quasi-stable isomer is possible under conditions that could be expected in a star[1]. Some of the observed[1] resonances that enable depopulation of the isomer have been associated[2] with known states in a $K^{\pi}=5^{-}$ rotational band[3] and specific predictions of the γ-ray decay branches towards the ground state and the isomeric state have been made[2]. We have used the ^{180}Hf(d,2n) reaction to populate the $K^{\pi}=5^{-}$ band with higher intensity than previous measurements. The results of our search for the predicted γ-ray decays will be presented.

[1] D. Belic *et al*, Phys. Rev. Lett. **83**, 5242 (1999)

[2] P. Walker *et al*, Phys. Rev. C **64**, 061302(R) (2001)

[3] G.D. Dracoulis *et al*, Phys. Rev. C **62**, 037301 (2000)

NUPP MOD24
Monday 1500–1520 hrs

The AMS Technique for ^{53}Mn

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Due to its long half-life (3.7My), manganese 53 could be useful for exposure-dating and erosion studies. However, this isotope has not been well explored because of the difficulty of separating it from its ubiquitous stable contaminant chromium 53. The goal of the present work is to develop the AMS technique for manganese 53 measurements, using a Gas-Filled Magnet and associated detector attached to the AMS system at the ANU. The production of calibrated ^{53}Mn/Mn standards and the chemical separation technique to lower its chromium content is also discussed. An AMS measurement of these samples is presented.

NUPP MOD25
Monday 1520–1540 hrs

Characterizing Uranium Ores with ^{236}U and ^{239}Pu

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Both ^{236}U and ^{239}Pu are produced naturally in uranium ores via neutron capture on ^{235}U and ^{238}U, respectively. Neutrons in the Earth's crust are produced almost entirely from (α,n)-reactions and spontaneous fission of ^{238}U. Neutron fluxes however, depend not only on the number of neutrons produced but also on the elemental composition of the rock. Therefore, concentrations of ^{236}U and ^{239}Pu might be used to characterize different uranium ores.

Only limited data is presently available and thus we are in the process of performing accelerator mass spectroscopic measurements and calculations for a wide variety of different ores.

NUPP MOD31
Monday 1620–1700 hrs

ATLAS Status and Physics Program

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The ATLAS detector will observe proton collisions in the Large Hadron Collider (LHC) at CERN, which is scheduled for commissioning in 2007. When operational the LHC will collide protons at a centre-of-mass energy of 14 TeV with nominally 2 X 10^{8} collisions per second at each of four beam-crossing points. ATLAS has been optimised for the detection of the hypothesised Higgs Boson, the only missing component of the otherwise experimentally well-verified electro-weak theory. In addition ATLAS is also sensitive to many other physics processes including QCD, b-physics, heavy ion interactions and those that could provide first evidence for super-symmetry. The current status of the LHC and the various aspects of the ATLAS detector will be discussed as well as the ability of ATLAS to observe new physics. The Australian contributions to the ATLAS project will also be described. These include:

- Development and implementation of components of the Semi-Conductor Tracker (SCT), which provides spatial information for charged particles traversing the ATLAS inner detector.
- Fast algorithms for simulating electromagnetic events in the calorimeter.
- Development and application of fast reconstruction algorithms within the ATLAS software framework.
- Analysis of Monte-Carlo data produced using simulated models of the ATLAS detector. The information provided will determine the most efficient strategies in searching for new physics once collisions at the LHC commence.

- Advances in grid computing to handle the storage, transfer and offline processing of data amassed by LHC experiments, which totals over 2.4 P-bytes per annum.

NUPP MOD33
Monday 1700–1720 hrs

Lattice Study of Possible Proton Anti-proton Bound State and H-dibaryon

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Based on the general symmetry consideration and available experimental information we study the mass spectrum of possible proton anti-proton bound state observed by BES collaboration. Using interpolating diquark operators we measure the correlation functions with improved gauge and fermion actions and extract the mass spectrum of the spin-zero isoscalar candidate for proton anti-proton hexaquark state in the quenched approximation of lattice QCD. As a by-product we calculate the mass of the lowest spin-zero, strangeness (–2), flavour singlet state in the dibaryon sector. We find that the mass of the H-dibaryon is compatible with twice the mass of the lambda baryon on all lattice sizes investigated in this study. No evidence for a bound H-dibaryon is apparent from current calculation in the quenched QCD. We conclude that such six quark state may be considered as unbound assembly of two lambda baryons.

NUPP MOD34
Monday 1720–1740 hrs

Fusion Mechanism of Light Weakly Bound Nuclei

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Fusion at energies around the fusion barrier is strongly influenced by the structure of the participating nuclei. A controversial question in recent years is the effect on fusion of cluster structure and weak binding in light nuclei. Fusion of weakly bound stable nuclei like ^{6}Li, which has an α–d cluster, is reduced[1] due to breakup. The unstable nucleus ^{6}He has neutrons weakly bound to an α–core. Do these neutrons in ^{6}He play a similar role in fusion[2,3] as the weakly bound d in ^{6}Li? I will discuss this question and the interpretation[4] that is currently emerging.

[1] M. Dasgupta et al., Phys. Rev. C 70, 024606 (2004)

[2] A. Navin et al., Accepted in Phys. Rev. C (2004)

[3] R. Raabe et al., Accepted in Nature (2004)

[4] D.J. Hinde and M. Dasgupta, Accepted in Nature (2004)

NUPP MOD35
Monday 1740–1800 hrs

Scanner for the Detection of Contraband in Air Cargo Containers

Brian Sowerby and James Tickner

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There is a growing worldwide need to rapidly scan bulk air cargo for contraband such as illicit drugs and explosives. CSIRO has been working with Australian Customs Service to develop an innovative and cost-effective solution capable of directly scanning air freight containers in 1–2 minutes without unpacking. A new scanner has been developed that combines fast neutron and gamma-ray radiography to provide high-resolution images that include information on material composition. A full-scale prototype scanner has been successfully tested in the laboratory and a commercial-scale scanner will be installed at Brisbane airport in 2005.

POSTERS

NUPP PMO 84

Multiparticle and Octupole Couping Effects in Translead Po and Rn Nuclei

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Yrast high spin states in nuclei near the doubly magic ^{208}Pb core often have a relatively structure in terms of the coupling of the valence orbitals. This is in part due the availability of high-j orbitals for both the protons and neutrons, but it is also due to coupling of particle excitations to the collective octupole vibrational excitation, thus selectively lowering the energy of specific configurations. The results of a study of the high spin structure of the isotope ^{210}Rn will be presented. The understanding of the structure of the highest states in this system are complicated by the presence of neutron hole excitations. Very recent results aimed at populating high spin, octupole mixed states in ^{212}Po obtained using the SPIRAL facility will also be covered.

NUPP PMO 85

Decay out of Superdeformed Bands in Pb Isotopes

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A recently developed two-level mixing model[1] of the transition from superdeformed to normal-deformed nuclear shape is applied to evaluate the tunnelling width of the decay-out process in ^{192}Pb, ^{194}Pb[2] and ^{196}Pb. We estimate the level densities and gamma-decay widths for the normally-deformed states at the excitation energy of the decay, and use observed properties of the superdeformed states as input for the model. The relationship between the extracted widths and the potential barrier between the shapes is discussed.

[1] D.M. Cardamone, C.A. Stafford and B.R. Barrett, Phys. Rev. C **91**, 102502 (2003)

[2] A.N. Wilson and P.M. Davidson, Phys. Rev. C **69**, 041303(R) (2004)

NUPP PMO 86

Why Three Generations?

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Finite repetitions of particle multiplets are difficult to explain from first principles. I show that a possible solution to this so-called “generation problem” can be found by attaching anticommuting (Lorentz scalar) “property coordinates” ε to the usual commuting space-time “location coordinates” x. A very general relativistic formulation of space-time-property then accommodates the gauge fields in the x-ε sector and the Higgs fields in the ε-ε sector. Fermionic matter supermultiplets $\Psi(\varepsilon)$ then encompass the known three generations as well as exotic quarks. The latter offer an alternative interpretation for recently discovered narrow hadronic states currently believed to be tetra- and penta-quarks.

NUPP PMO 87

Accelerator Mass Spectrometry (AMS) of 26Al—Enhanced Sensitivity with a Gas-filled Magnet

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AMS of ^{26}Al has employed the atomic negative ion exclusively to date, because it eliminates the isobaric interference from ^{26}Mg. Magnesium does not form a stable negative ion. The low output of Al^- ions from negative ion sources has, however, inhibited wide application of ^{26}Al in studies of landscape evolution. We report the use of a gas-filled magnet which separates ^{26}Al from the intense flux of ^{26}Mg ions after acceleration, and thereby enhances the sensitivity of ^{26}Al AMS by an order of magnitude by allowing use of the factor of 20 more intense AlO^- beam.

NUPP PMO 88

Quokka: The Small-Angle Neutron Scattering Instrument at the Australian Replacement Research Reactor

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A small-angle neutron scattering (SANS) instrument is being designed as part of the initial instrument suite for the 20-MW Australian Replacement Research Reactor. The new instrument, receiving neutrons from a large liquid-D_2 cold source, will be in the spirit of the world’s best facilities and will greatly build upon the Australian Nuclear Science and Technology Organisation’s existing expertise and facilities. Scheduled for completion in July 2006, it will provide Australian and international researchers with opportunities to access state-of-the-art SANS instrumentation. The details of the new SANS will be presented.

[1] E. Gilbert, C.J. Garvey, J.C. Schulz and R.B. Knott, Neutron News, 14, 27 (2003)

NUPP PMO 89

Evolving Fundamental Constants and Metrology

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Astrophysical observations suggest that the fine structure constant (alpha) may (or may not) be evolving over the cosmological timescale. This raises a much debated question: is alpha variation due to the variation the speed of light (c), elementary electric charge (e) or the Planck constant (h)?

We propose a metrological approach based on the analysis of the relationships between the fundamental units (e.g. of the length and time) and the fundamental constants. Our methodology allows one to find how each of the fundamental constants e, c, h evolves in time and offers a new outlook for this area.

NUPP PMO 90

Low Velocity Two-stub Superconducting Resonator for Heavy Ion Accelerators

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Many heavy ion accelerators worldwide exploit superconducting RF cavities as accelerating structures. A novel two-stub accelerating structure, optimized for ion velocity of 5% the speed of light, is described for use on the Heavy Ion Accelerator at the ANU. The main electromagnetic and mechanical parameters are discussed. The technological aspects of manufacturing are described; in particular the low-loss RF joints and a novel tuner design. The resonators will extend the capability of the ANU LINAC from mass 60 to mass 100.

NUPP PMO 91

Implications of New Data on B Meson Decays to Non-charmed States

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Recent data on B meson decays to non-charmed states is taking B physics into a precision stage. We analyse this data in a model independent way, and find that the decays to $K\pi$ states form a consistent picture, as to decays to $\pi\pi$ states. But the parameters which are deduced have unexpected values. Moreover, when one tries to combine both using flavour SU(3) symmetry, inconsistencies appear in the global data fit, although the best measured CP violating asymmetries are consistent.

NUPP PMO 92

Performance Tests of an Accelerator-based Prompt Gamma Ray Setup

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A thermal-neutron capture based Prompt Gamma ray Neutron Activation Analysis (PGNAA) setup has been developed to analyze bulk material samples. The cylindrical PGNAA sample is located in a rectangular moderator. The setup has been tested with elemental analysis of a Portland cement sample. The gamma ray yield from calcium, silicon and iron in a Portland cement sample was measured as a function of thermal neutron intensity at the sample location. The thermal neutron intensity was varied at the sample location through the front moderator thickness change. The results of the experimental study have an excellent agreement with the results of Monte Carlo simulations.

[1] Naqvi A. A. and M.A.Garwan. Validity test of design calculations of a PGNAA setup. Nuclear Instruments & Methods in Physics Research B (In press)

NUPP PMO 93

Construction and Analysis of a Many-body Neutrino Model

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In literature on the early universe and supernova the neutrino system is separated into beam and background. The ensemble can then be analysed via a one-body density matrix. The induced mass terms in this neutrino system have off-diagonal components which make it possible for entanglement between the beam and background to occur. The separation into beam and background then becomes ambiguous and hence it is not clear if the system admits a one-body description.

The validity of the one-body density matrix used in the context of the early universe and supernova has been addressed by[1–3] with different results, due to different models considered. We have generalised the system of[2] to non-equal flavour distribution. We find that the one-body description is valid and if the flavour asymmetry and the total number of particles is large then the system behaves analogously to a spin precessing in a classical magnetic field.

[1] N.F. Bell, A.A. Rawlinson, R.F. Sawyer, Phys. Lett. B **573**, 86 (2003)

[2] A. Friedland and C. Lunardini, JHEP 0310, 043 (2003)

[3] A. Friedland and C. Lunardini, Phys. Rev. D **68**, 013007 (2003)

NUPP PMO 94

Prospects for a Linear Collider

Lawrence S. Peak

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There is general agreement that the next major world accelerator should be an electron linear collider. There is much world-wide activity in the planning for such a machine. This talk will summarise developments in this field and will review the physics questions that can be addressed with such an accelerator.

NUPP PMO 95

A Composite Model for Leptons and Quarks

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A unified classification scheme, known as the Generation Model, has been proposed[1] for leptons and quarks. This scheme has been shown to lead to a relation between strong isospin and weak isospin. This relation indicates that these two isospin symmetries are simply different SU(2) subgroups of a new flavor SU(3) symmetry, associated with both leptons and quarks. The simplest conjecture is that this symmetry is connected with a substructure of leptons and quarks. One such composite model, based upon this symmetry, will be discussed.

[1] B.A. Robson, Int. J. Mod. Phys. **E11**, 555 (2002), ibid **E13**, (2004) (in press)

NUPP PMO 96

Determination of |Vcb| and Heavy Quark Parameters from Inclusive B–>Xc l nu Decays

Phillip Urquijo

In the framework of the Standard Model, the quark sector is characterized by a rich pattern of flavour-changing transitions, described by the Cabibbo-Kobayashi-Maskawa (CKM) matrix. We report a measurement of the quark mixing parameter, |Vcb|, via the inclusive measurement of semileptonic B meson decays. We have measured the moments of the inclusive electron energy spectrum in semileptonic decays, B–> Xc lnu, using data recorded with the Belle detector at the KEKB asymmetric e+e- collider. From these moments we determine |Vcb| and other heavy quark parameters, including the b-quark mass, using Heavy Quark Expansions (HQE) in the kinetic mass scheme.

NUPP PMO 97

Measuring the CKM Matrix Element Vub with an Upgraded Belle Detector

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The Cabibbo-Kobayashi-Maskawa (CKM) matrix describes the weak mixing between quark flavours in the Standard Model of Particle Physics. We review the prospects and methodology for precisely measuring the poorly determined element Vub of this matrix, using the proposed SuperBelle detector [1]. Precise measurements of Vub help to overconstrain the corresponding unitarity triangle arising from the CKM matrix, enabling the effects of physics beyond the Standard Model to be searched for.

[1] SuperKEKB Letter of Intent (LoI) , KEK Report 04-04, see http://belle.kek.jp/superb/

NUPP PMO 98

Molecular Beams from a Differentially Pumped Gas Cathode for an NEC Sputter Negative Ion Source

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A new geometry gas cathode is reported for sputter ion sources in which NH_4 gas is sprayed onto metal a sample to produce a negative metal hydride molecular beam. Performance will be improved by differential pumping with a turbo pump on the source head and impedances between the sample, the vacuum pump and the beam line. Tests though without the differential pumping, demonstrate 1.8 μA for MgH^- and CaH^-. Spraying either CO_2 or O_2 onto a Li metal sample enhances Li^- beams. The gas cathode also improved Li^- beam intensity by a factor of 10 over the previous ion source.

[1] R. Middleton, Nucl. Instr. and Methods **233** (1984) 193.

NUPP PMO 99

Development of a Detection Method for 182Hf, a Potential Supernova Isotope Signature on Earth

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The astrophysical r-process—responsible for the production of some of the heaviest nuclides in nature—is assumed to take place in supernovae. In that case it could be possible to detect radionuclides in geological archives, deposited by a nearby supernova. A very sensitive method of detection is required. We have taken steps towards developing an AMS-method for the measurement of ^{182}Hf with the 14UD-accelerator at the ANU. Projectile x-rays are detected to discriminate ^{182}Hf ions from the isobaric interference (^{182}W). Implications for a future detection of a ^{182}Hf signature in deep-sea sediments will be discussed.

NUPP PMO 100

Preliminary Analysis of LLFP Transmutation in the FDS Dual-cooled Waste Transmutation Blanket

ZHU Xiao-xiang, WU Yi-can, WANG Wei-hua, GAO Chun-jing, and FDS team

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Transmutation of long-lived Fission Products (LLFPs) is very difficult because the capture cross sections to transmute them into short-lived or stable nuclides are very

small. The dedicated dual-cooled long-lived radioactive waste transmutation blanket (DWTB) for the Fusion-Driven sub-critical System (FDS) has been considered to transmute LLFP. This paper discussed the effect of loading material candidate with different moderators and loading forms for LLFP transmutation on the burning capacity. The optimized LLFP compositions and form designs have been done to improve the performance of LLFP transmutation. Neutronics calculation about LLFP transmutation has been carried out to compare the performances of different LLFP transmutation designs.

NUPP PMO 101

Quantification of Trace Metals in Adsorbents

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Adsorbents are porous materials used to remove contaminants from water supplies. Presently, the quantitative trace metal analysis of adsorbents has been carried out using atomic absorption spectroscopy (AAS) and neutron activation analyses (NAA) despite these techniques having many inherent problems. We have used the technique of particle induced x-ray emission (PIXE) to overcome some of the current problems associated with the current techniques and compared the results against NAA and AAS. The results indicate that PIXE is capable of quantifying trace metals in adsorbents although some issues need to be resolved relating to the inhomogeneous internal structure of the adsorbent.

NUPP PMO 102

ANSTO's Accelerators

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Throughout its history, ANSTO demonstrated sustained excellence in accelerator-based science and technology. The 40 years old KN3000 Van de Graaff accelerator provided more than 110 000 running hours. The 10 MV ANTARES Tandem Accelerator is delivering leading edge Accelerator Mass Spectrometry (AMS) and Ion Beam Aanalysis (IBA) services. An additional HVEE 2 MV Tandetron accelerator has been recently commissioned and is expected to be applied across a very wide range of applications utilising IBA and AMS techniques.

After a short review of the technical aspect of the 3 ANSTO accelerators, we will present a summary of the most exciting accelerator applications across a wide variety of scientific fields including air pollution, radiocarbon dating of precious artefacts and global climate change studies.

NUPP TUD11

Tuesday 1040–1100 hrs

A Broad Look at Mesons with Lattice QCD

J.N Hedditch[1], B.G Lassock[1], D.B Leinweber[1], A.G Williams[1], J.M Zanotti[2]

1. Special Research Center for the Subatomic Structure of Matter, (CSSM), University of Adelaide; 2. John von Neumann-Institut fur Computing NIC, Deutches Elektronen-Synchrotron DESY, Zeuthen, Germany

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We present an overview of the calculation of meson properties using lattice QCD and proceed to summarise the results we have obtained, in particular meson mass spectra and form factors. We include in our study some attention to the role of gluonic excitations in observables, including the so-called 'exotic' mesons.

It is intended that the audience come away from the talk with a broad understanding

of the methods and challenges of Lattice QCD calculations for the investigation of

meson observables.

NUPP TUD12

Tuesday 1100–1120 hrs

Excitation Energy and Spin of the Yrast Superdeformed Band in ^{196}Pb

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Although rotational bands in superdeformed nuclei have been known for almost twenty years, experimental information about these states remains very limited. This is primarily because of the difficulties encountered in identifying the γ-ray decay pathways by which the nucleus changes from the superdeformed shape to more normal (less deformed) nuclear shapes. Without such information, fundamental properties of the superdeformed nucleus such as excitation energy and spin are unknown.

Recent work establishing the excitation energy and spin of the yrast superdeformed band in ^{196}Pb will be presented, and the results compared to data in neighbouring nuclei and theoretical predictions.

NUPP TUD13
Tuesday 1120–1140 hrs

Shell Structures in Exotic Nuclei from Magnetic Moment Measurements on Radioactive Beams

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Magnetic moment measurements have always presented a challenge. The new frontier in nuclear physics, opened by a new generation of radioactive beam accelerators, raises new challenges, which must be met because magnetic moment measurements provide a sensitive probe of nuclear structure. Great progress has been made recently, both with beams produced by projectile fragmentation, and with beams produced by isotope separation on-line. This progress will be demonstrated by our latest results for exotic, neutron-rich nuclei. It will be shown that the interpretation of the data obtained at international facilities rests on measurements with stable beams performed here in Australia.

NUPP TUD14
Tuesday 1140–1220 hrs

Visually Revealing the Secrets of QCD

Derek B. Leinweber[1] for the CSSM Lattice Collaboration

1. Special Research Centre for the Subatomic Structure of Matter, and Department of Physics, University of Adelaide, SA, Australia

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Supercomputer simulations on a space-time lattice provide the only first-principles approach to revealing the properties of QCD and the manner in which it constructs the world around us. This seminar will focus on numerous visualizations and animations of QCD from leading-edge[1] Lattice QCD simulations. The animations reveal new insights into quark-gluon interactions and the manner in which quarks and gluons manifest themselves as protons, neutrons and other particles. Highlights include instantons in the QCD vacuum[2], quark-eigenmode densities[3], gluon flux-tubes in mesons and baryons[4], and recent results exposing the meson-cloud surrounding the proton[5]. The talk will close with the presentation of new lattice simulation results illustrating the impact of centre vortices on QCD vacuum structure[6].

[1] S. O. Bilson-Thompson, D. B. Leinweber and A. G. Williams, Annals Phys. **304**, 1 (2003) [arXiv:hep-lat/0203008].

[2] S. O. Bilson-Thompson, D. B. Leinweber, A. G. Williams and G. V. Dunne, Annals Phys. **311**, 267–287 (2004) [arXiv:hep-lat/0306010].

[3] D. J. Kusterer, J. Hedditch, W. Kamleh, D. B. Leinweber and A. G. Williams, Nucl. Phys. B **628**, 253 (2002) [arXiv:hep-lat/0111029].

[4] F. Bissey, *et al.*, to appear in Nucl. Phys. Proc. Suppl.

[5] R. D. Young, D. B. Leinweber and A. W. Thomas, Nucl. Phys. Proc. Suppl. **129**, 290 (2004) [arXiv:hep-lat/0309187].

[6] K. Langfeld, Phys. Rev. D 69, 014503 (2004) [arXiv:hep-lat/0307030].

NUPP TUD21
Tuesday 1400–1440 hrs

Deformed Nuclear Isomers

G.D. Dracoulis

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Metastable (isomeric) states[1] have played an important role in the development of nuclear collective models and as a tool for identifying new nuclei and exotic states. Emerging techniques for the population of deformed heavy nuclei near and to the right of the stability line, where such isomers are likely to occur[2] include deep-inelastic collisions and incomplete-fusion.

A selection of new results for the deformed Yb-Lu-Hf-Ta region will be presented in the context of the mapping of intrinsic orbitals, the configurational structure of multi-quasiparticle states, and the factors which govern the purity or otherwise of the K-quantum number.

[1] P. Walker and G. Dracoulis, Nature, 399, 35 (1999)

[2] P.M. Walker and G.D. Dracoulis, Hyperfine Interactions 135, 83 (2001)

NUPP TUD23
Tuesday 1440–1500 hrs

Lifetime of a New High-spin Isomer in 150Dy

H. Watanabe[1,*] Y. Wakabayashi[2], Y. Gono[2], T. Fukuchi[2], H. Ueno[1], W. Sato[1], A. Yoshimi[1], D. Kameda[3], H. Miyoshi[3], T. Kishida[1], Y. Kobayashi[1], T. Morikawa[2], S. Motomura[2], O. Kashiyama[2], K. Saito[2], A. Odahara4 and K. Asahi[1,3]

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A new high-spin isomer in ^{150}Dy has been observed at an excitation energy of 10.3 MeV by combining the inverse-kinematic reaction induced by a pulsed beam of ^{132}Xe and the γ-ray recoil-shadow technique. The half-life of this isomeric state has been determined to be $T_{1/2}$ = 1.6 ± 0.6 ns using the conventional centroid-shift method with the ^{141}Pr(^{16}O, p6n)^{150}Dy reaction at 165 MeV. In this congress, the mechanism producing the high-spin isomers in N = 83, 84 isotones is qualitatively discussed in terms of the difference of neutron particle-hole configuration between the high-spin isomer and the lower-lying state.

NUPP TUD24
Tuesday 1500–1520 hrs

Structure of ^{188}Tl

P. Nieminen[1], G.D. Dracoulis[1], G.J. Lane[1], A.M. Baxter[2], A.P. Byrne[1,2], P.M. Davidson[1], T. Kibédi[1], K.H. Maier[1], H. Watanabe[1] and A.N. Wilson[1,2]

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Most recent studies of shape coexistence in the very light Z ~ 82 nuclei have concentrated on the even-even Hg, Pb and Po isotopes[1,2]. In contrast, little is known about the close-lying odd-odd nuclei. While partly expected to resemble their neighbours, the presence of unpaired protons and neutrons can provide insight into the active single-particle orbitals and they may also affect the relative energies of the shape co-existing minima. The ^{188}Tl nuclei were studied in two experiments utilising the Gammasphere (LBNL, USA) and CAESAR (ANU, Canberra) spectrometers. The observed structures and associated intrinsic configurations which significantly extend the earlier knowledge[3], will be discussed.

[1] G.D. Dracoulis *et al.*, Phys. Rev. C. **69**, 054318 (2004)

[2] R. Julin, K. Helariutta and M. Muikku, J. Phys. G. **27**, R109 (2001)

[3] B. Singh, Nucl. Data Sheets **95**, 387 (2002)

NUPP TUD25
Tuesday 1520–1540 hrs

Measurement of BR(B $\Rightarrow \pi l \upsilon$) and V_{UB} Using Neutrino Reconstruction at Belle

S. Cole[1], N. Parslow[1] and K.E. Varvell[1]

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V_{ub} is the smallest and least experimentally constrained element of the CKM (quark mixing) matrix. Semileptonic decays, such as B $\Rightarrow \pi l \upsilon$, are particularly useful in extracting a value for this matrix element as they are well understood theoretically, have a clear experimental signature (a single high-energy charged lepton), and have greatly reduced strong interaction effects since two of the daughters are leptons. We employ a neutrino reconstruction method, which allows a comparatively high signal efficiency, to extract this rare branching fraction and V_{ub} using 140 fb^{-1} of data from the Belle detector.

NUPP TUD31
Tuesday 1620–1640 hrs

How Can We Discover New Chemical Elements?

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In 1867 Mendeleev established the periodic table of elements. Recent discoveries of new elements push further its upper limit. To synthesise a new element a fusion reaction between nuclei is needed. The theoretical description of this process is subtle for reactions between heavy nuclei as the Coulomb repulsion has a tremendous influence on the reaction process and stability of compound nuclei[1,2].

Moreover producing these elements is a technological challenge. First the experiment done in GANIL(France) to produce the element of charge 114 will be detailed. Then the stochastic model of fusion that permit to guide the experiments will be presented[1,2,3].

[1] Abe Y., Bouriquet B., Shen C. and Kosenko G. Nucl. Phys. A722 241c-247c (2003)

[2] Abe Y. and Bouriquet B. Acta Physica Polonica B Vol 34, 1927 (2003)

[3] Bouriquet B., Abe Y. and Kosenko G . To appear in to EPJA (2004)

NUPP TUD32
Tuesday 1640–1700 hrs

Electro Magnetic Properties of Octet Baryons

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We present a calculation of the electromagnetic properties of the octet baryons. The properties are calculated using a numerical simulation of quenched QCD on a 20x20x20x40 periodic lattice with a lattice spacing of 0.128fm. We use the Fat-Link Irrelevant Clover (FLIC) fermion action which allows efficient access to the light quark mass regime. The extraction of baryon mass and electromagnetic form factors proceeds through the calculation of the ensemble average of two and three point Green functions. Magnetic moments and charge radii are extracted from the electric and magnetic form factors. We compare our results with experimental measurements and other lattice calculations.

NUPP TUD33
Tuesday 1700–1720 hrs

Family Symmetries and the Peculiar Neutrino Mixing Matrix

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Neutrino oscillation experiments indicate that two out of the three mixing angles in the neutrino mixing matrix take extreme values in parameter space: One angle is maximal, one is zero. Extending the Standard Model by adding a family symmetry has been suggested as a way of explaining the peculiar form of the neutrino mixing matrix. However, I show that all simple family symmetry models create mixing matrices that are ruled out by experiment, so more complicated models involving extra Higgs fields are needed for a family symmetry to produce the mixing, indicating that the origin of the neutrino mixing matrix is still a mystery.

NUPP TUD34
Tuesday 1720–1800 hrs

Reaching the Super-heavies

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Superheavy element research is currently an active field, with recent claims of creation of nuclei with atomic numbers up to 118, by fusing two heavy nuclei. Fusion leads to superheavy element formation only when the combined many-body quantum system, travelling through a multi-dimensional potential landscape, survives the competing processes, which cause the system to break apart (fission, quasi-fission). Understanding the formation of heavy elements is challenging due to the complexity of the process and the extremely low fusion yields. Precision experiments at the ANU[1,2] have investigated the reaction conditions affecting the fusion probability of forming lighter nuclei, which has led to unexpected results. Implications for forming very heavy elements will be discussed.

[1] A.C. Berriman *et al.*, Nature **413**, 144 (2001)

[2] D.J. Hinde *et al.*, Phys. Rev. Lett. **89**, 282701 (2004)

NUPP WED11
Wednesday 1040–1100 hrs

An the Spectrum for the Time Evolution of a Periodically Rank-N Kicked Hamiltonian

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We find the conditions under which the spectrum of the unitary time evolution operator for a periodically rank-N kicked system remains pure point, generalising the work of Combescure[1] and providing a unitary equivalent to the self-adjoint work by Howland[2]. Relaxing this condition, we characterise the emergence of a continuous spectrum (as in[3]) and comment on the importance of such a continuous spectrum in the field of quantum chaos. A number of generally held misconceptions in the physics literature will be highlighted, including mistakes made in[3]. Much of this work is presented in detail in[4].

[1] M. Combescure, J. Stat. Phys, **59**, 679 (1989)

[2] J.S. Howland, J. Func. Anal, **74**, 52 (1987)

[3] B. Milek & P. Seba, Phys. Rev. A, **42**, 3213 (1990)

[4] J.M. McCaw & B.H.J. McKellar, math-ph/0404006 (2004)

NUPP WED12
Wednesday 1100–1120 hrs

In-matter Three-body Problem

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The in-matter three-body problem plays an important role in describing a large variety of interesting phenomena. However, even non-relativistic in-matter descriptions are four-dimensional. To avoid the numerical difficulties of a four-dimensional approach, equal-time Green functions have been used to obtain a three-dimensional description[1–8]. To derive equations, these works approximate the effective pair-interaction kernels by terms linear in the physical two-body potentials, while the exact expression for the effective pair-interaction kernel involves an infinite series of higher order terms as well. We solve this problem by formulating three-dimensional equations that take into account the full infinite series for the effective pair-interaction kernel.

[1] P. Schuck F. Villars and P. Ring, Nucl. Phys. A208, 302 (1973).

[2] M. Beyer, W. Schadow, C. Kuhrts and G. Ropke, Phys. Rev. C 60, 034004 (1999).

[3] M. Beyer, Few-Body Syst. Suppl. 10, 179 (1999).

[4] M. Beyer, S. Mattiello, T. Frederico and H. J. Weber, Phys. Lett. B521, 33 (2001).

[5] S. Mattiello, M. Beyer, T. Frederico and H. J. Weber, Few-Body Syst., 31 159 (2002); Few-Body Syst. Suppl. 14, 379 (2003).

[6] M. Beyer, G. Ropke and A. Sedrakian, Phys. Lett. B376, 7 (1996).

[7] M. Beyer, Nucl. Phys. A684, 566c (2001).

[8] M. Beyer and G. Ropke, Phys. Rev. C 56, 2636 (1997).

NUPP WED13
Wednesday 1120–1140 hrs

New Methods of Testing Lorentz Violation in Electrodynamics

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We investigate experiments that are sensitive to the scalar and parity-odd coefficients for Lorentz violation in the photon sector of the Standard Model Extension (SME) of particle physics. We show that of the classic tests of special relativity, Ives-Stilwell (IS) experiments[1] are sensitive to the scalar coefficient, but at only parts in 105 for the state-of-the-art experiment[2]. We then propose asymmetric Mach-Zehnder interferometers with different electromagnetic properties in the two arms, including recycling techniques based on travelling wave resonators to improve the sensitivity[3]. With present technology we estimate that the scalar and parity odd coefficients may be measured at sensitivity better than parts in 10^{11} and 10^{15} respectively, which represents six orders of magnitude improvement in the former and four orders for the latter.

[1] H. E. Ives and G. R. Stilwell, J. Opt. Soc. Am. 28, 215 (1938).

[2] G. Saathoff, S. Karpuk, U. Eisenbarth, et al., Phys. Rev. Lett 91, 190403 (2003).

[3] M.E. Tobar et al, submitted to Phys. Rev. D (2004).

NUPP WED14
Wednesday 1140–1220 hrs

Effects of Variation of Fundamental Constants from Big Bang to Atomic Clocks

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Theories unifying gravity with other interactions suggest temporal and spatial variation of the fundamental “constants” in expanding Universe. I discuss effects of variation of the fine structure constant alpha=e^2/h c, strong interaction and quark mass. The measurements of these variations cover lifespan of the Universe from few minutes after Big Bang to the present time and give controversial results. There are some hints for the variation in Big Bang nucleosynthesis, quasar absorption spectra and Oklo natural nuclear reactor data. A very promising method to search for the variation of the fundamental constants consists in comparison of different atomic clocks. A billion times enhancement of the variation effects happens in transition between accidentally degenerate atomic energy levels.

Education (PEG)

PEG TUF11
Tuesday 1040–1120 hrs

Key to Participation

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Overall student satisfaction and participation were high for regular online quizzes in a first year physics unit at Edith Cowan University in 2004. Students overwhelmingly believed that the quizzes helped them learn physics and study more consistently over the semester. The key elements have been compulsory and formative assessment where students have been allowed to use detailed feedback to improve their quiz scores.

PEG TUF13
Tuesday 1120–1140 hrs

The Missing Factor for Students in 1st Year Physics?

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When the author came to UTS, the failure rate in 1st year Physics was about 40%. As a result he initiated a diagnostic testing program. This paper describes the evolution of that program and discusses what has been achieved. The testing incorporated items on Mathematics, Language, Science Concepts, Critical Thinking and a number of different Learning Styles. In the analyses there seemed to be a missing factor, and the search for it is described. A possible factor was found in a study with transnational students undertaking pre-University Physics in a Foundation (Enabling) course.

PEG TUF14
Tuesday 1140–1200 hrs

Using Student Authored Questions to Encourage Deeper Learning in Physics

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One of the main problems involved in the teaching & learning of physics is the formulation of concepts and their logical application. In this paper we wish to outline preliminary studies into the effectiveness of a teaching method designed to encourage students to pose their own questions as an assignment task. The questions themselves provide considerable feedback on the progress and/or engagement of students with the material, and the methodology could prove a useful tool in capability based degree programs.

PEG TUF15
Tuesday 1200–1220 hrs

Online Assessment in First Year Physics

R. J. Kruhlak[1], T. G. Mullins and C. Coghill[2]

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We report on Online ASsessment and Integrated Study (OASIS) software used in first year physics courses at the University of Auckland. OASIS allows us to conduct flexible online assignments in our large stage one physics courses. Some advantages of OASIS assignments over traditional assignments, namely instant feedback, multiple opportunities for students to practice key concepts, automatic marking of assessments, and detailed statistics about results and student usage, will be presented. Positive student feedback and a noticeable improvement in student problem solving skills in the first full year of OASIS assignments at the stage one level are very encouraging.

PEG TUF21
Tuesday 1400–1440 hrs

Comprehensive Photonics Education Model—The Albuquerque Ladder—"A Progress Report"

A. H. Guenther[1] and Leno Pedrotti[2]

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In direct response to the needs of the local optics and photonics sector, both industrial and government. Albuquerque has established a comprehensive optics education program from middle school (grades 6, 7, 8) to post graduate. Briefly, individuals may enter and return to the workforce routinely as they ascend the degree chain. More quantitative details and progress will be presented as well as curricula. Recently an additional component, a minor in Optical Science and Engineering for Physical Science of Engineering Degree Program has been added at New Mexico Tech primarily focused on physical optics to support Department of Defense and astronomy interests.

PEG TUF23
Tuesday 1440–1500 hrs

Mathematics Transfer of First Year Science Students

A.L. Roberts[1], M.D. Sharma[1], S. Britton[2], P.B. New[3]

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Transfer of learning and knowledge is vital in education. The application of knowledge to different contexts is a

universal phenomenon, yet it has been difficult to measure in qualitative studies[1]. First year science students at the University of Sydney sat a two-part test from which a transfer rating was derived. The method of data collection for this project is described, the variables are defined and preliminary results of statistical correlations are given. Future work includes incorporating data from interviews that were conducted. The strongest association of variables found thus far is between the transfer rating and the test questions that involved graph reading and interpretation skills.

[1] S.M. Barnett and S.J. Ceci, Psychological Bulletin 128 (4), 612 (2002).

PEG TUF24
Tuesday 1500–1520 hrs

Developing Investigative Skills Through a 'Challenge' Experiment

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We report on how 150 students in their second semester of mainstream university physics describe their experience in designing and carrying out a two-hour 'challenge' experiment supervised by their normal laboratory demonstrator. Responses to open-ended questions and features of students' flowcharts were categorised, based on the range of student answers. The value of the experiment in promoting enquiry and investigative skills—providing some of the same benefits as traditional (expensive) supervised individual projects—is evident. Aspects valued most by students were teamwork, deeper conceptual understanding, independence, ownership of the experiment, and sheer fun.

PEG TUF25
Tuesday 1520–1540 hrs

Back to the Future: Cafeteria Laboratories in First Year Physics

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Both Science and Electrical Engineering streams undertake an eight-week laboratory program in each Session of their First Year at ADFA. In 2004, these programs were changed from the homogenous system of "everyone does the same experiment each week", to a self-paced system where students could choose what they wanted to explore within a set framework. We will explore the motivations for this change, the implementation, and present a summary of student feedback from the first year of operation. In particular, the "three pillars" of pre-lab activities, checkpoint-style progressive marking, and criterion versus norm referencing in assessment will be discussed.

PEG TUF31
Tuesday 1620–1700 hrs

Changing Times—Changing Teaching

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Complex changes have occurred in university teaching. Students come from diverse backgrounds with differing abilities, expectations and motivations. Governments, employer groups and universities demand that students demonstrate the attainment of generic outcomes and lifelong learning skills. These changes require teaching staff to rethink both their beliefs about teaching and their teaching practices. Furthermore, physics education research has shown that traditional modes of teaching physics are not as effective in helping students learn key concepts as had been assumed. I will present a number of practical strategies for both individual teaching staff and for physics departments which will assist in modifying physics teaching in these changing times.

PEG TUF33
Tuesday 1700–1720 hrs

Video Physics Education: Falling Cats and Terminal Velocity

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As an introduction to the topic of terminal velocity, some first year physics students at the University of Sydney are shown the popular science video "Falling Cats." Three focus groups, each with participants from different physics backgrounds, were held to understand how students engaged with the physics presented in the video. Participants actively voiced their conceptions of terminal velocity and were open to discussing factors related to the physics of falling bodies. Those with greater interest and experience in physics spoke more confidently about a wider range of issues and formed opinions on the physics, facilitated by the video context.

PEG TUF34
Tuesday 1720–1740 hrs

The RTASO Physics Olympiad Program

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The Physics Olympiad program is part of the Rio Tinto Australian Science Olympiads. The program begins with a National Qualifying Exam, sat by around 1000 (mainly) year 11 students. The students are from across Australia are nominated by their teachers. Of these students the top

24 are invited to an intensive Scholar School over January, during which we cover most of first year university physics, at a typical “main stream” level. From these students the teams for the Asian and International Physics Olympiads are chosen.

The process of team training and selection will be discussed, as well as some interesting data from the 2004 National Qualifying Exam.

PEG TUF35
Tuesday 1740–1800 hrs

The Science and Engineering Challenge

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There has been a well documented decline in the participation rate of senior secondary students in Physics, Chemistry and Advanced Mathematics. To address this decline a new format activity called the Science and Engineering Challenge has been developed which engages the broader community. It has documented a high level of success in increasing year 11 enrolments in Physics and Advanced Mathematics. This has won the highest Engineering Excellence Award in 2003 (the Sir William Hudson Award) and it has been funded by the Federal Government to go nationwide.

POSTER

PEG PTU 124

A Little Introductory and Intermediate Physics with the Lambert W Function

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The recently defined Lambert W function[1] is used to express two commonly encountered problems from introductory and intermediate physics, namely; the Wien peaks which occur in the spectral distribution curves of blackbody radiation; and the time of flight and range for a projectile in a linear resisting medium, in exact analytic form. Such examples provide accessible accounts of the increasing applicability which the Lambert W function now finds in physics. By highlighting a range of problems whose solution depend on W, the intention is to convince the reader of the general utility and usefulness of this function so as to warrant its inclusion in standard undergraduate mathematical methods courses for physicists.

[1] R. M. Corless, G. H. Gonnet, D. E. G. Hare, D. J. Jeffrey and D. E. Knuth, Adv. Comput. Math., **5**, 329 (1996)

PEG THE11
Thursday 1040–1120 hrs

Key Findings from the National Physics Project on Learning and Teaching

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A national project, commissioned by the Australian Universities Teaching Committee, has reviewed learning and teaching in physics at Australian universities in 2004 using questionnaires, interviews and focus groups. This paper reports on how physics departments are responding to change. Issues of interest include the background and aspirations of students, employment options, approaches to learning and teaching, and initiatives such as the creation of multidisciplinary courses. Good practices addressing these issues will be reported and the implication of these findings for the future of physics education in Australia will be discussed.

PEG THE13
Thursday 1120–1220 hrs

Implications of the National Physics Project for Teaching and Learning—a Workshop

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This workshop considers implications of the key findings of the 2004 Physics Project on teaching and learning for physics departments and academics in Australia.

- How do departments implement good learning and teaching practice?
- How are departments handling staff shortages?
- How do we assure a quality laboratory experience?
- How have our students changed?
- How we can best disseminate successful good practices?

Plasma Physics (PP)

PP PMO 103

Action Conservation for Drift-waves

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A powerful advantage of Lagrangian formalisms is the ability to generate conservation relations (Noether's Theorem). This has given motivation for finding a Lagrangian for the Hasegawa-Mima equation for drift waves in plasmas and Rossby waves in geophysics. An action conservation relation can naturally be derived from the Lagrangian. A nonlinear Wentzel-Kramer-Brillouin trial function is used in the derivation and the averaged Lagrangian is obtained using Whitham's variational approach. Variation to the phase variable in the averaged Lagrangian leads to an equation of action conservation for drift-waves.

[1] G.B. Whitham, J. Fluid Mech., **22**, 273 (1965)

[2] A. Hasegawa, C.G. Maclennan, and Y. Kodama, Phys. Fluids, **22**, 2122(1979)

[3] N. Mattor and P. Diamond, Phys. Plasmas **1**, 4002(1994)

[4] D. Biskamp and W. Horton, Phys. Lett., **75A**, 359(1980)

[5] R.L. Dewar, J. Plasma Phys., **7**, 267(1972)

PP PMO 104

A Pulsed, Supersonic Helium for Plasma Diagnostics

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A supersonic helium beam has been developed to measure the electron density, n_e, and electron temperature, T_e, in a plasma[1,2]. Development has been for the H–1 heliac[3] at the ANU and has subsequently been adapted for lower energy laboratory plasmas. Characterisation of the beam[4] shows centreline densities of $n_{He} \sim 1x10^{18}$ m^{-3} and a velocity $v \sim 1.72x10^3$ ms^{-1} which agrees well with the terminal velocity for helium. These measurements were made at a source pressure of, $P_0 = 6$ atm, and nozzle skimmer distance of $x_s = 30$ mm. The beam width at a distance, X = 30 cm from the nozzle is d ~ 10 mm and agrees well with geometrical estimation of the beam width.

Application of the beam will be to measure n_e and T_e on H–1, a pulsed cathodic arc and helicon plasma will be compared to Langmuir probe measurements. This requires the additional use of a collisional radiative model for helium and uses line intensity ratios to help calculate the plasma parameters[5,6].

[1] B. Schweer et. al, J. Nuc. Mater, **196–198**, 174–178 (1992).

[2] E. Hintz et. al, Plasma Phys. Control. Fusion, **37** A87–A101 (1995).

[3] J. Harris et. al, J. Plasma Fusion Res., **1**, 30–37 (1998).

[4] D. Andruczyk et. al, Rev Sci Instrum. Submitted (2004).

[5] S. Sasaki et. al, Rev. Sci. Instrum. **67** (10), 3521–29 (1996).

[6] M. Goto et. al, NIFS-DATA-43, (1997).

PP PMO 105

A Stochastic Analysis of Fluctuations in the Vacuum Arc Centrifuge

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In this work, a stochastic treatment of electric probe data of the floating potential and ion saturation current from the Vacuum Arc Centrifuge[1] is presented. Analysis of the power spectra, probability density function (pdf) and autocorrelation reveal cyclic fluctuations with a varying envelope and frequency, and non-Gaussian pdfs. A model is proposed comprising the superposition of wave harmonics and noise populations, whose interaction explains the dominant features of the pdfs, and provides a mechanism for the appearance of fine structure through phase selection of the harmonics. The wave populations are then reconciled with existing plasma wave and stochastic fluctuation models.

[1] M. J. Hole et al. Phys. Rev. E, **64(4)**, 046409 (2002)

PP PMO 106

The Effect of Magnetic Configuration on the H-1 Heliac Plasma

B.D. Blackwell[1], F. Glass[1], D.G. Pretty[1], J.H. Harris[1], J. Howard[1], C.A. Michael[2], M.G. Shats[1], S.M. Collis[1], and H. Punzmann[1]

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The H-1 heliac is a current-free stellarator with flexible magnetic geometry. The effect of geometry (magnetic twist, shear and well) on plasma is studied over a wide range of magnetic configurations, varied within a pulse, or from shot to shot under computer control. Ion-cyclotron range RF excitation produces plasma in H:He and H:D mixtures at densities up to $n_e \sim 210^{18} m^{-3}$, T<50eV, showing a stronger configuration dependence than electron-cyclotron produced plasmas which are considerably hotter and centrally-peaked. RF plasmas exhibit magnetic fluctuation spectra which also depend in detail on magnetic configuration. The relationship to magnetic geometry is discussed.

PP PMO 107

A Directional Gas Injection System for the H-1NF Heliac

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The temporal evolution of electron density profiles during resonantly heated helium and hydrogen plasmas in the H-1NF heliac suggest that the maximum attainable density is limited by the heating power. This is in part due to the plasma being formed in a background of neutral gas that fills the 30 cubic metre vacuum vessel, acting as a reservoir of particles that thermally diffuse across the plasma boundary into the confinement region. To help achieve density control we have designed, built and tested a directional gas injection system which delivers a controlled gas dose to the plasma region alone. In this presentation I will detail the characterization of the gas injector as well as spectroscopic measurements of the electron density and temperature evolution during injector-fueled resonantly heated discharges.

PP PMO 108

Ion Magnetic Detachment in the HDLT Space Propulsion Concept

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Detachment of the ions in the beam exhaust from the magnetic field produced by a plasma space thruster is an element of thrust vector analysis which involves experimental, analytic and computational studies. This analysis is devoted to simulating the orbits of the ions in the supersonic beam observed experimentally in the laboratory development of the Helicon Double Layer Thruster. In Particular the study will analyse the influence of the magnetic field, created by the solenoids surrounding the plasma source, on the ion beam exhaust to determine whether thrust is gained.

[1] C. Charles and R.W Boswell, Physics of Plasmas, **10**(4), April (2004)

[2] A.V. Ilin et al, 40th AIAA Aerospace Sciences Meeting and Exhibit, 2002–0346, January 2002

PP PMO 109

Small to Mid-sized Stellarator Experiments: Topology, Confinement, and Turbulence

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The large experiments LHD (operating) and W7X (under construction) move stellarator plasmas into the near-reactor regime. Continuing experiments on smaller devices with heating powers from kW to MW are exploring the effects of magnetic configuration stability and turbulence on plasma confinement. Key issues being studied are the relation of rational magnetic surfaces and magnetic configuration characteristics such as helical ripple to plasma transport, confinement scaling and turbulence. The robust stability of currentless stellarator plasmas contributes importantly to these studies. Many of the phenomena most clearly evident in stellarators are increasingly implicated in tokamak experiments.

PP PMO 110

Multi-wire Tomography for Magnetic Island Studies in the H-1NF Heliac

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Formation of magnetic islands in fusion devices has serious impact on plasma confinement. Accurate mapping of vacuum magnetic islands is essential for a complete understanding of this issue. Multi-wire tomography in H-1NF enables mapping of vacuum flux surfaces without significant disruption of plasma operations. Recent experimental results have proved, for the first time, this technique to be a highly accurate and high resolution method for mapping magnetic islands. This has also enabled determination of best-fit empirical values for magnetic field parameters of H1. Experimental and computational results are presented and compared.

PP PMO 111

Electronically Scanned Millimeter-wave Interferometer for the Study of Resonantly Heated Plasmas in the H-1 Heliac

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Measurement of the time-resolved spatial distribution of the plasma electron density is crucial to our understanding of resonantly heated plasmas confined in the H-1 heliac magnetic confinement device. We have installed a voltage-tunable high power backward-wave oscillator as a replacement radiation source for the multi-view tomographic H-1 interferometer. When combined with a fixed diffraction grating it is possible to effect a rapid spatial scan of the plasma region for tomographic imaging of the electron density. First results from the upgraded H-1 interferometer will be presented.

PP PMO 112

Debye Plasma Layers Generalized to Nuclear Forces Explaining Quark-Gluon State and Endothermic Nuclear Production with Limit at Uranium

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The Debye length at laser-plasma interaction was generalized to metal electrons with Fermi energy instead of temperature resulting in measured surface tensions. Taking the Fermi energy in the Debye length for nucleons[1] results in a theory of nuclei with stable confinement of protons and neutrons at the well-known nuclear density. Increasing the nuclear density by a factor 6 leads to the change of the Fermi energy into its relativistic branch where no surface energy is possible and particle masses are not defined (quark-gluon plasma). Boltzmann equilibrium explains endothermic nuclear synthesis in the Universe limited to about uranium[2].

[1] H. Hora, Plasma Model for Surface Tension of Nuclei and the Phase Transition to the Quark Plasma, Report CERN-PS/DL-Note-91/05, August 1991, see also H. Hora, Laser Interaction and Related Plasma Phenomena (Plenum NY, 1992) Vol. 10, p. 19

[2] H. Hora, G. Miley, F. Osman, P. Hammerling, High Power Laser Ablation V, C.P. Phipps ed., SPIE Vol. 5448, 1190–1200 (2004); H. Hora, G. Miley and F. Osman, Astrophys. & Space Science in print (2004)

PP PMO 113

Magnetic Fluctuation Analysis of RF Heated Plasma in the H-1NF Heliac

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The H-1NF Heliac is a helical axis stellarator with uniquely high precision control of rotational transform, _, (ratio of poloidal to toroidal magnetic field). Detailed configuration scans show that confinement of RF heated plasma is very sensitive to rational values of _ within the plasma volume.

A poloidal array of Mirnov coils enclosing the plasma column has been used to investigate the nature of MHD activity throughout configuration scans. Clustering algorithms from the WEKA[1] suite of datamining tools have been used in spectral feature detection to retain scalability for large datasets. Poloidally localised fluctuations have been observed, and large amplitude m=2 modes have been associated with low order rational _ values.

[1] http://www.cs.waikato.ac.nz/~ml/weka

PP PMO 114

Maintaining an FRC by Two Counter-rotating Magnetic Fields

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Field-Reversed-Configurations (FRCs) can be sustained using a rotating magnetic field (RMF) to drive the current by entraining the electron fluid. A steady state cannot be achieved in this way since the electrons impart angular momentum to the ions by collisions. It is possible, however, to control the motion of the ions using a counter-rotating RMF and hence achieve a steady state where the net angular momentum transfer vanishes. Both RMFs penetrate into the plasma much farther than the skin depth because of nonlinear effects. We present a numerical investigation of the accessibility of these equilibria from suitable initial conditions.

PP PMO 115

Interferometry and Spectrometry Diagnostics for Plasma Transport Studies in a Pulsed High Current Cathodic Arc

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We will present early results from interferometry and spectrometry diagnostics being installed to study and optimise plasma transport through the quarter-torus magnetic macroparticle filter in the University of Sydney pulsed high-current cathodic arc[1]. In high-current pulses (~3 kA) measured electron densities are >2_10^{20} m^{-3} in the middle of the filter and are ~2_10^{18} m^{-3} in the substrate region at the filter exit. We will report on early spectroscopic measurements and progress on installation of a high-resolution interference spectrometer for ion Doppler measurements. We will report on comparisons of the results with a two-fluid model of the transport[2].

[1] R.N. Tarrant, M.M.M. Bilek, J. Pigott and D.R. McKenzie, Surf. Coat. Technol., **186** (2004) 10–16.

[2] B. Alterkop, E. Gidalevich, S. Goldsmith and R.L. Boxman, J. Phys. D: Appl. Phys. **29** (1996) 3032–3038.

PP PMO 116

Modeling and Simulation of a One Atmosphere Dielectric Barrier RF Glow Discharge by using the Pspice code

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We have designed and fabricated a one atmosphere dielectric barrier parallel plate reactor to make hydrophobic and hydrophilic materials. Using a Pspice simulation code, we developed an equivalent circuit model of our dielectric barrier parallel plate reactor to understand the electrical characteristics of atmospheric rf glow discharge plasmas. The plasma characteristic, such as voltage and current have, been investigated for a range of gap distances between the electrodes for various input powers. We compare the simulated and experimental results.

PP PMO 117

Charge States Distribution of Au Plasma from First-principles Theory

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The present work proposes first-principles theory without any experiments to derive the charge state distribution in the highly ionized non-LTE Au plasma. The first step is to calculate the ionic average lifetime τ_i and its first-order ionization rate constants ki by relativistic quantum mechanics, then, derive the second-order ionic recombination constants k-i based on the statistical ionization-recombination equilibrium constants Ki and ki , and finally, the ionic concentrations and their charge state distribution will be obtained from the solution of differential equations of consecutive-irreversible or reversible processes. The effect of electron density, electron temperature and system pressure all are derived by configuration integration Qu . The calculated average positive charge 49.24 of Au48+–Au52+ is comparable with 49.3 ± 0.5 of LLNL, which is fitted from the analysis of emission measurements of Au 5f–3d transition arrays in the wavelength range 3.3–3.9 A0 . It is so-called first-principles theory

PP PMO 118

The Fall and Associated Compression of the Night Ionosphere at Equatorial Latitudes

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The equinoxes at equatorial latitudes to the north of Australia in the post-sunset period are characterised by a rise in ionospheric height followed by a larger fall as the direction of vertical ionospheric drift turns downward. The occurrence of Equatorial Spread F associated with ionospheric bubbles also peaks under these conditions. However Equatorial spread F is not always present. At such times, the ionosphere below the foF2 maximum is seen to compress as it falls in height occasionally resulting in very large values of foF2 (surges). The localisation of the phenomena is investigated using a combination of vertical and oblique ionosondes.

PP WEB11

Wednesday 1040–1120 hrs

Advances in Magnetic Fusion Science and the ITER Project

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The last decade has seen dramatic advances in the scientific understanding of magnetically-confined high-temperature plasmas for fusion energy, due to advances in plasma measurement techniques and large-scale computing. A “standard model” of ion turbulence has been tested successfully in many experiments, and understanding of the global stability of plasmas has advanced to the point where measurements allow accurate prediction and control of instabilities. The world is on the verge of construction of ITER, a device capable of producing hundreds of megawatts of fusion power, at high gain, for thousands of seconds.

PP WEB13
Wednesday 1120–1140 hrs

Equilibrium and Stability of the Mega Ampere Spherical Tokamak

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In this work, the equilibrium and stability of several high performance Mega-Ampere Spherical Tokamak (MAST) plasmas is investigated. Kinetic equilibrium reconstructions, in which the thermal pressure profile is fitted to thermal data, suggest normalized beta βn up to 4.95 and bootstrap fractions up to 30%. Full-orbit simulations suggest that up to 25% of the total stored energy is in the fast-ion population: lifting βn to 5.56. Using these reconstructions, ideal MHD stability thresholds of n=1,2 and (displacements are examined, and it is concluded that passive stabilization may soon be required to access higher performance.

PP WEB14
Wednesday 1140–1200 hrs

New Type of Laser Produced Ions for Simplified Fusion

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The dramatic difference to the usual stream of laser-plasma interaction with 50 times lower ion energies at TW-ps laser interaction is explained by a skin-layer acceleration by the nonlinear (ponderomotive) force (SLAN). Suppression of prepulses (contrast ratio up to 108) was essential avoiding relativistic self-focusing. Only plane wave front interactions take place and plasma blocks with ion current densities above 1010 W/cm2 were measured and reproduced by extensive numerical calculations. The deuterium tritium plasma blocks moving with energies of 100 keV into the target may be used for a controlled initiation of fusion in uncompressed solid deuterium tritium.

*Team: Osman, F., Jablonski, S., Glowacz, S., Cang Yu, Evans, P., Toups, P., He Xiantu, Zhang Jie, Badziak, .J, Boody, F.P., Gammino, S., Höpfl, R., Jungwirth, K., Kralikowa, B., Kraska, J., Laska, L, Liu, Hong, Miley, G.H, Parys, P., Peng Hansheng, Pfeiffer M., Rohlena, K., Skala, J. Skladanowski, L., Torrisi, L., Ullschmied, J., Wolowski, J. & Zhang Weiyang, (Sydney, Warsaw, Beijing, Regensburg, Deggendorf, Catania, Prague, Urbana)

PP WEB15
Wednesday 1200–1220 hrs

Imaging Plasma Spectroscopy Using Novel High-resolution, High-speed Optical Coherence-based Methods

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We have recently developed novel 2-d coherence-imaging systems for both high and low-spectral-resolution, time-resolved plasma spectroscopy. The instruments, which utilize time and/or frequency multiplex methods to encode the coherence information, have significant advantages over standard colour-domain methods. In this paper I describe a new static approach where quadrature images of the spectral coherence are multiplexed to four quadrants of a CCD array. This system, which is in-principle 100% light-efficient, opens the possibility for 2d spectral imaging of high-speed plasma phenomena, and has revealed new information about the nature of ion heating and cooling processes in the H-1 heliac.

PP THB11
Thursday 1040–1100 hrs

Stability for Kinetic Ballooning Modes in Stellarators

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The pressure gradient in magnetically confined plasma is often limited by ballooning instabilities; these are most dangerous at moderately small wavelengths, where finite Larmor radius corrections to ideal magnetohydrodynamics are important. In a strongly 3-D device like the H-1NF experiment, spatial inhomogeneity leads to a semiclassical dynamics which is at best nearly-integrable but is often quite chaotic. We explain why a semiclassical approach is justified in cases where fully complex wave frequencies arise, and how recent developments in semiclassical theory allow an accurate wave quantisation in a configuration where half the phase space is ergodic.

PP THB12
Thursday 1100–1120 hrs

One-dimensional PIC Simulation of a Current-free Double-layer in an Expanding Plasma

A. Meige[1], R.W. Boswell[1], C. Charles[1,2] and M. M. Turner[3]

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In this paper we present results from a one-dimensional Particle-in-Cell simulation which confirm our earlier experimental results showing that a double-layer can form in a current-free plasma expanding along a diverging magnetic field. These results differ from previous experimental or simulation systems where the double-layer is driven by a current or imposed by potential differences. The results show that this particular type of DLs is in Boltzmann equilibrium which is rather different to those which create the electron beams of the aurora and are seen in current driven PIC simulations.

PP THB13
Thursday 1120–1140 hrs

Reactive Plasma-assisted Nanofabrication: Unique Features and Future Challenges

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This presentation is focused on reactive plasma-assisted chemical vapour deposition (PACVD) systems and their unique features that make them indispensable for numerous nano-scale applications. The underlying physics of such systems is examined and compared with common CVD processes. Unique features, benefits, and challenges of using reactive plasmas for various nanofabrication processes are critically analysed. The examples include ordered carbon nanotips, nanostructured silicon films, semiconductor quantum dot arrays, and nanostructured calcium phosphate biocompatible films. Special attention is paid to the identification and control strategies of the main building units both in the ionised gas phase and on deposition surfaces.

PP THB14
Thursday 1140–1200 hrs

High-Density Pulsed Cathodic Arc Plasmas

R.N. Tarrant[1], G.B. Warr[1,2], M.M.M Bilek[1], D.R. McKenzie[1] and J.H.H. Harris[2]

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The development of a pulsed cathodic arc system[1] delivering highly reproducible plasmas with average densities of $10^{19}/m^3$ at the substrate and $10^{22}/m^3$ at the anode mouth has enabled us to examine plasma transport and sheath dynamics in high-density drifting plasmas. Pulsed arc plasmas are 100–1000 times denser than in dc systems, producing very high deposition rates (>0.1 nm /pulse at 10 Hz). The plasma is generated using pulsed cathode currents of 3 kA and transported via a quarter torus open-wound magnetic particle filter. The pulsed arc provides a flexible system for developing high-density plasma diagnostics.

[1] R.N. Tarrant et al, Surf. Coat. Techol. 186, 10 (2004)

PP THB15
Thursday 1200–1220 hrs

Self-organization in Turbulence as a Route to Order in Plasma and Fluids

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Transitions from turbulence to order are studied experimentally in thin fluid layers and magnetically confined toroidal plasma. It is shown that turbulence self-organizes through the mechanism of spectral condensation. The spectral redistribution of the turbulent energy leads to the reduction in the turbulence level, generation of coherent flow, reduction in the particle diffusion and increase in the system's energy. The higher order state is sustained via the nonlocal spectral coupling of the linearly unstable spectral range to the large-scale mean flow. The similarity of self-organization in two-dimensional fluids and low-to-high confinement transitions in plasma suggests the universality of the mechanism.

Renewable Energy (RE)

RE PTH 52

Modeling and Simulation of a Solar Still Coupled with Energy Storage Device

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The process pf purifying saline or brackish water can be done easily and economically by solar distillation. Though a lot of advantages are present in the utilization of solar energy, the disadvantages associated with it are its rarified nature and duration of availability. These disadvantages have curbed the commercialization of the solar distillation process. In this study we present an innovative design of a solar desalination unit that is expected to produce high efficiencies. This is accomplished by incorporating features such as utilization of latent heat of condensation, maintenance of a large temperature drop between the condensing vapors and the condensation surface, use of phase change materials(PCM) for energy storage and longer time of operation etc. Further the possibility of algae formation that is present in conventional solar stills is omitted by employing a continuous flow of brackish water through the system. Modeling and simulation studies are performed on the designed system to assess the performance of the system at various operating conditions. Optimum operating conditions of the system are reported based on the analysis of simulated results.

RE PTH 53

Efficiency Analysis of a Tio_2 Photoelectrode used for Solar Water Splitting

P. R. F. Barnes[1,3], A. B. Murphy[1,3], L. K. Randeniya[1,3], I. C. Plumb[1,3], P. B. Gwan[1,3], I. E. Grey[2,3], C. Li[2,3] and M. D. Horne[2,3]

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The efficiency of solar water splitting using semiconductor electrodes depends on factors including the incident radiation spectrum, its absorption in the semiconductor and the transport of charge carriers to the electrolyte. We measured the efficiency and photoresponse of a thin film of TiO_2, and compared these results theoretical predictions. Using a Schottky barrier model for rutile and the measured conversion efficiency for incident photons the diffusion length of charge carriers is estimated to be 300nm. For a single crystal rutile electrode the predicted theoretical efficiency in sunlight is ~0.4%. The measured efficiency for such an electrode in sunlight was 0.29±0.06%.

RE PTH 54

Doped Tio_2 Photoanodes for High Efficiency Hydrogen Production

A.B. Murphy[1,3], L.K. Randeniya[1,3], P.R.F. Barnes[1,3], J.A. Glasscock[1,3], I.C. Plumb[1,3], I.E. Grey[2,3] and C. Li[2,3]

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Anion-doped TiO_2 offers great promise for high water splitting efficiencies, because anion doping should move the valence band of TiO_2 upwards, without changing the position of the conduction band edge significantly. This should result in a smaller band gap, thereby increasing the utilization of the solar spectrum, without having a negative impact on the energetics. Doped TiO_2 is prepared using a range of synthesis techniques, including sol-gel processing, controlled atmosphere high temperature processing of powdered materials, filtered arc deposition, and high-intensity ball milling. The presentation will include a comparison of efficiencies obtained using different dopants (N, C and S), synthesis techniques and post-synthesis treatments.

RE FRF11
Friday 0820–0840 hrs

See EP FRF11

Radar Interrogation of High-flying Insects: What Bug is That?

Drake

RE FRF12
Friday 0840–0900 hrs

See EP FRF12

Ultrasonic Destruction of Contaminants in Soil

Collings

RE FRF13
Friday 0900–0920 hrs

Crystalline Silicon Thin-film Solar Cells on Glass—Cheap Electricity from the Sun?

Armin G. Aberle, Andrew Blakers

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Photovoltaics (PV), i.e. the direct conversion of solar energy into electrical energy using solar cells, is a promising technology for the production of affordable clean electric power. Today's PV market is totally dominated by crystalline silicon wafers, however, due to its material intensiveness, it appears unlikely that wafer-

based technology will ever reach the cost levels ($/Watt) required for a widespread application of PV. The solution to this problem might be polycrystalline silicon thin-film solar cells on glass which, per unit area, require less than 1% of silicon compared to today's wafer-based technology. This paper describes the significant advances towards such thin-film cells realised in recent years at The University of New South Wales and its spin-off company CSG Solar (formerly Pacific Solar).

RE FRF13
Friday 0900–0920 hrs

Sliver Solar Cells

Andrew Blakers, Klaus Weber, Vernie Everett, Sanju Deenapanray and Evan Franklin

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The Sliver solar cell process uses standard materials and techniques in novel ways to create thin single crystalline solar cells with superior performance and reduced cost. They are highly efficient, flexible and versatile. The technology offers offer a 10-fold reduction in the mass of silicon per kW, which means that silicon shortages are not an issue for Sliver cells. The technology also offers a 20-fold reduction in the number of wafer starts per kW. A company called Origin Energy is constructing a $35 million pilot plant in Adelaide to manufacture Sliver modules. First product is expected in 2005.

RE FRF14
Friday 0920–0940 hrs

Modifying the Solar Spectrum: Bridging the Gap between First and Third Generation Photovoltaics

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The application of luminescent devices to existing silicon solar cells has the potential to bridge the gap between first and third generation photovoltaics (PV) and enhance the energy conversion efficiency. Two mechanisms that limit the efficiencies of conventional solar cells are, firstly, the transmission of sub-bandgap light and, secondly, the thermalisation of charge carriers generated by the absorption of photons with an energy greater than the silicon bandgap (Eg) of the semiconductor. In this paper we discuss ways of reducing these losses via the application of passive optical devices called up- and down-converters, respectively.

RE FRF15
Friday 0940–1000 hrs

Photoelectrochemical Hydrogen Production

J.A. Glasscock[1,3], P.R.F. Barnes[1,3], L.K. Randeniya[1,3], A.B. Murphy[1,3], I.C. Plumb[1,3], P.B. Gwan[1,3], I.E. Grey[2,3], N.C. Wilson[2,3], C. Li[2,3] and M.D. Horne[2,3]

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The commercial production of hydrogen from water using sunlight as the energy source requires an efficiency around 10%. We are investigating flame-oxidised titanium, doped titanium dioxide (TiO_2), reduced TiO_2 and cadmium sulphide (CdS) for use as photo-anodes in an electrochemical cell. TiO_2 electrodes prepared by flame oxidation or controlled atmosphere oven oxidation have a maximum efficiency around 0.31% in sunlight, close to the theoretical maximum for TiO_2. Treated CdS electrodes have a maximum efficiency of around 0.98% in sunlight. Better understanding of the physical, electronic, optical and chemical properties of the materials are required to achieve the target efficiency.

Solar-Terrestrial and Space Physics (STSP)

STSP MOB11
Monday 1040–1120 hrs

Climate and Weather of the Sun-Earth System (CAWSES): SCOSTEP's New Interdisciplinary Research Program

Sunanda Basu (presented by Kozyra)

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Climate and Weather of the Sun-Earth System (CAWSES), the new program for 2004–2008, developed by ICSU's interdisciplinary body Scientific Committee for Solar Terrestrial Physics (SCOSTEP), aims to bring together the world's scientists in a cooperative effort to study the entire interactive Sun-Earth system. SCOSTEP recognizes the very impressive past, present, and planned space missions; ground-based observations; and theory, modeling, and data analysis efforts aimed at understanding aspects of this coupled system. CAWSES, seeks to mobilize the international solar-terrestrial science community to fully utilize such data archives, and future data streams; to produce improvements in space weather forecasting, design of space- and Earth-based technological systems, and understanding the role of solar-terrestrial influences on Global Change. The CAWSES Science Steering Group has organized the program around five themes: Solar Influence on Climate, Space Weather: Science and Applications, Atmospheric Coupling Processes, Space Climatology, and Capacity Building and Education. The aim of this talk is to provide information to the international science and applications community on the CAWSES goals, objectives and implementation plans and to solicit inputs for future updates of the science plan. Some results from the first CAWSES Space Weather and Atmospheric Coupling Campaigns held during March-April, 2004 will also be discussed.

STSP MOB13
Monday 1120–1140 hrs

The Intensity of 558 nm Airglow at Adelaide, Australia

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A three-field photometer has been operated at the University of Adelaide's Buckland Park (35°S, 138°E) field site to collect observations of the intensity of 558 nm OI and 730 nm OH airglow emissions since April 1995. Night-time intensity data have been collected on an almost continuous basis with observations made when the effect of the moon is not evident in the instrumental field of view. Interpretation of the 730 nm data is limited by the presence of the Milky Way and we will discuss them elsewhere. Here we discuss the variability of the intensity of the OI 558 nm airglow, which exhibits solar cycle, quasi-biennial, annual, semi-annual and ter-annual periodicities.

STSP MOB14
Monday 1140–1200 hrs

Expanding Our Understanding of Atmospheric Ozone through CAWSES

Martin G. Mlynczak[1], Dan Marsh[2], Rolando Garcia[2], Ray Roble[2], Franz-Josef Luebken[3] Janet Kozyra[4], Sunanda Basu[5]

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Ozone exerts significant control over the atmospheric thermal structure through absorption of ultraviolet radiation and emission of infrared radiation. Through its influence on the thermal structure, ozone variability affects the circulation of the atmosphere. This fundamental process remains a frontier of atmospheric science research. We examine the prospects for comprehensively assessing our understanding of atmospheric ozone within the framework of the Climate and Weather of the Sun-Earth System (CAWSES) program. Relevant space-based observations of the ozone profile from the surface to 100 km will be reviewed, and emerging "whole atmosphere" modeling capability to analyze the data will be presented.

STSP MOB15
Monday 1200–1220 hrs

Geospace System Behavior from Global Observing Campaigns: Science at the Core of the CAWSES Space Weather Focus

J. U. Kozyra[1], K. Shibata[2], S. Basu[3], A. J. Coster[4], N. Gopalswamy[5], I. R. Mann[6] and M. G. Mlynczak[7]

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The Sun-Earth interaction forms a dynamical system in which close couplings and feedbacks can change the zeroth order geospace response to solar eruptions. In fact, this system behavior lies at the frontier of knowledge in space science. Recent community campaigns utilizing satellites observing at vantage points from Sun to the middle atmosphere along with worldwide ground-based facilities have allowed us to follow physical processes from start to finish, and contribute to efforts to characterize the global system. We will highlight examples of this from some recent cross-disciplinary campaigns including the March/April 2004 CAWSES (Climate and Weather of the Sun-Earth System) campaign.

STSP MOB21
Monday 1400–1420 hrs

Nowcasting and Forecasting at the Australian Space Forecast Center

P. Maher, R. Marshall, J. Kennewell, G. Patterson

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The Australian Space Forecast Center at IPS Radio and Space Services, an organisation within the Australian Government, is the delivery point for space weather information and services to the Australian region and beyond. IPS operates a network of observatories from Antarctica to equatorial regions that provide solar, geomagnetic and ionospheric data in near real-time. These data sources drive models and alert systems to produce nowcasts and forecasts in an operational environment. This presentation illustrates the nowcasts and forecasts made during operations by tracking the progress of space weather events such as solar flare detection, CME shock speed determination, magnetospheric impact, magnetic storm detection, ionospheric storm monitoring and the impact they have on the Earth.

STSP MOB22
Monday 1420–1440 hrs

Observing the Open-closed Boundary Using Pc5 ULF Waves

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We present a new ground-based diagnostic of magnetic merging at the magnetopause using data from two close (~110 km), magnetic azimuthally spaced magnetometer sites, Davis and Zhongshan. During average IMF conditions these sites pass just equatorward of the last closed field lines in the dayside magnetosphere, and field line resonances (FLRs) are seen. During active conditions (IMF Bz<<0) the FLRs disappear and are replaced by intervals of broadband activity, with the azimuthal component of propagation directed towards noon. Two example days are given in which the dynamics of the open-closed boundary (OCB) can be inferred.

STSP MOB23
Monday 1440–1500 hrs

The Ionospheric Convection Response to Transient Reconnection

S.K. Morley[1,2] and M. Lockwood[1,3]

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Using the Cowley-Lockwood (CL) flow excitation theory, a numerical model[1] has been developed, which we can use to generate time series of maps of parameters such as the sheath ion flux, the low-energy cut-off, as well as the convection patterns and maps of the consequent ion heating. Model results show that quasi-global convection responses are commensurate with the CL paradigm and that the response is relatively invariant to reconnection rate variations, given that the total displacement from equilibrium is constant and takes place on a shorter timescale than the inductive response time.

[1] M. Lockwood and S.K. Morley, Ann. Geophys., 22, 73 (2004)

STSP MOB24
Monday 1500–1540 hrs

Solar Wind Driven Storms and Substorms with High Energy Electron Injections into the Inner Magnetosphere

Wendell Horton

The solar wind punctuated with shocks from coronal mass ejections produces periods of days with intense stormy conditions in the Earth's magnetosphere and ionosphere. Spacecrafts monitoring the solar wind make possible some degree of forecasting for storms and substorms. Energy pathways into the inner magnetosphere from the solar wind dynamo are described. Coordinated storm datasets collected for a community wide challenge are used to illustrate the phenomena. The physics transport models are used to interpret and predict the geomagnetic index AL for the nightside auroral currents in the E-layer ionosphere and the equatorial magnetic disturbance index Dst from the ring current.

STSP MOB31
Monday 1620–1700 hrs

Diagnosing Solar Particle Acceleration and Propagation Using Radio Emissions

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A recent study[1] finds that all prompt solar energetic particle (SEP) events are preceded by type III radio bursts. This association suggests that ions accelerated in

reconnection regions may make a significant contribution to SEP events. Furthermore the drift rates of the bursts provide information about particle propagation in the inner heliosphere not obtainable in any other way at the present time. Results obtained in this manner will be placed in the context of other recent SEP studies.

[1] H. V. Cane, W. C. Erickson and N. P. Prestage, J. Geophys. Res., 107, SSH 14–1 (2002)

STSP MOB33
Monday 1700–1720 hrs

Type II Radio Bursts: Theoretical Predictions of Dynamic Spectra and Source Regions

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The source regions of type II radio bursts lie upstream of high Mach number shocks. Here we present theoretical predictions from an analytic, semi-quantitative model of type II radio bursts, which involves electron reflection and acceleration at a shock moving through the inhomogeneous solar wind, beam formation upstream of the shock via time-of-flight effects, Langmuir wave growth driven by the electron beams, and the conversion of Langmuir waves into freely propagating radiation by nonlinear wave-wave processes. A diverse range of commonly observed spectral structures are shown to be naturally produced by a relatively simple theoretical model.

STSP MOB34
Monday 1720–1740 hrs

Timing of the 2–3 kHz Radio Emission within the Solar Cycle

J.J. Mitchell[1], Iver H. Cairns[1], H-R. Mueller[2,3] and G.P. Zank[3]

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High power radio emissions near 2–3kHz from the outer heliosphere have been observed by the Voyager spacecraft. Recent theories for these emissions combine acceleration of electrons at global merged interaction region shocks with formation of a superthermal electron tail by lower-hybrid drive, associated with pick-up ions, beyond the heliopause. This paper examines the efficiency of this process based on the availability of pick-up ions associated with periodic solar cycle variations in the solar wind ram pressure. Strong emission is predicted approximately 2–3 years after solar maximum, in close agreement with the observed events, providing further evidence for the proposed model.

STSP MOB35
Monday 1740–1800 hrs

The Ion Aurora and Its Seasonal Variations

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Recent studies have shown that intense discrete aurora are more intense in the winter hemisphere than in the summer, particularly in the dusk to midnight sector. Here, we use one solar cycle of DMSP satellite particle data to investigate the seasonality of the ion aurora. The ion aurora proves to be approximately equal in the summer and winter hemispheres in the dusk-midnight sector (with the summer hemisphere favored by 0 to 4%). However in the MLT hours from midnight to dawn, the ion precipitating energy flux is 15–40% higher in winter than in summer. The absolute magnitude of the ion effect is smaller than was found for discrete electron aurora (which show a 3-fold difference between winter and summer). The seasonal behavior of the ions may reflect the observation that diverging electric fields, which accelerate ions downward, are found mainly postmidnight, and are stronger in the winter.

POSTERS

STSP PTH 55

Plasma Structuring in the Middle and Equatorial Ionosphere During Intense Magnetic Storms

Santimay Basu[1], Sunanda Basu[2], K.M. Groves[1], E MacKenzie[3], F. Rich[1], and , M.J. Keskinen[4]

Near-simultaneous formation of plasma density structures in the ionosphere at middle and equatorial latitudes during intense magnetic storms under solar maximum conditions is investigated. The evolution of these structures in the scale length range of tens of km to tens of meter is studied by measuring amplitude scintillation of satellite signals at VHF and L-band, phase fluctuations of GPS signals and by detecting equatorial plasma bubbles with DMSP satellites. It is shown that at the time of the fast rate of change of SYM-H (high resolution Dst index), that often characterizes the high latitude electric field penetration into the plasmasphere, an impulsive onset of scintillation occurs at sub-auroral locations. The associated plasma structures in the equatorial ionosphere are observed only in specific longitude sectors for which the early evening period corresponds to the universal time of rapid SYM-H variation. From continuous measurements of amplitude scintillation and phase fluctuations, it is found that the onset of equatorial plasma structures is delayed by about 20 minutes from the onset of midlatitude scintillation. This delay is discussed in the framework of instantaneous storm-time electric field penetration from high latitudes to middle and equatorial latitudes and the instability growth time of sub-km scale irregularities. It is also shown that during intense storms, the equatorward neutral wind can

cause the post-sunset plasma drift in the equatorial region to be as large as 200 m/sec in the westward direction in contrast to the quiet time drift of 100 m/sec in the eastward direction.

STSP PTH 56

Research on Solar-Terrestrial and Space Physics at the University of Sydney

Iver H. Cairns[1] and colleagues

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Space and solar physics, together with the requisite plasma physics, are major research foci at the University of Sydney. The team includes 4 members of continuing academic staff (including 1 Federation Fellow, 2 Australian Professorial Fellows, and 1 Queen Elizabeth II Fellow), 5 postdoctoral scientists, and three PhD students. This poster summarizes some of the team's recent research on solar, interplanetary and magnetospheric phenomena associated with coronal mass ejections (CMEs), solar flares, and propagation of shocks into the local interstellar medium. Emphasis is placed on understanding these phenomena and other "space weather" events by developing theories and testing them with data from international spacecraft, as well as on the breadth of fundamental plasma physics researched, which ranges from the growth of plasma waves and radiation to particle acceleration, shock waves, self-organization and complex systems.

STSP PTH 57

Electron Acceleration due to Lower Hybrid Waves in Magnetic Reconnection Regions

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Magnetic reconnection is widely believed to produce significant plasma heating and acceleration of particles to high energies. Little agreement exists as to how this

is done. Here it is shown that critical theoretical difficulties are posed by differences between recent solar and magnetotail observations of electron acceleration in reconnection regions. Lower hybrid waves are common in Hall-MHD simulations and Wind spacecraft observations of reconnection. It is suggested that lower hybrid waves are important in accelerating electrons and heating ions in reconnection regions, via so-called "lower hybrid drive". Analytic theory is used to support this suggestion and to argue that lower hybrid drive should be much more efficient under solar conditions.

STSP PTH 58

Latitudinal and Temporal Variation of Trans-Ionospheric Radio Wave Scintillation in the South-East Asian Region

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We investigate the spatial and temporal distribution of scintillation of GPS signals traversing the equatorial ionosphere in the South-East Asian longitude sector using data collected during 1998 to 2002 with our network of GPS based scintillation monitors[1]. The aim of this work is to better understand the morphology and climatology of ionospheric irregularities in our region in order to improve the existing model of scintillation occurrence, *viz.* WBMOD. Previous work has shown that this model does not adequately characterise the South-East Asian equatorial ionosphere[2].

[1] R.M. Thomas, M.A., Cervera, K. Eftaxiadis, S.L. Manurung, S. Saroso, Effendy, A.G. Ramli, W. Salwa Hassan, H. Rahman, M.N. Dalimin, K.M. Groves, and Y. Wang, Radio Sci., **36(6)**, 1545–1557, 2001.

[2] M.A. Cervera, R.M. Thomas, A.G. Ramli, Effendy, and K.M. Groves, Radio Sci., **36(6)**, 1559—1572, 2001.

STSP PTH 59

An Australian Space Weather Plan

D.G. Cole[1], J.A. Kennewell[2] and P.J. Wilkinson[1]

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Space weather can damage spacecraft vehicles, their solar cells, and electronics. Adverse ionospheric conditions impair the operation of HF communications and radar. Geomagnetic fields and ionospheric currents can cause costly damage to terrestrial power systems and long pipelines.

Monitoring space weather conditions and the delivery of timely forecasts are necessary prerequisites for successful operation of many systems, space-based or ground-based. To be effective, services need accuracy that depends on global data and techniques developed through research. A national plan advocating space weather monitoring, research and public outreach has brought these factors into clear focus. Implementation of this plan will be discussed.

STSP PTH 60

IPS Radio Propagation and Space Weather Services

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IPS supports and enhances national security, defence, emergency services, public safety, and industry, by providing services and advice on space weather conditions.

The successful operation of many radiocommunication, navigation, spacecraft, power and pipeline systems is dependent on space weather. Space weather is highly variable and IPS advice is a major factor in minimising the impairment of systems that provide vital information, surveillance and emergency infrastructure services.

The IPS Poster provides a summary of IPS services, its network of observatories within the Australasian region and details of the World Data Centre for Solar-Terrestrial Science

STSP PTH 61

Doppler Shifts in HF Signals due to ULF Plasma Waves in the Ionosphere

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The ionosphere plasma is continually perturbed by ultra-low frequency (ULF; 1–100 mHz) plasma waves, incident from the magnetosphere. We present an experimental and modeling study of the frequency shift of HF signals caused by ULF wave energy in the ionosphere. Modeling the interaction shows that the **e×B** plasma drift is the dominant mechanism affecting HF frequencies with reflection altitudes >200 km. The ULF wave spatial structure is shown to be a critical parameter that determines the magnitude of the frequency shift of HF signals propagating through the ionosphere.

STSP PTH 62

Backscatter Sounder Observations of Sporadic E

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Backscatter sounder data, recorded by the Jindalee over-the-horizon radar's Frequency Management System from 1985 to 1999, has been used to study the morphology of sporadic E in the Jindalee surveillance area. Results will be presented on the daily, seasonal, sunspot cycle and azimuthal variations in the occurrence probability of sporadic E and of blanketing sporadic E. In general, the morphology of sporadic E observed by the Jindalee backscatter sounder is similar to that reported by vertical incidence studies. However, in the case of blanketing sporadic E, its occurrence probability, as observed by the Jindalee backscatter sounder appears to be inversely correlated with sunspot number whereas vertical incidence observations have reported a positive correlation.

STSP PTH 63

A Comparison of the Australian Space Weather Plan with Developing International Space Weather Needs

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The Australian Space Weather Plan has been developed specifically to serve current Australian needs. It is interesting to compare the current Plan with the techniques and requirements identified in similar plans developed in other countries. A survey of papers, conference presentations and various national space weather plans produced over the last five years are used to determine the overseas viewpoint. This is then contrasted with the Australian Plan. Differences will be highlighted and if appropriate, recommendations will be made regarding future updates to the Australian Plan.

STSP PTH 64

On Monitoring Nuclear Quadrupole Resonance Signal Level During Astronomical Events with a Very Simple Spectrometer

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This simple paper will briefly report on monitoring of the N .Q. R resonance signal of 35 Cl nuclei in sodium chlorate , during some astronomical events such as solar and lunar eclipses and during a comet-fragment impact with Jupiter. The modus operandi of the extremely simple spectrometer will be outlined. The simplicity of the spectrometer and of its usage may be of interest.

STSP PTH 65

Heterogeneous Chemistry's Role in Stabilizing CO2 in the Venus Atmosphere

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The most successful photochemical models of the Venus atmosphere[1,2,3] have relied on chlorine catalytic chemistry to explain the apparent stability of CO_2 in the Venus atmosphere. However, key model reaction rates are poorly constrained and unresolved differences remain between model calculations and observations, so alternative catalytic schemes, such as heterogeneous chemistry, should be explored. This paper uses numerical simulations to assess the significance of heterogeneous chemistry as a guide for future laboratory measurements.

[1] Yung and DeMore, Icarus, **51**, 199 (1982)

[2] Krasnopol'sky and Parshev, in Venus, 431 (1983)

[3] Pernice, et al., PNAS, **101**, 14007 (2004)

STSP PTH 66

Equatorial Ionospheric Irregularity Occurrence at Vanimo During Space Weather Month, September 1999

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Recent progress has been made towards achieving reliable forecasts of ionospheric equatorial irregularity occurrence and the associated phenomena of satellite scintillation and spread-F[1,2]. Benefits are expected to follow in the areas of satellite communications, satellite navigation, HF communications and HF radar, making this an important aspect of Space Weather. In this paper we explore the relationships between various regional ionospheric datasets in order to gauge the feasibility of providing a future irregularity forecasting capability for local users.

[1] R.J.Stening, Space Science Reviews, **107**, 263 (2003)

[2] S. Basu et al, J Atm Sol-Terr Phys, **64**, 1745 (2002)

STSP PTH 67

Solar Cycle and Dynamical Influences on D-Region Electron Densities

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Long-term measurements of electron densities in the *D*-region made using MF partial reflection techniques at Adelaide will be discussed. Observations include some of the first detailed studies of electron densities in the nightime lower ionosphere (80–100 km). The results show the influence of coupling from both above and below, with long term changes linked to solar cycle variations in ionising fluxes and seasonal changes that are linked to dynamical effects. In particular, seasonal changes seem to be associated with vertical transport of NO by the (1, 1) diurnal tide.

STSP PTH 68

Dusty Plasmas in Solar System and Near-Earth Environment

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Here, I overview various dusty plasmas existing in Solar system and near-Earth environment such as those in the Earth ionosphere and magnetosphere, in the interplanetary space, in comets, and planetary rings. Various plasma conditions are discussed. The fundamental feature of a dusty plasma is the charge appearing on dust particles. Collective properties of such a plasma are strongly related to the influence of the additional charged plasma component.

STSP PTH 69

Attractors and Singularities in the Magnetosphere

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The energy flux from the solar wind through the coupled potential and kinetic energy subsystems of the Earth's magnetosphere and ionosphere is formulated in the WINDMI model[1] as a low-dimensional dynamical system, comprising a superposition of linear and nonlinear rate processes for energy inputs, transfers, and dissipation. In this work a smooth pathway is surveyed through the structure of the WINDMI model by systematically interrogating degenerate singularities and bifurcations in various versions. Since higher-order singularities are diagnostic of important physical properties and processes

such as symmetries and hysteresis[2], their unfoldings can enhance the capabilities of the model to describe and predict magnetosphere substorms.

[1] W. Horton, M. J. Mithaiwala, and E. A. Spencer (2004). WINDMI: A family of physics network models for storms and substorms. Preprint: http://www.ph.utexas.edu/dept/research/horton/.

[2] R. Ball (2004). The case of the trapped singularities. Preprint: http://wwwrsphysse.anu.edu.au/~rxb105/rb.html.

STSP PTH 70

Multivariate Analysis Of 630-Nm Airglow Observations from Mawson Station, Antarctica

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An extensive set of airglow observations of red line emissions, from a height of approximately 240km, have been made with a Fabry-Perot Spectrometer. The observations were made between 1992 and 1999 at Mawson Station (67.6° S. 62.9°E). The results of multivariate analysis will be presented and discussed in relation to the relative correlation between the observed thermospheric winds, temperatures and airglow intensities, and possible influences such as sunspots, geomagnetic activity, solar declination and zenith angle, and lunar phase and zenith angle. Chronology of the data set will be illustrated.

STSP PTH 71

Climatic and Diurnal Variability in the Occurrence of 10-M Scale Irregularities in the Auroral Ionosphere

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SuperDARN HF backscatter radars measure the power and Doppler characteristics of echoes backscattered from 10-m scale irregularities in the high-latitude ionosphere. Occurrence statistics of these echoes were compiled for the TIGER SuperDARN radar for the four-year interval of declining solar activity, 2000 to 2003. The occurrence rates tended to decline with decreasing solar activity, probably due to weaker F-region refraction. They tended to be largest during March equinox and post-midnight, but were otherwise suppressed by increasing solar-elevation angle. This is consistent with the Pedersen conductance assisting formation of irregularities via the interchange instability, yet suppressing them via enhanced cross-field diffusion.

STSP PTH 72

A Comparison of Observed and Modelled Aircraft Radiation Dose Rates During Cosmic Ray Transient Variations

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Coronal Mass Ejections can suppress the cosmic ray intensity and reduce the background radiation dose at all aircraft altitudes. Conversely, during Ground Level Enhancements, relativistic solar protons produce a dose increase. In both cases the modulation parameter used as an input to the aircraft flight dose estimation models incorrectly describes the cosmic ray environment resulting in erroneous estimates. In October and November 2003 onboard dosimetry monitoring equipment observed the effects of both types of variation during a commercial passenger aircraft flight. A comparison of these observations with the model dose estimates is presented.

STSP PTH 73

Tomographic Observations of the Plasmasphere using Fedsat

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The constellation of GPS satellites provide a convenient means of continually monitoring the Total Electron Content (TEC) of the ionosphere and plasmasphere using ground-based receivers. Networks of receivers can then be used to map the electron density structure by means of tomography. However, because the ionosphere near the F2 peak provides the dominant contribution to the TEC, relatively little can be determined about the plasma in the plasmasphere. FedSat orbits at 800 km altitude, well above the bulk of the ionospheric plasma, so tomography applied to FedSat GPS observations reveals plasmaspheric structure. This paper will present the first results from FedSat which show more variability and structure in the plasmasphere than expected.

STSP PTH 74

Research on Solar-Terrestrial and Space Physics at the University of Newcastle

B. J. Fraser and the Space Physics Group

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Research within the Space Physics Group (SPG) primarily studies ultra-low frequency (ULF) hydromagnetic and ion-cyclotron (EMIC) plasma waves, plasma convection and current systems in the Earth's plasmasphere, magnetosphere and ionosphere. Data from spacecraft, including the Australian microsatellite FedSat, and ground magnetometer arrays at low and high latitudes, supported by theory, are used to study; ULF and EMIC waves in the magnetosphere and ionosphere; high latitude field-aligned currents (FAC); magnetosphere-ionosphere coupling, using HF radars; magnetosphere plasma properties using ULF waves as diagnostic probes; and the energy flux coupling the ionosphere to the atmosphere. The SPG is a core partner in the CRC for Satellite Systems, which built FedSat, a low-Earth polar orbiting microsatellite launched in December 2002, carrying the NewMag magnetometer experiment to measure the Earth's main field, current systems and ULF waves. This poster will illustrate some of the recent achievements relating to the above research.

STSP PTH 75

Electromagnetic Ion Cyclotron Waves, Plasma Density Structures and Ring Current Decay

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Pitch angle scattering of ring current ions by electromagnetic ion cyclotron (EMIC) waves is a commonly postulated mechanism employed to explain ring current losses during the geomagnetic storm recovery phase. Sub-auroral proton arcs have been associated with proton precipitation and enhanced cold plasma densities in the plasmasphere/magnetosphere. Proton anisotropy favourable to the generation of EMIC waves has also been seen. The missing link in the ring current loss mechanism is the observation of the associated EMIC waves. Specific event examples relating EMIC wave observations from the GOES geostationary satellites to thermal plasma density enhancements and precipitation will be discussed.

STSP PTH 76

SuperDARN: A New Network of HF Radars for Oceanographic Research

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Large military OTH radars can measure ocean wave heights, surface currents, and surface wind directions over vast, remote regions. It has long been a dream to deploy a network of relatively compact, portable sky-wave radars dedicated to the provision of real-time oceanographic and meteorological data. We demonstrate the potential for the SuperDARN radars to achieve this. This has become possible with the implementation of a new radar operating system which permits the acquisition of complex time series data. The detection of illegal fishing vessels in the remote Southern Ocean may become possible with planned advances in hardware and software.

STSP PTH 77

Observations Of A Phase Transition In The Plasma Characteristics Across The Open-Closed Magnetic Field Line Boundary

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The TIGER HF radar is the most equatorward SuperDARN radar, enabling it to routinely observe a sharp transition from large spectral widths located on open field lines to low spectral widths on closed field lines. The large spectral width regions are dominated by Lorentzian Doppler spectra and the low spectral width region by Gaussian spectra. This implies a phase transition from fast flowing, turbulent plasma with a correlation length of velocity fluctuations less than the scattering wavelength to a slow moving plasma with a correlation length greater than the scattering wavelength. The large conductivity of nightside auroral oval probably plays a role in forming this phase transition.

STSP PTH 78

High Resolution Measurements of Ionospheric Variations on an Oblique Path

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High resolution observations were made of the elevation, azimuthal, power and Doppler variations for oblique propagation at fixed HF frequencies on a mid-latitude path during a 48 hour period in April 2004. During this period several large scale travelling ionospheric disturbances were evident and their effect on the propagation path observed. More commonly observed were shorter time scale variations associated with smaller spatial scale ionospheric variability. The dimensionality of the data allows the inference of ionospheric gradients near the path midpoint, and the separation of the effect in Doppler between the great-circle path rays and energy from out-of-plane paths.

Although investigations are continuing, preliminary results will be presented and discussed.

STSP PTH 79

Polarization Statistics of Stochastic Waves

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A method is described to compute the statistics of the measurable Stokes parameters and degrees of polarization, resulting from the vector addition of multiple wave populations. Several striking results ensue, including the appearance of fine structure in the distribution function for the degrees of polarization, and the generation of circularly polarized light with opposite handedness from the superposed wave populations. These results have important consequences for the interpretation of polarity resolved data (e.g., pulsars, auroral kilometric radiation, edge oscillations in laboratory plasmas), as they show that inference of the underlying polarization and statistical properties of the component wave populations is not trivial.

STSP PTH 81

Leading Edge Detection using a Two-Dimensional Discrete Wavelet Transform

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Backscatter ionograms are a powerful means of assessing radio wave propagation in the ionosphere and have become an important tool for frequency management in HF communications and Over-the-horizon Radar. The boundary between significant and negligible backscattered power, the leading edge, is of particular interest providing information about skip zones and the maximum frequency propagated to a given region.

Leading edges can be extracted in real time from the backscatter ionogram using a two-dimensional discrete wavelet transform (2D-DWT)[1]. The DWT algorithm has been further developed to fit irregularities where the first and second leading edges are not well separated.

[1] M. D. McDonnell, 'Wavelet Based Detection and Fitting of Backscatter Ionogram Leading Edges', Proceedings of the Workshop on Applications of Radio Science, Hobart, 2004

STSP PTH 82

Planetary Foreshock Radio Emissions

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The electron foreshock region upstream of Earth's bow shock and of travelling interplanetary shocks are known to produce strong radio emissions. A quantitative theoretical model has been developed for terrestrial foreshock radio emissions[1], and for coronal and interplanetary type II radio bursts[2]. Here, we present a detailed comparison between the predicted and observed levels of terrestrial foreshock radio emissions. We also generalize the theoretical model to other planetary foreshocks, and we compare the predicted levels of radio emissions from the foreshocks of other planets to that from Earth's. Contrary to some expectations, our theoretical results predict exceptionally strong radio emissions from Mercury's foreshock, in particular, and relatively weak radio emissions from the Jovian and Saturnian foreshocks. These predictions may be testable with forthcoming space missions such as Messenger and Beppi Colombo, as well as existing missions such as Galileo and Cassini.

[1] Z Kuncic, I. H. Cairns, S. A. Knock, J. Geophys. Res., **109** (2004)

[2] S. A. Knock, I. H. Cairns, Z. Kuncic, J. Geophys. Res., **108**(A3) (2003)

STSP PTH 83

IMAGE, Geotail, and TIGER Observations of a Magnetospheric Substorm

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We present observations during a magnetospheric substorm of ionospheric flows by the TIGER radar in conjunction with global auroral images from IMAGE and in situ measurements of the magnetic field, plasma density, and velocity in the plasmasheet by Geotail. The estimated ionospheric footprint of Geotail is within the TIGER radar field of view. We observe enhancements of flow

associated with each auroral brightening throughout the substorm and Geotail observes clear rapid changes of the magnetic field configuration and plasma velocity at the time of substorm onset. We discuss the results in terms of the current models for magnetospheric substorms.

STSP PTH 84

A Theory of the Stepped Leader in Lightning

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Lightning strikes are preceded by a “stepped leader”, invisible to the eye. This leader proceeds from the cloud to the ground, in a series of steps, usually with branches, each step being about 50 m in length, but new steps only form after a period of darkness of about 50 _s. The principal features of the stepped leader are explained by the motion of electrons and ions in air at ambient temperature, accounting for effects of space charge distortion of the electric field. The dark time between steps is due to a period when all electrons become attached to form negative ions. A new step is formed when ion motion produces a negative ion sheath and a high local electric field at the head of the leader.

STSP PTH 85

Simulation of Travelling Ionospheric Disturbances Using Ray Tracing Techniques

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Travelling Ionospheric Disturbances often show up strongly in HF radar range-time plots of echo power. Simulations of these disturbances have been made using the numerical ray tracing program Raymag to first order by assuming that the TID is causes a simple wave like perturbation of the electron density. These simulations are then displayed as range-time plots of echo power and compared to real TID data observed by the TIGER HF radar component of the SUPERDARN network. The changes made to the Raymag program now allow for parameters such as wavelengths to be evaluated by finding the best suited simulation to observed TID’s in the ionosphere.

STSP PTH 86

The Effects of Main and Lithospheric Geomagnetic Field Models on Low Latitude Current Systems

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Using satellite magnetic observations to derive transient currents systems is not a straight forward task. First we must remove the main field because it masks all other components by an order of 10^4(nT). Using the dip equator as a base we will show that constraints and laxations exist for the satellite data. The static lithospheric field must next be removed. If the model of this field is not determined correctly then significant errors reside in the residuals. This is most noticeable when determining the signature of the equatorial electrojet because the lithospheric anomalies have a similar wavelength.

STSP PTH 87

Mass Density at L=2.5 During a Magnetic Storm: a Case Study

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Two independent ground-based techniques have been used to examine properties of field-aligned ducts in the inner magnetosphere. In one technique the resonant frequency of ULF waves is determined from the cross-power and -phase spectra between paired magnetometers. The other technique involves analysis of artificially produced whistler-mode signals propagating along field-aligned ducts. These signals are Doppler shifted by radial motions of the flux tube driven by the electric field of the ULF waves. We examined data collected over 2001 from a VLF receiver and 3 closely spaced magnetometers near Rothera, Antarctica, corresponding to the L=2.5 flux tube. We discuss example events and find new information on the propagation of ULF wave modes deep within the magnetosphere.

STSP PTH 88

The Characteristics and Dynamics of Polar Mesosphere Summer Echoes (PMSE) above Davis, Antarctica

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The first observations of Polar Mesosphere Summer Echoes (PMSE) above continental Antarctica were detected at the polar station Davis (68.6ϒS) using a 55 MHz atmospheric radar during the 2003–04 austral summer. In this paper we present the characteristics and dynamics of PMSE events observed on 27 days. Satellite temperature measurements revealed that PMSE exist for mesosphere temperatures < 150K. Mesosphere horizontal wind field radar measurements showed that PMSE occurred during conditions of westward zonal winds and equatorward meridional winds. We also consider vertical coupling processes in the PMSE layer at 82–90 km, including: from above with cosmic noise absorption and E-region ionospheric plasma instabilities; and from below with tidal, gravity and planetary waves.

STSP PTH 89

All-Sky Doppler Imaging of the Aurora at 557.7-nm

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Doppler spectroscopy of auroral 557.7-nm emissions can measure wind and temperature between 100– and 140–km altitude, where large vertical gradients occur in both quantities. However, previous observations have been difficult to interpret, because of variability in the emission height under changing auroral conditions. A new instrument in Alaska can now record two-dimensional *images* of Doppler spectra across the whole sky, every few minutes. These data identify times when emission altitude actually does *not* vary significantly, and meaningful wind estimates are indeed possible. Conversely, when the emission altitude is highly variable, it is possible to obtain height-resolved profiles of E-region wind.

STSP PTH 90

A Comparison of Ionospheric Propagation Conditions Derived from Backscatter Soundings using Instrumentation Hosted by the Jindalee Operational Radar Network

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A Frequency Management System, consisting of a Backscatter Sounder and other HF monitoring tools, is incorporated into the design of each Over The Horizon Radar. Such equipment provides real-time assessment of HF environmental conditions, and by regularly sampling ionograms over time, a synoptic picture of ionospheric propagation can be realised. A comprehensive database, spanning a complete sunspot cycle, exists for the Alice Springs Radar. Supplementing this dataset are soundings from the new radar installations at the Longreach and Laverton sites. These two sites provide a means of sounding the ionosphere from different geometrical perspectives. This paper endeavours to explore whether the Alice Springs backscatter ionograms can be transformed, by appropriate shifts, to match the observations from the new sites. The paper is concluded by comparing real observations with synthetic ionograms.

STSP PTH 91

Statistical Addition Method for External Noise Sources Affecting HF/MF/LF Systems

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The accepted statistical method[1] for the addition of external component noise sources in the LF, MF and lower HF band (100 kHz to 3MHz) produces total median noise levels that can be less than the largest component median in some cases. Several case studies illustrate this anomaly[2]. Methods used to sum the components rely on their power (dB) distributions being represented as normal by the statistical parameters. The atmospheric noise component[3] is not correctly represented by its decile values when it is assumed to have a normal distribution, causing anomalies in the noise summation when components are similar in magnitude. A revised component summation method is proposed and the way it provides a more physically realistic total noise median for LF, MF and lower-HF frequencies is illustrated.

[1] CCIR Report 322–3, International Telecommunications Union, Geneva (1986)

[2] Neudegg D.A., Radio Sci., 36, 6 (2001)

[3] Warber C.R. and B. Prasad, Radio Sci., 32, 5, 2027 (1997)

STSP PTH 93

Ionospheric Sounding Using Occultation Measurements from GPS Receivers On-board the Low Earth Orbiter Fedsat

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The Australian Low Earth Orbit (LEO) satellite Fedsat was launched in 2002. Fedsat has on-board GPS receivers and thus receives GPS radio occultations, which are the GPS signals received from negative elevations. Using the occultation measurements, techniques have been developed to model and map the distribution of the electron density up to the altitude of the Fedsat orbit, which is 800 km above the Earth's surface. The technique for determining the electron density involves generalizing the Abel transform of the slant TEC measurements and a new technique for determining the impact parameter. This new impact parameter aids the mapping and modelling of the Earth's electron density distribution.

STSP PTH 94

Comparison of an HF Directional Noise Model with the Jindalee 360 degree Background Noise Database

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DSTO requires a high frequency (HF) directional noise model (DNM), for projects including the next generation Jindalee over-the-horizon radar (OTHR), for which azimuthal and elevation angle variations in background noise are important. We have implemented a DNM that will generate background noise data as a function of frequency, sunspot number, season, time, azimuth and elevation angle, at any geographic location. The model is based on ray tracing through a monthly median ionosphere, and uses a lightning database to predict the environmental noise component that will propagate to a given point. The Jindalee OTHR facility near Alice Springs has begun collecting 360° background noise data that is being used for validation. It is anticipated that the new model will replace the currently used CCIR model that has known limitations and that does not provide azimuthal or elevation angle information.

STSP PTH 95

Performance Analysis of Two Autoscaling Software

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Due to the need for more timely availability of ionospheric data manual scaling of ionograms is being replaced by automatic computerized scaling of the digital ionograms. Compared to manual scaling the autoscaling software does have its limitations. This paper presents a comparative study of the performance of ARTIST and IPS autoscaling software with manual scaling for ionograms from Learmonth, which is a mid-latitude station.

STSP PTH 96

Are there Signatures of Complexity in Fluctuating Magnetospheric Electric Fields Implied by HF Radar Observations of Ionospheric Doppler Shift?

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Signatures of complexity and self-organised criticality in natural systems include intermittency and self-similarity over extended spatial and temporal scales. Generic re-scaling techniques have been applied to the probability distribution functions (PDFs) of fluctuating magnetospheric electric fields implied by SuperDARN measurements of Doppler velocity made in the high-latitude ionosphere. The PDFs were sorted according to the orientation of the interplanetary magnetic field, magnetic local time, and ionospheric regions of high and low Doppler spectral width (regions of open and closed magnetic flux, respectively). Mono-fractal re-scaling of the PDFs was strongest on open field lines in the noon sector during the winter.

STSP PTH 97

ULF Wave Studies Using SuperDARN TIGER Radar (Tasmania)

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Since 1950s radio waves, via Doppler shift measurements of ExB drift, have been used as a convenient tool for directly probing the ULF wave electric field at ionospheric heights. The advent of the HF Super Dual Auroral Radar Network (SuperDARN) covering auroral/polar cap regions in both hemispheres created another dimension in ULF wave studies by radars. Recently, using the TIGER radar (Tasmania) the authors demonstrated that SuperDARN radars are capable of routine day-to-day ULF wave monitoring over large areas of the Earth's ionosphere. Several types of ULF waves have been observed. Here we present detailed discussion on daytime Pc3-4 pulsations.

STSP PTH 98

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Adelaide is a lower mid-latitude site and potentially simpler from a geophysical point of view for instrument development or initial studies of new techniques. In the Mesosphere Lower Thermosphere (MLT) region we are pursuing integrated observations of the aeronomy using radar, lidar and passive optical techniques. The Buckland Park Research Station near Adelaide (35°S, 138°E) was established in 1964, and the large MF aerial array constructed over the next 3 three years. The original large MF array was refurbished in the early 1990's, and is still being actively used for research into the upper atmosphere. Several other field sites are operated by the group, including those at Katherine, Christmas Island, and the Tiwi Islands, and sites at Pontianak in Indonesia in collaboration with Indonesia's LAPAN and RISH of Kyoto University, and the Davis Station VHF and MF radars operated in collaboration with the Australian Antarctic Division. A number of optical instruments are also operated at the Buckland Park site. These include a three-field photometer, a spectrometer, and an all-sky imager. A combined Rayleigh and Na lidar is presently under development. In this poster, these instruments and representative results will be presented.

STSP PTH 99

New Regimes of Stochastic Wave Growth

P.A. Robinson, B. Li, I.H. Cairns, J. Roberts

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Burstiness of plasma wave emissions has been addressed via stochastic theories of wave growth. These include elementary burst theories (EBT) of solar microwave spikes, and stochastic growth theory (SGT) of type III radio bursts and other sources. These theories are unified here, the SGT and EBT regimes are elucidated, and new regimes uncovered. It is predicted that all subregimes have lognormal wave-intensity statistics. This is verified using data on type III radio bursts, magnetospheric waves, pulsar emissions, and simulations, yielding data collapse onto one theoretical curve without free parameters. Dynamical equations for generalized SGT are proposed and results are compared with theory and simulations—the first simulations to show SGT. Divergence of correlation lengths near a critical point is seen, suggesting occurence of self-organized criticality.

STSP PTH 100

A Numerical Model for the Propagation of ULF Waves Through an Ionosphere with an Oblique Magnetic Field

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A 1-D computational model for the propagation of ultra-low frequency (ULF; 1–100 mHz) waves from the Earth's magnetosphere through the ionosphere, atmosphere and into the ground is presented. The model is formulated to include solutions for high latitudes where the Earth's magnetic field, B_0, is near vertical to oblique magnetic fields at low latitudes. The model is used to investigate changes in ULF wave polarisation azimuth from the magnetosphere to the ground as a function of the dip angle of B_0 as well as the partitioning of energy deposition associated with ULF wave interaction with the ionosphere.

STSP PTH 101

The Sq Current System Over Australia

R.J. Stening[1], T. Reztsova[1], D.E. Winch[2], D. Ivers[2] and J. Turner[2]

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Data from the AWAGS distribution of magnetometers over the Australian mainland during 1989–90 have enabled an accurate pinpointing of the position of the focus of the Sq current system. We use this to examine other methods of determining the focus position from a smaller number of observatories. We also describe a persistent eastward current flow during the morning before the arrival of the Sq current whorl.

STSP PTH 102

A Comparison of HF Doppler Backscatter from Two OTHR Sites

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The operational effectiveness of a new Over-The-Horizon Radar (OTHR) installation can be characterised by developing trusted system performance models. Testing the validity of OTHR system performance models is achieved by comparing predicted estimates with real observations. In this paper, the propagation environments from two OTHR sites are compared using data derived from HF Doppler Backscatter Sounding equipment, namely the Alice Springs and Longreach Mini-Radar sub-systems. In terms of physical location, both sites share

roughly the same latitude and are approximately 11 degrees apart in longitude. Thus, after applying the relevant modelling corrections, including the resultant 45 minute time delay, the data sets should show similar features. This paper concludes by examining whether this simple transformation is justified.

STSP FRB11
Friday 0820–0900 hrs

The Alfvénic Aurora

C. C. Chaston[1], C. W. Carlson[1], J. P. McFadden[1], R. E. Ergun[1], R. J. Strangeway[2], F. S. Mozer[1], T. D. Phan[1], M. Andre[3], Y. Khoyaintsev[3], H. Reme[4], I. Dandouras[4], A. Fazakerley[5], M. Acuna[6], M. Goldstein[6],A. Balogh[6]

1. Space Sciences Laboratory, University of California, Berkeley, USA; 2. Institute for Geophysical and Planetary Physics, University of California, Los Angeles, USA; 3. Swedish Institute of Space Physics, Uppsala, Sweden; 4. CESR, Toulouse, France; 5. Mullard Space Science Laboratory, Dorking, United Kingdom; 6. NASA Goddard Space Flight Center, Greenbelt, Maryland, USA; 7. Imperial College, London, United Kingdom

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Traditionally, the discrete aurora has been described as the result of the closure of large-scale quasi-static field-aligned currents through the ionosphere. However, this description is only appropriate for scales larger than the characteristic scales of the plasma and for time scales longer than the longest period plasma resonance. We present observations of the aurora from space revealing a hierarchy of temporal and spatial scales extending from hours to less than a second and 100's of km to down 10's of meters. Since these scales extend from essentially DC up to the ion cyclotron period and from larger than inertial lengths down to ion gyro-radii building a model that includes the physics appropriate for each temporal and spatial scale is a non-trivial task. We show, however, that by considering kinetic corrections to the usual MHD description of the plasma we can account for much of this structuring through the dispersion of Alfvén waves. From a close examination of the data coupled with the solution of eigenmode equations for these waves over the range of scales observed it is shown how these waves may lead to both electron and ion acceleration and the subsequent formation of aurora.

STSP FRB13
Friday 0900–0920 hrs

Fine-scale Field-aligned Current Structures: Distribution and Relation to Dayside Magnetospheric Particle Boundaries

M. B. Terkildsen[1,2], B. J. Fraser[1,2] and P. Stauning[3]

1. Cooperative Research Centre for Satellite Systems, Physics Building, University of Newcastle, NSW; 2. Space Physics Group, School of Mathematical and Physical Sciences, University of Newcastle, NSW; 3. Danish Meteorological Institute, Copenhagen, Denmark

High precision vector magnetic field measurements using the Newmag magnetometer onboard Australian research satellite Fedsat, are being used in combination with similar magnetometer data from the Ørsted satellite to investigate the fine-scale structure of polar field-aligned currents (FAC). In particular, the relation of filamentary FAC structure to magnetospheric particle boundaries identified using data from DMSP satellites, and its longitudinal distribution identified through simultaneous FAC observations with multiple satellites. This research aims to address the outstanding questions of the generation mechanism behind fine scale FAC structures, their relation to the polar cusps and boundary layers, and how they are affected by geomagnetic storms.

STSP FRB14
Friday 0920–0940 hrs

Gasdynamical Description versus Quasilinear Simulations for a Hot Electron Beam Propagating in a Plasma

G. R. Foroutan[1,2], B. Li1, P. A. Robinson[1] and I.H. Cairns[1]

1. School of Physics, The University of Sydney, NSW, Australia; 2. Faculty of Physics, University of Tabriz, Tabriz, Iran

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The propagation of a cloud of hot electrons in a plasma and generation of Langmuir waves are investigated in the regime of fast relaxation using analytic gasdynamic theory and numerical simulation of quasilinear equations. The validity of gasdynamic equations derived by Ryutov and Sagdeev and criticized recently by Mel'nik and Kontar, is confirmed. It is shown that even for initial conditions satisfying a fast relaxation requirement the front part of the cloud streams freely and there is a transition between free streaming part and plateaued part. The validity of self-similar solutions of the gasdynamic equations is also investigated numerically.

STSP FRB15
Friday 0940–1000 hrs

Quasilinear Simulation of Second Harmonic Electromagnetic Emission

B. Li, A.J. Willes, P.A. Robinson, and I.H. Cairns

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The linked nonlinear processes of electrostatic Langmuir decay and electromagnetic emission at the second harmonic plasma frequency are studied for situations in which Langmuir waves are driven by an electron beam. An approximate method for simulating wave decay and emission in three spatial dimensions is developed, based on the Langmuir and ion-acoustic wave dynamics in one spatial dimension. The first numerical quasilinear simulations to study electromagnetic emission starting from the electron dynamics are carried out. The evolution of the transverse waves shows the combined effects of local emission and propagation away from the source.

STSP FRB21
Friday 1040–1120 hrs

Implications of Height-varying Vertical Winds in Earth's Auroral Thermosphere

M. Conde[1], M. F. Larsen[2], E. Wescott[3], H. Stenbaeck-Nielsen[3], J. D. Craven[3], D. Lummerzheim[3], J. Hawkins[3], and B. Johnson[3]

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Measuring vertical winds and their relationship with the horizontal wind field remains one of the most difficult practical problems in thermospheric dynamics. In particular, it is inadequate to measure vertical wind (V_z) at just one single height; rather, it is the height variation of V_z that matters. Only 3–4 height profiles of V_z have ever been measured at altitudes above 120 km. Here we present one such measurement, obtained during the HEX rocket mission in March 2003. Despite a maximum vertical wind of only 20 m s^{-1} downward, this height profile of V_z requires a surprisingly large yet spatially localised horizontal divergence to conserve mass.

OR

Indications of Small-scale Wind Systems in Earth's Auroral Thermosphere

M. Conde[1], M. F. Larsen[2], E. Wescott[3], H. Stenbaeck-Nielsen[3], J. D. Craven[3], D. Lummerzheim[3], J. Hawkins[3], B. Johnson[3], and R.W. Smith[3]

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Atmospheric kinematic viscosity increases with height and, above ~90 km altitude, so does temperature. These two conditions oppose respectively the establishment of spatial velocity gradients and of vertical motion. Thus, it has long been assumed that small-scale circulation systems (<100 km) are absent in the middle and upper thermosphere. However, we will present observational evidence that such motions do indeed occur. In particular, we will show that height profiles of vertical wind observed during the HEX rocket experiment require surprisingly large yet spatially localised horizontal divergence. Such observations imply thermospheric circulation at hitherto unexplored spatial scales, the implications of which remain unknown.

STSP FRB23
Friday 1120–1140 hrs

Tomographic Observations of the Plasmasphere using FedSat

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The constellation of GPS satellites provide a convenient means of continually monitoring the Total Electron Content (TEC) of the ionosphere and plasmasphere using ground-based receivers. Networks of receivers can then be used to map the electron density structure by means of tomography. However, because the ionosphere near the F2 peak provides the dominant contribution to the TEC, relatively little can be determined about the plasma in the plasmasphere. FedSat orbits at 800 km altitude, well above the bulk of the ionospheric plasma, so tomography applied to FedSat GPS observations reveals plasmaspheric structure. This paper will present the first results from FedSat which show more variability and structure in the plasmasphere than expected.

STSP FRB24
Friday 1140–1200 hrs

A Comparison of Observed and Modelled Aircraft Radiation Dose Rates during Cosmic Ray Transient Variations

I. L. Getley[1], and M.L.Duldig[2]

1. Department of Aviation, University of New South Wales, Sydney, Australia; 2. Australian Antarctic Division, Kingston, Tasmania, Australia

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Coronal Mass Ejections can suppress the cosmic ray intensity and reduce the background radiation dose at all aircraft altitudes. Conversely, during Ground Level Enhancements, relativistic solar protons produce a dose increase. In both cases the modulation parameter used as an input to the aircraft flight dose estimation models incorrectly describes the cosmic ray environment resulting in erroneous estimates. In October and November 2003 onboard dosimetry monitoring equipment observed the effects of both types of variation during a commercial passenger aircraft flight. A comparison of these observations with the model dose estimates is presented.

STSP FRB25
Friday 1200–1220 hrs

Comparison of Large-scale Field-aligned Currents Calculated from SuperDARN and Iridium

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The magnetospheric component of the ionospheric field aligned currents (FACs) over all local times and from 90º –60º magnetic latitude is computed from the divergence of the ionospheric electric field. A comparison of these results with FACs calculated from Iridium magnetic field observations shows that the assumption of zero ionospheric conductivity gradients when estimating the FAC structure from the ionospheric electric field is too simplistic. On the dayside the ionospheric componet accounts for small shifts in latitude of the major current features while on the nightside the magnetospheric and ionospheric currents may flow in opposite directions.

Women in Physics (WIP) and History of Physics (HOP)

HOP THF31
Thursday 1620–1640 hrs

A History of the Australian Atomic Energy Commission

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The Australian Atomic Energy Commission was established, by an Act of Parliament, in 1953, as the means by which Australia could attain the latest power and defensive technology available. However, long before the Commission was formed Marcus Oliphant was attempting to interest the Australian government in the peaceful uses of atomic energy as a source of electric power and as a vehicle for the production of desalinated water for the Australian mainland. This paper will briefly explore the actual history behind the establishment of the Commission and its major contributions to Australian physics, science and the community as a whole.

WIP THF32
Thursday 1640–1700 hrs

Maximising Potential in Physics

M A. Stevens-Kalceff[1,2], M, Hunt[1], S Hagon[1] and A. Woo[1]

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A UNSW Equity Initiative Grant (2004) has enabled the investigation of the academic profile of School of Physics, which has 22 men and 6 (FTE) women academic staff. An extensive database of statistical data has been compiled for the period 2001–4. The data reveal some significant gender related differences in the academic profile particularly regarding workloads and promotion. Qualitative investigations (focus groups, submissions, interviews) have facilitated the interpretation of the statistics. Comparisons with other investigations provide added insight.[1–4] The data have enabled knowledge-based development of recommendations and establishment of an official School of Physics Equity Committee to review ongoing initiatives and an associated website.

WIP THF33
Thursday 1700–1720 hrs

Seating in Laboratory Classes—Achieving Critical Mass

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Students' voluntary seating patterns were charted in seven first year Science and Engineering units. This simple, non-intrusive sampling revealed that both male and female students exhibit a general preference for sitting with a same-sex laboratory partner. The smaller the minority, the more likely were students to choose a same-sex lab partner; it is suggested that this behavioural indicator may indicate social stress and allow determination of critical mass. A strategy for allocation of laboratory groups to exceed critical mass and create a more supportive, less stressful environment—to support efforts to retain members of minority groups—is suggested.

WIP THF34
Thursday 1720–1800 hrs

Status of Women in Physics in Australia and Overseas

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This paper will review the status of women working in Physics in government and academic institutions in Australia. It will show that government research laboratories are lagging large university physics departments. A recent survey identified that government research laboratories have less than 15% of physics trained staff being female while large university departments have over 20%. Consideration is given to understand why the level of women participating in physics research and university teaching is so low compared to other scientific and engineering fields and why the number of women in physics drops from about 40–50% in undergraduate physics. This will be reported in a framework that considers why lower numbers of women in physics should be an area of concern. I will also review recent research that has identified strategies by some overseas groups that have achieved female physics staff levels up to 40%. Finally some strategies will be suggested that may help to increase female physics staff levels in Australia and an action plan will be recommended.

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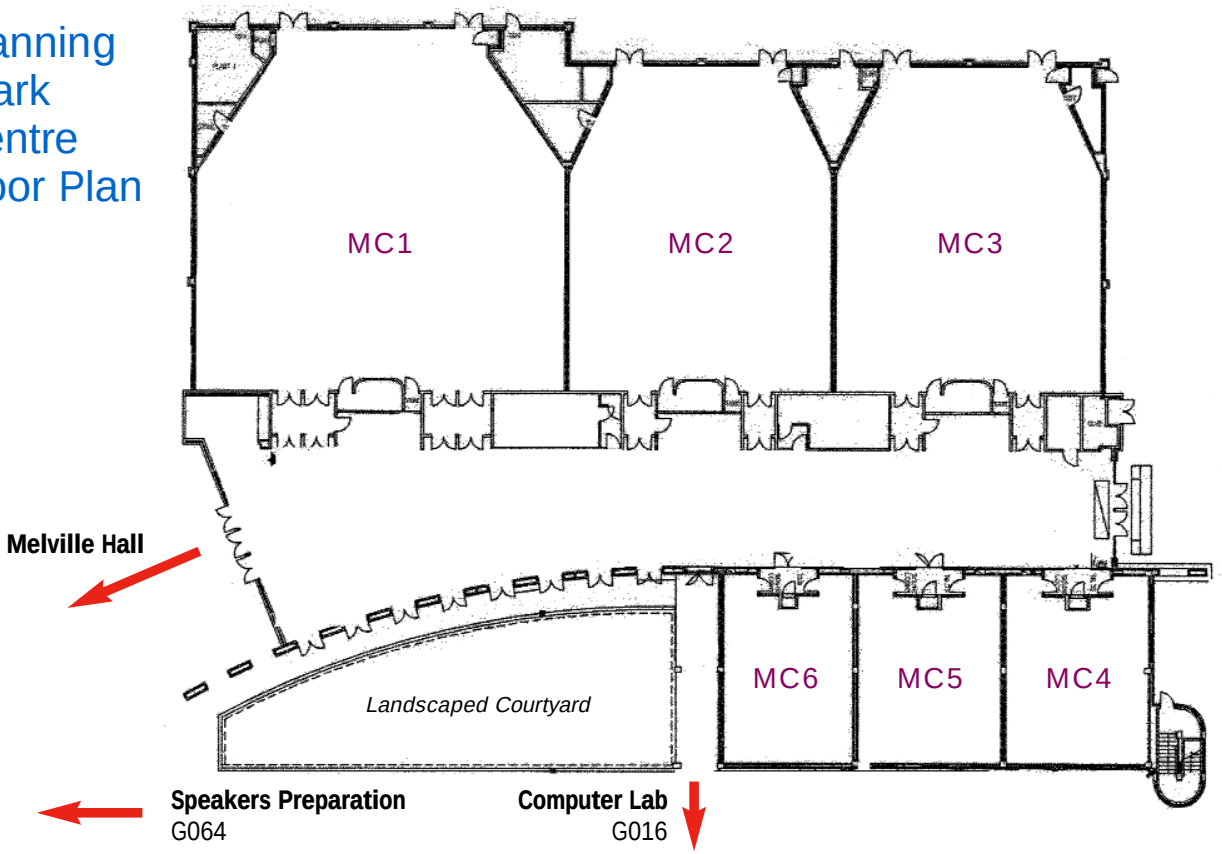
Notes

Manning Clark Centre Floor Plan



1 Novotel
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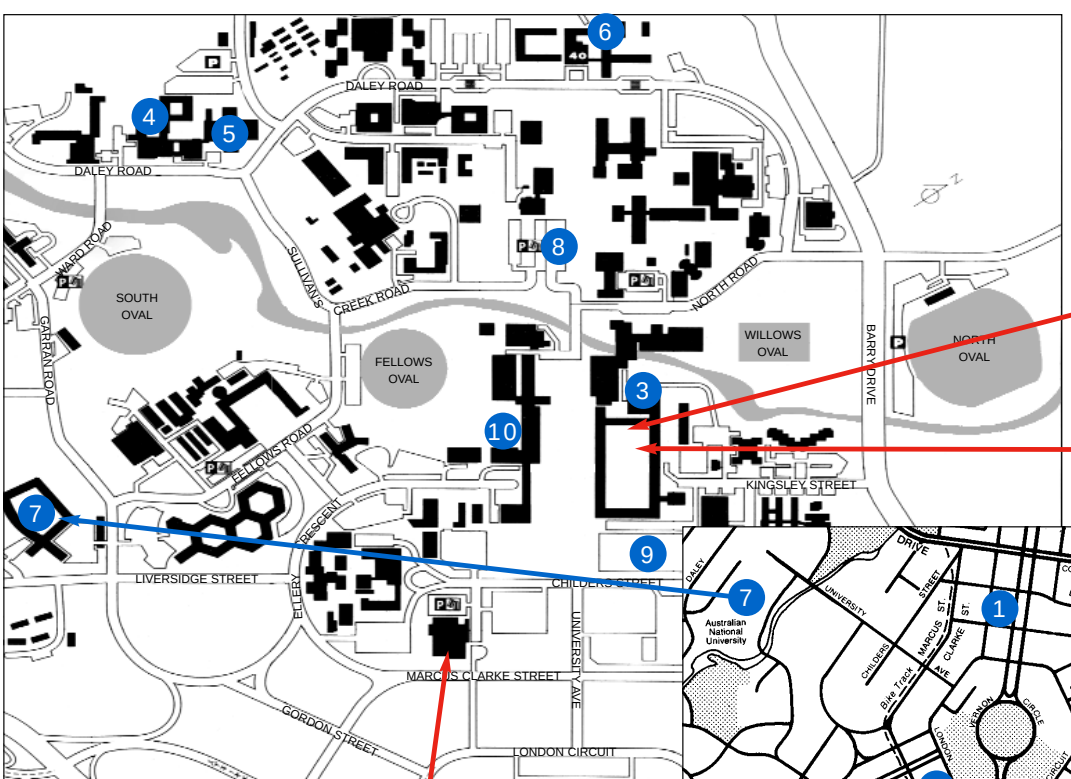
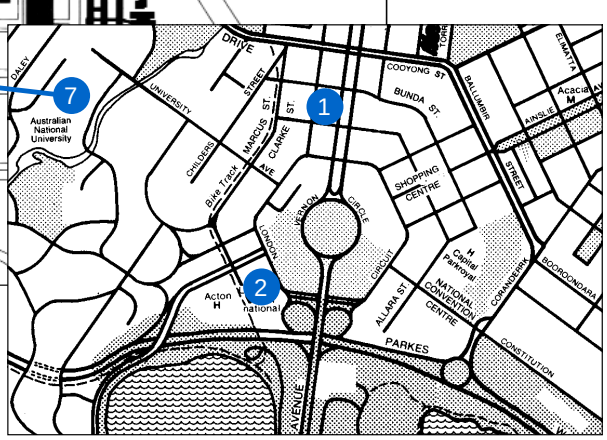
3 Manning Clarke Centre
4 John XXIII College
5 Ursula Hall
6 Bruce Hall
7 University House
8 Sullivan's Creek Carpark
9 Public Carpark
10 Melville Hall





Programme by Topic Area

SUNDAY

Venue	MC1	MC2
0830–0915		
0915–1000	Morning Tea	
1000–1040	**Physics in Industry Forum**	**Young Australian Physics Researchers**
1040–1220		
1220–1400	Lunch	
1400–1540	**Physics in Industry Forum**	**Young Australian Physics Researchers**
1540–1620	Afternoon Tea	
1620–1800	**Physics in Industry Forum**	**Young Australian Physics Researchers**
1800–2000	Welcome Reception	
1930–2130		

MONDAY

	MC1	MC2	MC3	MC4	MC5	MC6
	Congress Opening					
	Plenary—*Leggett*					
	Morning Tea					
	AOS	STSP	ASRP	NUPP	AMOS	BMP
	Lunch • **Sutherland Lecture**—*Home*					
	AOS	STSP	CMMSP	NUPP	AMOS	ASRP
	Afternoon Tea					
	AOS	STSP	CMMSP	NUPP	AMOS	BMP
	Poster Session 1					

TUESDAY

	MC1	MC2	MC3	MC4	MC5	MC6
	Plenary—*Danzmann*					
	Plenary—*Ullrich*					
	Morning Tea					
	AOS	AMOS	CMMSP	NUPP	ASGRG	PEG
	Lunch • **Press Club Address**—*Pearman*					
	AOS	AMOS	CMMSP	NUPP	ASGRG	PEG
	Afternoon Tea					
	AOS	AMOS	CMMSP	NUPP	BMP	PEG
	Poster Session 2					

WEDNESDAY

Venue	MC1	MC2	MC3	MC4	MC5	MC6
0830–0915	**Plenary**—Pearman					
0915–1000	**Plenary**—Chu					
1000–1040	Morning Tea					
1040–1220	AOS/ AMPQC	PP	CMMSP	NUPP	AMOS	GP
1220–1330	Lunch					
1330–1400	Poster Session 3					
1400–1530				**Schools Outreach: Future of Physics**		
				Entertaining Physics		
1530–1800				**Physics as a Life Skill**		
				Entertaining Physics		
				Einstein's Revolution		
1800–1930						
1930–2130	Conference Dinner 1900 hrs for 2000 hrs					

THURSDAY

	MC1	MC2	MC3	MC4	MC5	MC6
	Plenary—Van Leeuwen					
	Plenary—Cesarksy					
	Morning Tea					
	AOS/ AMPQC	PP	CMMSP	GP	PEG	ASA
	Lunch					
	AOS	AMPQC	CMMSP	GP	AAS	ASA/ ASGRG
	Afternoon Tea					
	AOS	AMPQC	CMMSP	CSCMP	AAS	WIP/HOP
	Poster Session 4					

FRIDAY

	MC1	MC2	MC3	MC4	MC5	MC6
	AOS	STSP	CMM	CSCMP	AMPQC	EP/RE
	Morning Tea					
	AOS	STSP	CMMSP	CSCMP	AMPQC	AOS
	AIP AGM					
	Prizes and Medals					
	Plenary—Bilek					
	Plenary—Quinn					
	ANU Tour					
	ANU BBQ					