



THE UNIVERSITY OF  
MELBOURNE



# SCHOOL OF PHYSICS

## **Annual Report 2011-2012**





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## THE UNIVERSITY OF MELBOURNE

### THE UNIVERSITY OF MELBOURNE

**Established in 1853, the University of Melbourne is a public-spirited institution that makes distinctive contributions to society in research, teaching and knowledge transfer.**

Melbourne's teaching excellence has been rewarded two years in a row by grants from the Commonwealth Government's Learning and Teaching Performance Fund for Australian universities that demonstrate excellence in undergraduate teaching and learning.

Melbourne was also one of only three Australian universities to win ten citations -- the maximum number of awards possible -- under the Carrick Citations for Outstanding Contributions to Student Learning. The citations recognise commitment by university staff who have shown outstanding leadership and innovation in teaching, and dedication and enthusiasm for student learning.

#### THE TRIPLE-HELIX

The University of Melbourne seeks to be highly regarded in research and research training, learning and teaching, and engagement.

Together these three activities are envisaged as a metaphoric triple-helix in which they are closely bound, each reinforcing the other. Growing Esteem takes into account current national and international research priorities, aims to assist the University to address the pressures of space, size and coherence in undergraduate education and ensures a much stronger link between public outreach and teaching and research.

The first strand – research and research training – is core to the mission of the University, linking Melbourne to the great centres of scholarship around the world. The research and research training strand allows us both to achieve what we call our research outcomes and output and also to train research higher degree students including PhD or Doctoral research and Masters by research.

The second strand – learning and teaching – refers to our curriculum (or our courses) and to the experience of being a student (such as study groups, support services and scholarships). Learning and teaching has been of great importance to the University since its origin in 1854, and with the inception of the Melbourne Model, undergraduate and graduate education have continued to be a central focus of thought and investment at the University.

The final strand – engagement – encompasses interaction between the University and the wider society. It includes knowledge partnerships, interactions with alumni, advancement activities and international programs.

Knowledge partnerships are interactions between the University and external groups or individuals and are essential to the ensuring the University's public-spirited character. Melbourne will continue to expand the number and scope of its knowledge partnerships and ensure effective metrics to promote excellence in these activities.

The University's international strategy permeates every aspect of the institution's activities. The University will continue to extend and develop its international character, through partnerships with international Universities and organisations and programs such as Melbourne Global Mobility. In addition, the University will work towards having a more 'cosmopolitan' campus, with a view to increasing the number of high calibre international staff and research higher degree students.

The University values its relationship with alumni, and acknowledges that there are many more opportunities to be explored. The University seeks to engage alumni as advisors on course content, as mentors for current students and guides for prospective applicants. The University also hopes to pursue new engagement opportunities with its growing international alumni. In return, alumni are able to attend many public events as well as access the University's knowledge base and infrastructure.

Advancement programs support research, provide scholarships to students from a variety of backgrounds, establish chairs in specific disciplines, expand and maintain library facilities and establish new infrastructure. The University will continue to expand its advancement activities with a major campaign in 2010 designed to treble the University's annual income from donations and gifts within five years.



# THE FACULTY OF SCIENCE

## FACULTY OF SCIENCE

**Through the quality of our research and teaching, the Faculty of Science enjoys a strong reputation, both nationally and internationally.**

The Faculty of Science is a thriving, passionate and internationally networked community with a history of leadership in research, innovation, teaching and learning. Comprising four schools and four departments, the Faculty offers a range of undergraduate, honours, graduate and research degrees; enrolling over 6,500 undergraduate and graduate students. We also provide community services and industry partnerships based on a solid foundation of research in the pure, and applied sciences.

We have active involvement in a number of competitively funded research centres, and our scientists include twenty five (25) Fellows of learned academies and seven (7) ARC Federation and Laureate Fellows.

The Faculty of Science also plays an important role in Australia's participation in the global knowledge economy. We partake in collaborative research ventures, staff and student exchanges, and overseas student recruitment – all of which ensures Melbourne Science maintains an international perspective





# THE SCHOOL OF PHYSICS

It is an exciting time to be studying physics in the 21st century: it is an enabling science that expands our knowledge of the universe and underpins new technologies that benefit our society. The School of Physics is well established and is internationally respected for its research excellence, broad-based undergraduate courses, and a challenging and rewarding postgraduate experience. Our collaborations are aligned with the world's leading research groups and facilities. We address some of the most important and fundamental problems of our age.

Our programs in astrophysics, theoretical particle and experimental particle physics explore questions relating to the origin, evolution and fate of our universe. Aligned with high energy physics programs taking place at CERN in Switzerland, the School has considerable expertise in grid computing, neutrino physics and physics beyond the 'Standard Model'.

The School has strengths in the exploration of matter and light interactions, particularly in advanced materials utilising diamond and silicon, quantum information science, photonics, advanced electron microscopy, nanoscale imaging, nanoelectronics, all the way down to the single atom and photon. The School houses the University's

newest Lead Australian Research Council Centre of Excellence, the ARC Centre of Excellence for Particle Physics at the Terascale (CoEPP). This Centre will provide a unified resource to fully exploit the data emanating from CERN, and a once-in-a-generation opportunity for fundamental scientific research in Australia with the prospect of understanding the origin of mass, discovering new physical laws, and producing and studying dark matter in the laboratory. The School also houses the ARC Centre of Excellence for All-Sky Astrophysics (CAASTRO), the Melbourne Materials Institute (MMI), Melbourne node of the Centre of Excellence for Quantum Computation & Communication Technology (CQC2T) leads the Centre for Coherent X-Ray Science (CXS) and the Micro-Analytical Research Centre (MARC).

The School of Physics comprises approximately 21 teaching and research staff, 50 research-only staff, more than 80 postgraduate students and 50 associates supported by 30 professional staff. Skilled technical staff operate, maintain and develop, complex instrumentation and equipment to support the teaching and research activities of the School. In addition, the School hosts 2 ARC Federation Fellows, 2 ARC Australian Professional Fellows, 2 ARC QE11 Fellows and one Australian Postdoctoral Fellow.

Located in the heart of cosmopolitan Melbourne, the School is part of a vibrant campus environment and is a great place to study, as evidenced by internationally benchmarked ranking indicators.



# HEAD'S REPORT

## PROFESSOR DAVID JAMIESON

The year 2012 was the year of the Higgs boson discovery, sometimes called the "Higgs Bonanza", and the School of Physics was at the centre of the action. The discovery was announced simultaneously on July 4 at CERN in Geneva and in Melbourne where the International Conference for High Energy Physics (ICHEP) was being hosted by Prof Geoff Taylor and his team from the Australian Research Council Centre of Excellence for Particle Physics at the Terra-scale. Just two days later I had the pleasure of chairing a public forum on the discovery attended by overflow crowds in one of the University's biggest lecture theatres. A panel of experts drawn from the international community attending the conference gave their personal views of the discovery and fielded insightful questions from the audience. In a related ceremony, the Director General of CERN, Prof Rolf-Dieter Heuer, was awarded an honorary Doctor of Laws (*honoris causa*) from the University Melbourne in recognition for his outstanding international contribution to science.

In the months leading up to the great announcement our David Caro building saw the completion of a major renovation. Starting on the ground floor we created a prominent entrance into the building for the new Laby IDEAS (Interact, Discuss, Explore, Analyse, Scientific ideas) Centre which is a large space specifically for undergraduate students and incorporates an electronic teaching classroom (*pictured left*). Development of the Laby IDEAS Centre was made possible by a generous grant from the Laby Foundation. In the floors above we created new spaces for two of our ARC Centres of Excellence (CoEPP and CAASTRO) to accommodate the new staff working in these centres. In July the CoEPP space was officially opened by Prof Heuer and the Laby IDEAS Centre by University Provost Prof Margaret Sheil.

Our staff and students were recognised for their accomplishments. Assoc Prof Robert Scholten was awarded the David Syme prize for his work with ultra-cold electrons, Dr Nicole Bell and Dr Archil Kobakhidze were awarded ARC Future Fellowships recognising the excellence of their research, the Bryan Scholarship in Natural Science for 2011 was awarded to Mr Timothy Trott, the Ramm Prize in Experimental Physics 2011 to Mr Lachlan Tantau, the E M & J

F Ward Prize 2011 to Mr Thomas Lucas, the Women in Physics Award 2012 to Ms Amelia Brennan, the Wyselaskie Scholarship in Natural Science 2011 to Ms Ada Yan and the Klein Prize in Experimental Physics 2011 to Mr Robert Barone-Nugent. In addition, Mr Andy McCulloch was selected by the Australian Academy of Science to attend the Lindau meeting where he got the chance to meet Nobel Laureates and fellow PhD students from around the world. Early career researchers received ARC Discovery Early Career Researcher Awards (DECRA) to work on projects from ranging from nanoscience, diamond to neutron stars and dark matter: Dr Igor Aharonovich, Dr Adrian D'Alfonso, Dr Brynmor Haskell, Dr David Garrett, Dr Jiao Lin and Dr Edward Taylor.

We also hosted a constellation of distinguished visitors in addition to Prof Rolf-Dieter Heuer and the other delegates to ICHEP. These included Miegunyah Fellow Prof David Awschalom now at the University of Chicago, Professor Joe Howard from the Max Planck Institute for Molecular Cell Biology & Genetics, Dresden and the Lockheed Martin chief scientist Dr Ned Allen.

Our outreach programs included the annual July Lectures incorporating a program of panels and lectures on the Higgs boson and high energy physics, the Physics Gymnasium lectures for secondary school students and our annual program for Physics teachers in November that featured a lecture on the physics of the Mars Curiosity Lander. In addition, the "Telescopes in Schools Program" run by Prof Rachel Webster, Dr Shane Huntington and Jacinta den Besten, with support from the Federal Government's Higher Education Participation and Partnerships Program (HEPPP), is an innovative new outreach program to inspire students from low-SES government schools to consider science as a career. Shane and Jacinta received the 2012 Vice-Chancellor's Award for their outstanding contribution towards fulfilling the goals, values and mission of the University in the categories "Creating Connections: contribution to engagement" and "Service to the community".

Our cohort of MSc and PhD students continues to be strong and we now have a significant role in the Faculty of Science with Dr Andy Martin awarded the role of Assistant Dean (Graduate Programs).



Congratulations also go to academic staff for their promotions: to Prof Elisabetta Barberio who was promoted to professor in recognition of her international leadership in the field of high energy physics especially for her work on the mysterious neutrino mass and the search for dark matter where she leads a program in CoEPP; to Assoc Prof Harry Quiney who was promoted for his many contributions to x-ray physics, quantum mechanics and chemical physics and their applications to bioscience in CXS where he is a program leader in theory and modelling.

In 2012 we farewelled Laureate Prof Keith Nugent who had been with us in many distinguished roles over more than two decades including a stint as Head of Physics, Director since 2005 of the ARC Centre of Excellence for Coherent X-ray Science, Director of the Australian Synchrotron and Assistant Vice Chancellor (Special Projects). Keith has taken up an appointment as Deputy Vice-Chancellor and Vice-President (Research) at La Trobe University and we wish him well in this new job.

Looking forward to 2013 we will welcome two new academic staff into the School in the field of computational cosmology who will join ARC Laureate Fellow Professor Stuart Wyithe in a significant and exciting expansion in a field that promises breakthroughs in our understanding of the early universe.

2012 was a very busy year. I would like to thank my colleagues in the School for all their contributions especially our deputy head Assoc Prof Ann Roberts. Also thanks to my fellow members of the Australian Physics Decadal Plan Working Group who delivered the first decadal plan in Physics since 1993. We look forward to building on our accomplishments in 2012 to support our vision to be international leaders in Physics with global impact.

## SCHOOL RECOGNITION

### UNDERGRADUATE 2011

- **The Dwight Prize** is awarded to the student achieving the highest results in First year advanced level, on recommendation by the Head: Tilen Rudd/Michael Li
- **The Ramm Prize** is awarded to a student enrolling in either Honours or postgraduate degree by research in Experimental Physics who has demonstrated excellent research potential: Lachlan Tantau
- **William Sutherland Prize** is awarded to the student achieving the highest results in Second Year Physics who is proceeding to study Physics at the Third Year level: Tudor Thomas
- **EM & JF Ward Prize** is awarded to the most outstanding student in experimental physics in the third or final year of the BSc majoring in physics: Thomas Lucas
- **Wyselaskie Scholarship** is awarded to the student who has the highest Third Year faculty honours score in the Schools of Chemistry and Physics, and who is proceeding to the Bachelor of Science (Degree with Honours): Ada Yan
- **T.F. Ryan Roentgen Prize:** Kevin Lee

### POSTGRADUATE 2011

- **Professor Kernot Research Prize** is awarded on recommendation of the Head to conduct research in Physics at postgraduate level: Amelia Brennan/Lyndon Koens
- **Dixson Research Scholarship in Physics** is awarded on recommendation of the Head to conduct research in Physics at postgraduate level: Peter Ryan/Catherine Deburg-Day
- **Klein Prize in Experimental Physics** is awarded to a student in the School of Physics who is currently enrolled in a RHD at the University of Melbourne: Robert Barone-Nugent
- **John Tyndall Prize** is awarded to a student enrolled in a RHD who is conducting advanced studies or research in the School of Physics: James Wood
- **Women in Physics Prize** is awarded to a student based on academic excellence and demonstrated research potential: Amelia Brennan
- **Bryan Scholarship in Biological Science Prize** is awarded determined by academic merit and awarded to a student in the BSc in a Biological Science department: Timothy Trott
- **2011 Bragg Gold Medal** is awarded for the best PhD thesis by a student from an Australian University. Established to commemorate Sir Laurence Bragg and his father Sir William Bragg: Dr Adrian D'Alfonso

### UNDERGRADUATE 2012

- **The Dwight Prize** is awarded to the student achieving the highest results in First year advanced level, on recommendation by the Head: Matthew Geleta
- **The Ramm Prize** is awarded to a student enrolling in either Honours or postgraduate degree by research in Experimental Physics who has demonstrated excellent research potential: Jasper Cadusch
- **William Sutherland Prize** is awarded to the student achieving the highest results in Second Year Physics who is proceeding to study Physics at the Third Year level: Wee Chaimanowong
- **EM & JF Ward Prize** is awarded to the most outstanding student in experimental physics in the third or final year of the BSc majoring in physics: Millie McDonald
- **Wyselaskie Scholarship** is awarded to the student who has the highest Third Year faculty honours score in the Schools of Chemistry and Physics, and who is proceeding to the Bachelor of Science (Degree with Honours): Callum Jones
- **T.F. Ryan Roentgen Prize:** Minh Quan Cao/Ruiyi Jia

### POSTGRADUATE 2012

- **Professor Kernot Research Prize** is awarded on recommendation of the Head to conduct research in Physics at postgraduate level: Laurence Spiller
- **Dixson Research Scholarship in Physics** is awarded on recommendation of the Head to conduct research in Physics at postgraduate level: Stephen Lonsdale
- **Klein Prize in Experimental Physics** is awarded to a student in the School of Physics who is currently enrolled in a RHD at the University of Melbourne: Sophie Williams
- **John Tyndall Prize** is awarded to a student enrolled in a RHD who is conducting advanced studies or research in the School of Physics: Jasper Cadusch
- **Women in Physics Prize** is awarded to a student based on academic excellence and demonstrated research potential: Sophie Williams
- **N.D Goldsworthy Scholarship for Physics:** Pierre Taylor, Tomasz Dutka, Richard Taylor, David Wood, Angus McInnes
- **2012 Charlene Heisler Prize of Astronomical Society of Australia** awarded for PhD excellence for his PhD thesis titled "Superfluid spin up and pulsar glitch recovery: Anthony van Eysden



## STAFF 2011

### PROMOTIONS

**Associate Professor:** Jeff McCallum (2011), Andrew Melatos (2011)

**Principal Research Fellow:** Harry Quiney (2011), Andrew Greentree (2011)

**Professor:** Elisabetta Barberio (2012)

### SIR THOMAS LYLE FELLOWSHIP IN PHYSICS

**Sir Thomas Lyle Fellowship in Physics:** Professor Lawrence Krauss

### UNIVERSITY OF MELBOURNE AWARDS FOR EXCELLENCE

**Award for Outstanding Leadership of University Teaching:** Michelle Livett

Associate Professor Michelle Livett has made far-reaching contributions to learning and teaching at this University. Her influence extends beyond the excellence of her own teaching, to leadership of teaching in the School of Physics and the Faculty of Science. In recent years, Michelle has been extensively involved in the formation of the New Generation Bachelor of Science, and more broadly in Melbourne Model developments. In all aspects of her teaching leadership, Michelle demonstrates a deep interest in the quality of students' learning and their development as learners.

### UNIVERSITY ACADEMIC BOARD ELECTEES

**Academic Programs Committee:** Andrew Melatos

**Selection Procedures Committee:** Nicole Bell

**Research Higher Degree Committee:** Andy Martin

**Coursework Scholarships & Awards Committee:** Les Allen

**Melbourne Business School Committee:** David Jamieson

## STAFF 2012

### SIR THOMAS LYLE FELLOWSHIP IN PHYSICS

**Sir Thomas Lyle Fellowship in Physics:** Dr Chiara Roda & Professor Alon Hofmann

### PRIME MINISTER'S PRIZES IN SCIENCE

**Malcolm McIntosh Prize - Physical Scientist of the Year:** Professor Stuart Wyithe

### UNIVERSITY OF MELBOURNE OUTSTANDING PROFESSIONAL STAFF AWARDS

**Creating Connections: contribution to engagement:** Shane Huntington & Jacinta den Besten (Telescopes in Schools)

**Service to Community:** Shane Huntington & Jacinta den Besten (Telescopes in Schools)



*Profs Keith Nugent and Steven Prawer in the 'Dome of Silence', at the Laby IDEAS Centre Opening*

## PROFESSOR KEITH NUGENT



**In December 2012 the School said farewell to Professor Keith Nugent, who resigned in order to take up an appointment as Deputy Vice-Chancellor at LaTrobe University.**

Keith was appointed as Lecturer (Limited Tenure) in 1985, whilst still in his first year of a post-doctoral appointment at the ANU. This was the first academic appointment in our School of Physics for over a decade, following a far-sighted recommendation by an external, forward-planning review in 1984.

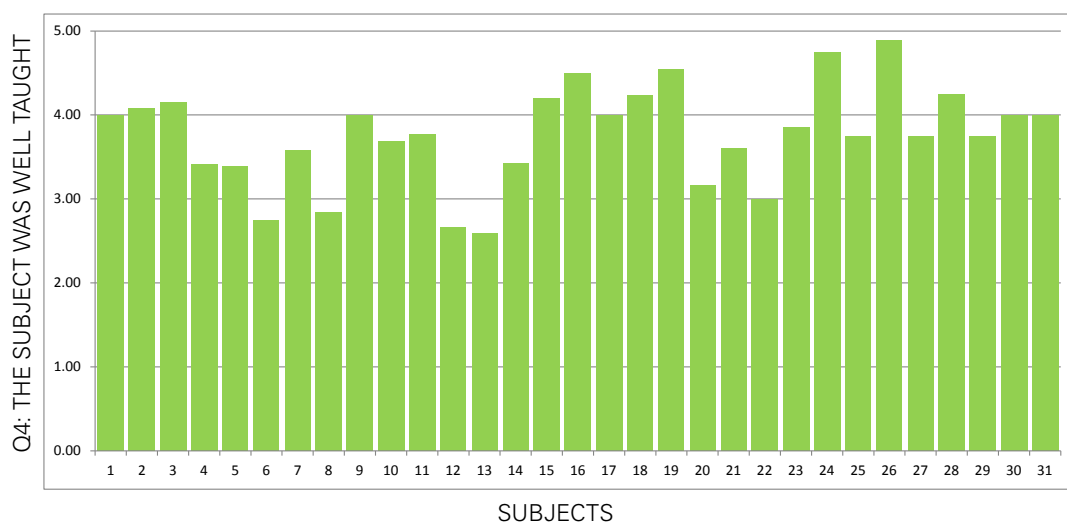
The outstanding research performance throughout his career led to a meteoric rise through the ranks, culminating with his appointment as Laureate Professor in 2007.

Keith served with distinction as Head of the School of Physics from 1996 to 2001 and was elected a Fellow of the Australian Academy of Science in 2000. Further success followed when Keith was selected for a Federation Fellowship in 2001, renewed in 2006. He was awarded a Centre of Excellence in Coherent X-ray Science in 2005, renewed in 2009, and held several influential positions including Directorship of the Australian Synchrotron.

He left the School with our best wishes - he will be sorely missed.

## TEACHING HIGHLIGHTS

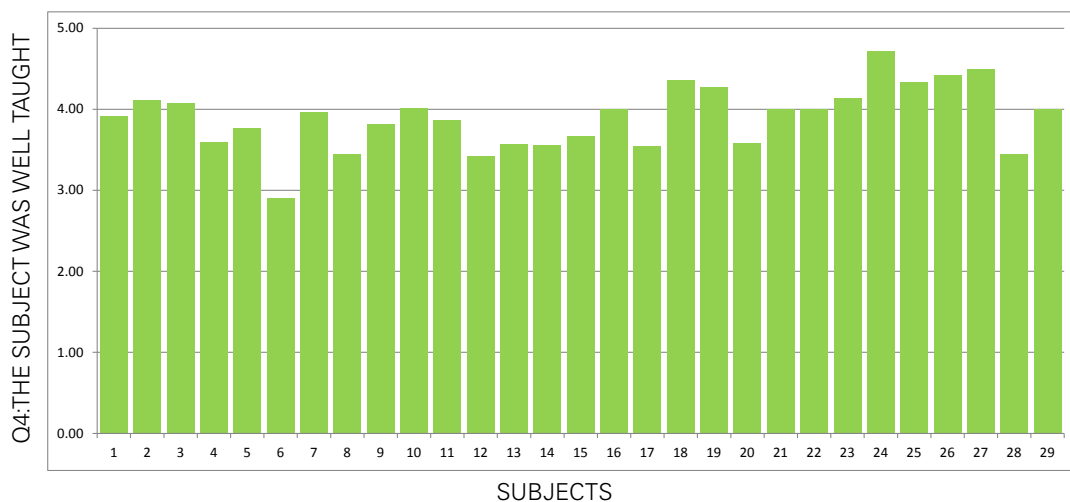
### STUDENT APPRAISAL OF TEACHING SEMESTER 1 & 2, 2011



Subjects 1 - 12 1st & 2nd Year  
Subjects 13 - 21 3rd Year  
Subjects 14 - 31 RHD

Student appraisal of teaching is measured on a 1-5 scale (with 5 being the best score)

### STUDENT APPRAISAL OF TEACHING SEMESTER 1 & 2, 2012



Subjects 1 - 12 1st & 2nd Year  
Subjects 13 - 21 3rd Year  
Subjects 14 - 29 RHD

Student appraisal of teaching is measured on a 1-5 scale (with 5 being the best score)

# RHD COMPLETIONS

## We congratulate the following students on their completions:

### 2011

**Paul Angel** (MSc) Neutrino Mass; **Robert Barone-Nugent** (MSc) Improving type 1A supernovas as distance indicators in the near infrared; **Tim Bedin** (MSc) Extended source subtraction with the MWA; **Amelia Brennan** (MSc) Electroweak bremsstrahlung and the search for dark matter; **Jackson Clarke** (MSc) Quark-lepton Symmetric Model; **Peter Cox** (MSc) Higgs-Radion mixing in warped extra dimensions; **Catherine De Burgh-Day** (MSc) Detecting and studying weakly lensed objects using neutral hydrogen velocity maps; **Chris Hodson** (MSc) The Search for the Higgs Boson; **Rhyan Hoey** (MSc) Stratified spherical Couette flow in neutron stars; **Lyndon Koens** (MSc) Quantized vortices in BECS; **Vesna Lukic** (MSc) Light absorption in quantum photosynthesis; **Viktor Perunicic** (MSc) Application of NV diamond magnetometry to biological systems; **Peter John Ryan** (MSc) Optical properties of si-nanocrystals Erbium doped; **James (Lachlan) Tantau** (MSc) Determination of Nanoroughness and X-ray Absorption Fine Structure from Mass Attenuation Coefficients; **Daniel Wells** (MSc) Theoretical studies of recent experiments in non linear optics; **James Wood** (MSc) Improving magnetometry sensitivity through quantum entanglement and control.

**Dougal Maclaurin** (MPhil) From geometric phases to intracellular sensing: new application s of the diamond nitrogen-vacancy centre.

**Joo Chew Ang** (PhD) Quantum computing and algorithm simulations; **Simon Bell** (PhD) Cold electrons extracted from an ultracold plasma; **William Davey** (PhD) Discovery potential of neutral MSSM Higgs bosons decaying to tau-lepton pairs in the ATLAS experiment; **Nadia Davidson** (PhD) Measurement of the ATLAS calorimeter response to charged pions using minimum bias events from the Large Hadron Collider; **Paul Geil** (PhD) Studying the epoch of hydrogen reionisation in redshifted 21-cm radiation; **Thomas Jacques** (PhD) Dark matter indirect detection and bremsstrahlung processes; **Lenneke Jong** (PhD) Spatial adiabatic passage techniques in mesoscopic quantum electronic systems; **Melissa Makin** (PhD) The Jaynes-Cummings-Hubbard model; **Anna Phan** (PhD) Searching for the

light supersymmetric top quark with the ATLAS experiment; **Sebastian Saliba** (PhD) A cold atom electron source for diffractive imaging; **David Sheludko** (PhD) Shaped electron bunches from ultracold plasma; **Alastair Stacey** (PhD) Surface engineering for quantum information processing in NV diamond; **Cornelis (Anthony) Van Eysden** (PhD) Superfluid spin up and pulsar glitch recovery; **Lila Warszawski** (PhD) Collective superfluid vortex dynamics and pulsar glitches; **Lachlan Whitehead** (PhD) Partially coherent diffractive imaging.

### 2012

**Michael Barson** (MSc) Fluid and cellular dynamic detection with nitrogen-vacancy centres in nanodiamonds; **Hamish Brown** (MSc) Electron microscopy using secondary electrons; **Craig Burnett** (MSc) Radio emission physics via stokes tomography; **Jasper Cadusch** (MSc) Novel plasmonic and metamaterial polarisers; **Sophie Dawson** (MSc) A wide-band, Synchrotron light-based beam position monitor; **Nikolai Dentschuk** (MSc) Diamond growth on aluminum nitride substrates; **Kyle Ewert** (MSc) Investigating scale and extensions of nanoroughness in Gold and Silver through X-ray absorption; **Robert Henry** (MSc) Negative refraction and cloaking in the Bose-Hubbard Model; **Henry Kirkwood** (MSc) Tick, Tock, The Auger Clock: Qualitative estimates of electronic damages due to a femtosecond XFEL pulse; **Mark Kowarsky** (MSc) The Nitrogen-vacancy centre in motion: Force tracking Berry phase; **Mark Leong** (MSc) Characterisation of ion-implanted point defects and porous structures in germanium; **Herianto Lim** (MSc) Optical switching and photoluminescence of Erbium doped vanadium dioxide thin films; **Stephen Lonsdale** (MSc) Domain-wall brane model based on the 650-dimensional irreducible representation of E6; **Tracey Ly** (MSc) The near-infrared broad emission lines of active galactic nuclei-how do they vary?; **Thomas Milburn** (MSc) Simulating topological quantum error correction codes; **Dene Murphy** (MSc) Self-field effects in a cold ion beam; **Truong Nguyen** (MSc) Relativistic calculation of the 557.7 nm oxygen forbidden transition line: Addressing issues of gauge invariance for astrophysical interest; **Lucas Ong** (MSc) Search for heavy lepton partners of the Type III Seesaw Model using the ATLAS detector at the LHC; **Tyson Pepler** (MSc) The quantum zeno effect in Nitrogen vacancy centres; **Pere Rados** (MSc) Observation of an excess of events in the search for the Higgs Boson in the  $H \rightarrow WW^{(*)} \rightarrow l\bar{\nu}l\nu$  Decay Channel produced through Gluon-Gluon Fusion

and Vector-Boson fusion, and a search for the Higgs Boson in the Associated Production Mode  $WH \rightarrow WW^{(*)} \rightarrow l\bar{\nu}l\nu$  using the ATLAS Detector; **Nicholas Rodd** (MSc) Analysis of neutrino mass effective operators and testing their signatures at the Large Hadron Collider; **Laurence Spiller** (MSc) Scalar mass bounds in supersymmetric models with split families; **Joshua Torrance** (MSc) Use of an optical dipole trap in a cold-atom electron source; **Sophie Williams** (MSc) Structure determination of proteins from X-ray powder diffraction data.

**Sudhir Raskutti** (MPhil) The thermal memory of reionization; **Jason Smith** (MPhil) Numerical and analytical approaches to modelling 2D flocking phenomena.

**Jay Bourke** (PhD) X-ray absorption fine structure and inelastic electron scattering in elemental and binary condensed matter systems; **Marcus Doherty** (PhD) The theory of the nitrogen-vacancy colour centre in diamond; **Jinghua Fang** (PhD) Fabrication, characterization and applications of anodic aluminum oxide; **Xiao Ming Goh** (PhD) Nanometric apertures in metallic films for lens and beaming applications; **Nathan Lugg** (PhD) Atomic-resolution imaging using inelastically scattered electrons; **Christina Magoulas** (PhD) The fundamental plane and peculiar velocities from the 6dF galaxy survey; **Liam McGuinness** (PhD) Nanoscale quantum sensing using nitrogen-vacancy centres in diamond; **David Peake** (PhD) Diagnostics and control of transverse coupled-bunch instabilities in third generation electron storage rings; **James Quach** (PhD) Novel applications of condensed matter theory: solid-light, quantum metamaterials, and quantum graphity; **Andrea Ruff** (PhD) The broad emission line region of quasars and gravitational lensing by early-type galaxies; **Jayne Thompson** (PhD) Thick-brane worlds; **Angela Torrance** (PhD) Fluctuation X-ray microscopy using curved beam illumination; **David Wang** (PhD) Topological quantum error correction and quantum algorithm simulations.



## SOUTH OAKLEIGH SECONDARY SCHOOL

On 17th May 2012, ten students from South Oakleigh Secondary College with Mr Hem and Mr de la Rambelya (*pictured below*) enjoyed another excellent after school Physics lecture at the University of Melbourne School of Physics. The lecture was on Einstein's Theory of Relativity and was delivered by Professor David Jamieson who is the Head of the School of Physics. It was a very thought provoking lecture well -pitched to the secondary school audience.

Professor Jamieson is a dynamic speaker and his talk was accompanied by excellent demonstrations assembled by Steven. On the way home in the car with Year Nine and Ten students, stimulated by David's lecture, the discussions were on what it would be like to travel close to the speed of light, and then moved to black holes, string theory, loop quantum gravity theory, what is a scientific theory, the experimental work of Michael Faraday, and the interplay between theory and experiment.....

Our Year 12 students appreciated greatly the lecture as they have just completed their study of Einstein's Special Theory of Relativity, so the lecture provided an excellent compliment to what they have learnt in the classroom and will assist them in doing well in the mid-year exam.

Dr Roger Rassool, and coorganiser of the VCE Physics Lectures Associate Professor Max Thompson, will soon be coming to visit us to discuss a Physics Research project our school will be participating in, which will involve taking measurements of cosmic ray showers, synchronised with the measurements being made by other schools.



## TELESCOPES IN SCHOOLS - PILOT PROGRAM

2012 saw the start of the Telescopes in Schools program initiated by the Astrophysics Group and funded via the HEPPP scheme.

Throughout the year nine 12" Meade Schmidt-Cassegrain telescopes were installed in Northwestern suburban and regional secondary schools. The staff at these schools were provided with a range of professional development in order to become proficient in using the telescopes.

Over 50 observing sessions were held, attended by teachers, students, parents and volunteers from the Astrophysics Group. More significant though is the numbers of students attending these observing sessions, which now total in the thousands. We have also seen the participants in the program grow from Astronomy and Science experts and enthusiasts to those with a Photography, French, English, Medical and Business background.

Standout events during the year were the **Transit of Venus** and the **Solar Eclipse**.



# DISCOVERY OF THE HIGGS-LIKE BOSON & ICHEP2012

All of the schools involved in the program held special observing sessions for these events and we also received a substantial amount of news coverage from local newspapers, University of Melbourne Newsroom and even the national television stations, Channel 7 and Channel 10! There was also a spot on the 3RRR radio station attended by three students and a teacher from the program, reviewing the year.

The close of 2012 saw Dr Shane Huntington and Jacinta den Besten awarded the University of Melbourne Professional Staff Award for "Creating Connections: contribution to engagement" and "Service to the Community." We look forward to increasing the number of schools participating and really extending the astrophotography side of the program in 2013, while continuing with observing and developing our astronomy skills.

*Dr Alan Duffy (pictured below) at Pascoe Vale Girls College during the 2012 eclipse*



In the words of CERN's Director-General: Professor Rolf Heuer, the 36th International Conference on High Energy Physics (ICHEP2012) was a 'landmark conference'. Particularly in light of the announcement of the discovery of the 'Higgs-like' particle as curtain-raiser to the conference. The impact of the Higgs discovery and its announcement in Melbourne was an enormous coup for the School.

The Higgs was first postulated 50 years ago, and until 2012 it remained the last piece of the Standard Model to be confirmed.

It describes how fundamental particles acquire mass and its discovery is significant to understanding the laws that govern the universe. On July 4, both the ATLAS and CMS experiments claimed evidence of a new particle in the mass region around 125–126 GeV. Experimentalists from the School played important roles in this discovery. For the past 25 years, particle physicists from the University of Melbourne's School of Physics have been contributing to the research and development of the ATLAS experiment, based at the Large Hadron Collider in CERN. They have also been involved in analysis of the data, and the development of advanced grid computing, the basis of research behind the experiments.

Since the time of the conference, the status of the newly-found particle has been upgraded from 'Higgs-like' to 'Higgs', indicating that it is indeed a Higgs boson. What type of Higgs remains to be determined and will take the analysis of more data.

ICHEP is one of the most prestigious international scientific conferences in the field of particle physics. Theorists and experimentalists from all over the world attend. The University of Melbourne played a lead role in the organization of this conference, with Professors Geoffrey Taylor (Chair) (pictured above), Ray Volkas (Co-Chair), and Elisabetta Barberio on its organizing committee. The conference was held from 4–11 July, 2012 at the Melbourne Convention and Exhibition Centre.



*Image by Laura Vanags*



## ASTROPHYSICS & CENTRE OF EXCELLENCE FOR ALL-SKY ASTROPHYSICS (CAASTRO)



The University of Melbourne node of CAASTRO is housed within the School of Physics. The Astrophysics group at Melbourne was founded less than 20 years ago, but has a track-record of excellence in observational and theoretical cosmology, areas which provide the basis for our contributions to CAASTRO. University of Melbourne researchers are primarily engaged within the Evolving Universe theme of which Professor Stuart Wyithe is lead, with an emphasis on Epoch of Reionisation science:

A wide field survey of neutral hydrogen in the high redshift Universe with the Murchison Widefield Array (MWA) of which the University of Melbourne was a founding partner (Wyithe, Webster, Mitchell, Pindor, Riding).

Numerical simulation of the evolution of early galaxies and their interaction with the high redshift intergalactic gas (Wyithe, Tescari, Bolton, Kim, Bruns).

Studies of the properties of elliptical galaxies from the 6df redshift survey (Magoulas).

The University of Melbourne is also making contributions to the Dark Universe theme:

The use of Ly-alpha in absorption and emission to study Baryonic acoustic oscillations at high redshift using the next generation of widefield spectroscopic surveys (Wyithe, Bolton, Greig).

2011 and 2012 saw a rapid ramp up of activity at Melbourne in all these areas – the CAASTRO team now numbers more than 12, including 4 postdocs and 3 PhD students. Amongst our research highlights for the year were:

We showed that the dependence of Ly-alpha absorption on environment leads to significant non-gravitational features in the redshift space power spectrum of Ly-alpha selected galaxies. As a result, power-spectrum measurements could be used as a new probe to study the astrophysics of the galaxy-intergalactic medium (IGM) connection, and to measure the properties of outflows from star-forming galaxies. Applying the modified redshift space power spectrum to a Ly-alpha survey with parameters corresponding to the planned Hobby-Eberly Telescope Dark Energy Experiment (HETDEX), our study found that the dependence of observed Ly-alpha flux on velocity gradient and



ionizing background may compromise the ability of Ly-alpha selected galaxy redshift surveys to constrain cosmology using information from the full power spectrum.

Surveys of Ly-alpha emitters indicate that tens of sources should be visible within an observing field, whereas in the vicinity of bright quasars none are observed. The observed difference indicates that the quasar environment has a significant influence on the observed density of Ly-alpha emitters. To quantify this effect we have constructed a semi-analytic model to simulate the effect of a luminous quasar on nearby Ly-alpha emitters. We find the null detection implies that the minimum virial mass of the Ly-alpha emitter host halos is 100 billion solar masses. This indicates that the intense UV emission of the quasar may be suppressing the star formation in nearby galaxies. Our study illustrates that low redshift quasar environments may serve as a surrogate for studying the radiative suppression of galaxy formation during the epoch of reionization.

High-redshift measurements of the baryonic acoustic oscillation (BAO) scale from large Ly-alpha forest surveys represent the next frontier of dark energy studies. We constructed a model for producing fast, large-volume simulations of the Ly-alpha forest for this purpose. Utilizing a calibrated semi-analytic approach, we developed a method to run very large simulations in  $1 \text{ Gpc}^3$  volumes which fully resolve the Jeans scale in less than a day on a desktop PC using a graphics processing unit enabled version of our code. The Ly-alpha forest spectra extracted from our semi-analytical simulations are in excellent agreement with those obtained from a fully hydrodynamical reference simulation. We applied our model to simulations of the Baryon Oscillation Spectroscopic Survey, and also used our simulations to provide simple power-law expressions for estimating the fractional error on the BAO scale on varying the signal-to-noise ratio and the number density of background sources.



Using the 6dF galaxy redshift survey, we found that stellar population trends not just with velocity dispersion and fundamental plane residual, but with radius and surface brightness as well. The most remarkable finding is that the stellar population parameters vary through and across the plane, but show no variation at all along the plane, roughly corresponding to the parameter 'luminosity density'. A galaxy's position along this vector was being closely tied to its merger history, such that early-type galaxies with lower luminosity density are more likely to have undergone major mergers. This conclusion is reinforced by an examination of simulations, which show clear trends of merger history with this luminosity density.

In 2011-2012 we successfully installed and tested the MWA Real-Time System (RTS) on the real-time computer nodes that are temporarily housed at ICRAR, where it is being used to process data from the 32-tile prototype array. The RTS is a wide-field calibration and imaging pipeline that will run on-site at the Murchison Radio-Astronomy Observatory. More recently, the parallel RTS development effort used to process data from the prototype array has been incorporated back into the master code base, with the merged software soon to be made available as the first official RTS release. The software is regularly used to image data from site, both long integrations and wide surveys, and has been used to make the first detection of polarization from a radio galaxy with the MWA.

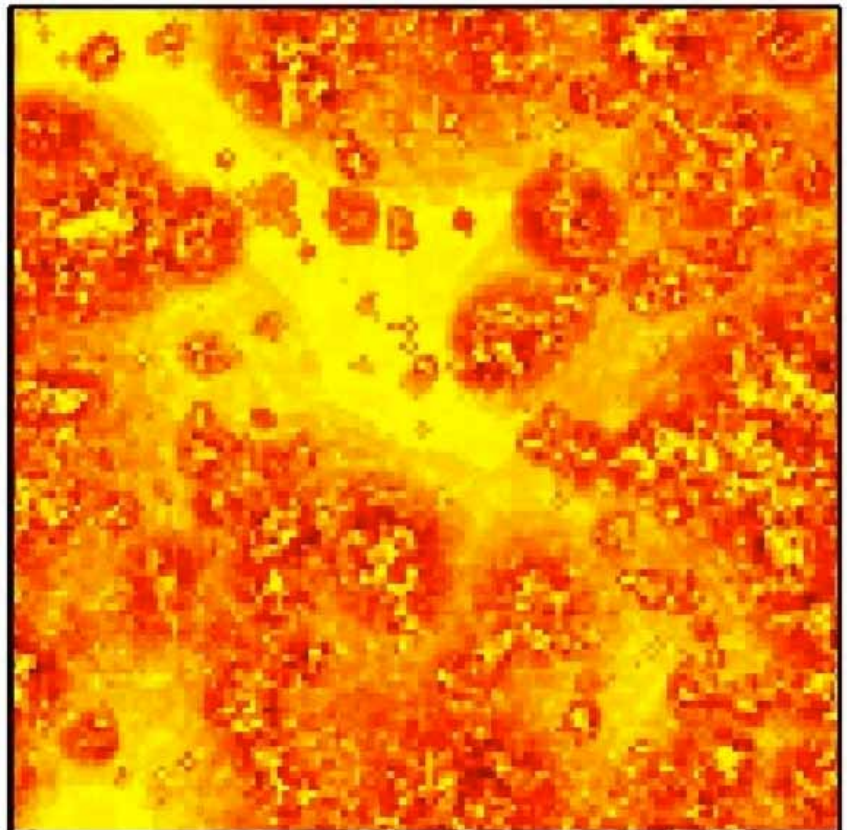
During 2012 we have initiated a new state-of-the-art program performing cosmological hydrodynamical simulations with which to better understand the interplay between galaxies and intergalactic medium (IGM) from redshift  $z \sim 2$  to the epoch of reionization at  $z = 6$  and above. In the next few years, deep and wide imaging campaigns with facilities such as SkyMapper will discover distant galaxies and quasars. At the same time, spectroscopic studies of bright, high redshift quasars with optical and near-IR facilities will probe the intergalactic gas which these early galaxies form from and subsequently interact with. Detailed models of this complex, non-linear interaction are vital for interpreting forthcoming data and guiding future observational programs. Our theoretical program will be used to understand the latest observations.

We presented the most up-to-date thermal constraints on the reionization of hydrogen by stellar sources. We used recent measurements of the IGM temperature in the near-zones of seven quasars at  $z \sim 5.8-6.4$ , combined with a seminumerical model for inhomogeneous reionization, to establish new constraints on the redshift at which hydrogen reionization

completed. The near-zone temperature measurements constrain the redshift by which hydrogen reionization was complete to be  $z > 7.9$ . This implies that future temperature measurements around other high redshift quasars will significantly increase the power of this technique, enabling these results to be tightened and generalised.



*Work experience students on a field trip to the IMAX Hubble 3D Film at the Melbourne Museum*



*Map of temperature fluctuations in the Universe due to the inhomogeneous reionization of hydrogen during early galaxy formation. (Sudhir Raskutti)*

# EXPERIMENTAL PARTICLE PHYSICS (EPP) & ARC CENTRE OF EXCELLENCE FOR PARTICLE PHYSICS AT THE TERASCALE (COEPP)

## ARC CENTRE OF EXCELLENCE FOR PARTICLE PHYSICS AT THE TERASCALE (COEPP)

A large part of the effort of the Experimental Particle Physics (EPP) group falls within the program of CoEPP. Experimental particle physics research at CoEPP focused on the mining of data collected with the CERN Large Hadron Collider (LHC). The dual purpose of this data analysis is to accurately measure the properties of the Standard Model and to search for evidence of physics processes that are not explained by this theory.

Research at the Melbourne node of CoEPP casts a wide net over the physics program of the ATLAS experiment at the LHC. The node has involvement in all aspects of ATLAS physics from detector performance and calibration, to particle reconstruction, simulation and the extraction and systematic evaluation of physical quantities.

### DISCOVERY OF THE HIGGS BOSON

Almost 50 years after it was first postulated, the nature and existence of the last remaining Standard Model particle to be discovered—the Higgs boson—remained a mystery until this year. The 2012 was a pivotal time where both the LHC experiments claimed evidence of a new particle in the mass region around 125–126 GeV in their quest to find the elusive Higgs particle.

Members of the Melbourne CoEPP group played important roles in this discovery. The team at the University of Melbourne focused on two Higgs boson decay modes: to a pair of W bosons and a pair of oppositely charged tau leptons. In the measured mass window the Higgs decay to two W bosons is one of its most preferred modes of decay, yielding charged leptons and missing momentum from the resulting W boson decay. Five postdoctoral researchers (Dr Sara Diglio, Dr Guilherme-Hanninger, Dr Takashi Kubota and Dr Matteo Volpi) and many PhD and Masters students participated to this discovery. In particular, one master student, Pere Rados, graduated with a thesis on the discovery of the Higgs into two W-bosons. This year Tony Shao graduated from his PhD with a thesis on the Higgs boson.

Experts in the reconstruction of the emerging charged leptons, the team performed energy scale calibrations of the tau leptons (essential for an accurate description of their calorimeter energy deposition), systematic optimization of the sensitive analysis variables and development of the tracking algorithms required to correctly reconstruct and assign the Higgs decay products. In 2013 the remaining data will be interrogated to improve sensitivity to the new particle's signal while



trying to pin down the properties of the boson—it's spin and parity—to prove beyond doubt that the new object is indeed the Standard Model Higgs boson.

The Melbourne node played crucial roles in searches for physics beyond the Standard Model, most prominently in the search for Supersymmetry. A light stop quark (the Supersymmetric analogue of the top quark) is widely regarded as a natural candidate for first discovery in most theories led by Martin White with collaborators from Cambridge (UK)

The last major discovery in particle physics before the Higgs was the observation of neutrino oscillations in the late 1990s, indicating that neutrinos must have a mass. We still do not know the mechanism by which this mass is acquired, nor whether the neutrino is what is known as a “Dirac” particle or a “Majorana” particle. Dr Kenji Hamano together with one master student (Nicolas Rodd) leads LHC searches for particles that may explain the origin of neutrino mass generation, in events with two leptons of the same sign, and events with four leptons.

An inclusive dilepton analysis (AIDA) has been performed with clear leadership from CoEPP research in a team spread across two nodes (Melbourne and Sydney) and a partner institute (Duke). This analysis, the first of its type at ATLAS, makes precision simultaneous measurements of the main processes contributing to the opposite sign electron and muon final state using proton on proton collision data taken at a energy of 7 TeV. The processes include the top quark pair, W boson pair and Z to tau lepton pair production cross-sections, which are measured with precision surpassing or competitive with the dedicated measurements. By mapping the inclusive phase space of jet multiplicity and missing transverse energy in regions beyond where standard model processes are expected to contribute, the approach also provides a model independent search for new physics. Future iterations of AIDA will explicitly exploit this novel feature.

### BELLE AND BELLE II

Belle is the experiment at the KEKB asymmetric electron-positron accelerator which provided the worlds' highest luminosity collider and made copious numbers of B-mesons. Belle has made numerous discoveries since it commenced data collection in 1999, including the observation of CP violation in B-meson decays, the first such measurement outside the neutral kaon system. The significance of Belle was recognized by the 2008 Nobel Prize for Physics, awarded to Nambu, Kobayashi and Maskawa for “the discovery of the origin of the broken symmetry which predicts the existence of at least three families of quarks in nature”. The citation prominently highlights the results of Belle. The EPP group has played a major role in the Belle collaboration and has significantly contributed to the success of this experiment.



KEKB ceased operation in 2010 and Belle is now completing the analysis of the data acquired during its operation. Many papers continue to be published from this dataset and in 2012, Belle published 21 new papers. The Physics for 2012 highlight was the paper titled "Observation of two charged bottomonium-like resonances in  $\Upsilon(5S)$  decays" in which we observe exotic mesons containing at least 4 quarks.

The Belle II project is to upgrade the original KEKB accelerator and increase its collision rate (luminosity) by a factor of 80 along with a commensurate upgrade to the Belle detector to enable it make full use of this massive increase in data. The aim of Belle II is to search for Physics beyond the standard model via precision measurements and rare or forbidden decays. Consequently, Belle II is complementary to the search at High energy made by the ATLAS experiment. Elisabetta Barberio was awarded an ARC Discovery Grant to construct layer 3 of the inner tracking detector and to search for lepton-flavour violation in tau-decays. Martin Seviar leads the distributed computing group charged with delivering a working grid system to the Belle II experiment.

Construction of the Belle II project is well underway and first collisions are expected in 2016.

#### NECTAR COMPUTING PROJECT

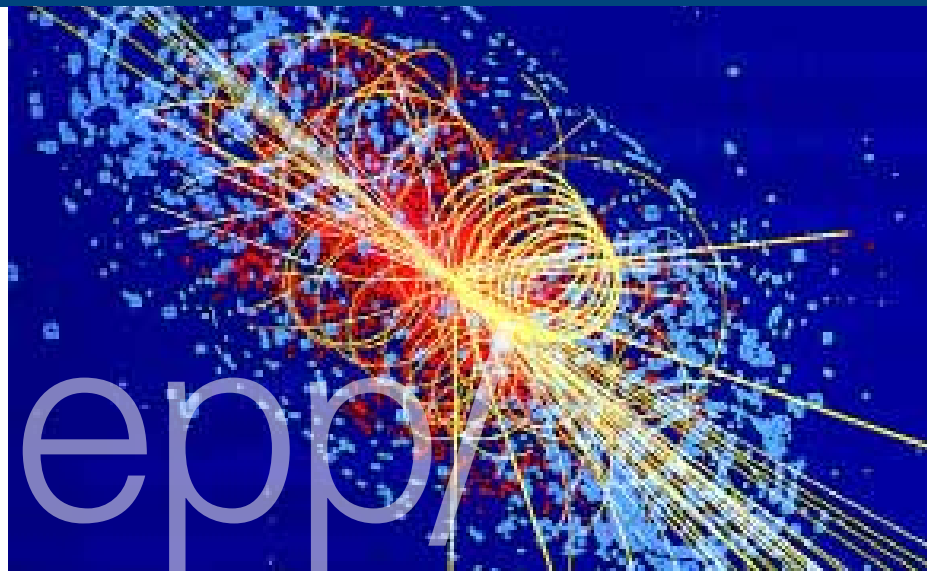
The NeCTAR Computing Project RT07 "High throughput computing for globally connected Science" aims to build eResearch Tools to enable the members of the CoEPP to be full participants in the hunt for New Physics at the CERN Large Hadron Collider (LHC) and to provide the tools and underlying infrastructure to enable other Australian groups to become full-participants in high throughput computing for nationally and globally distributed projects in their respective disciplines.

The project will provide:

- A national Cloud based, general purpose and high throughput data processing, simulation and analysis solution made up of three "local" (Tier 3) facilities at each of Adelaide, Melbourne and Sydney. These will be tightly integrated with each other and also with the Australian Tier 2 LHC site in Melbourne.
- An international Cloud-based grid site that corresponds to a World Large hadron collider Computing Grid (WLCG) "Tier 2" built on the Research Cloud provided NeCTAR and employing storage provided by RDSI.

While these tools will be primarily designed to satisfy the needs of CoEPP they will also be directly beneficial to other Australian research communities which require one or more of:

1. high throughput data processing, simulation and analysis;
2. national and global connectivity;
3. the need to share data and or compute resources; and



#### 4. large scale data analysis with complex software requirements.

This project is led by Martin Seviar. Joanna Huang is the team-leader of the developers. We receive substantial support from Lucien Boland and Sean Crosby within the CoEPP Research Computing team. By the end of 2012 we had developed a working Tier-3 facility of around 200 CPU cores and demonstrated the ability to run grid jobs directly in the NeCTAR Research Cloud. We will complete the project by the end of 2013.

#### ACCELERATOR PHYSICS AND INSTRUMENTATION

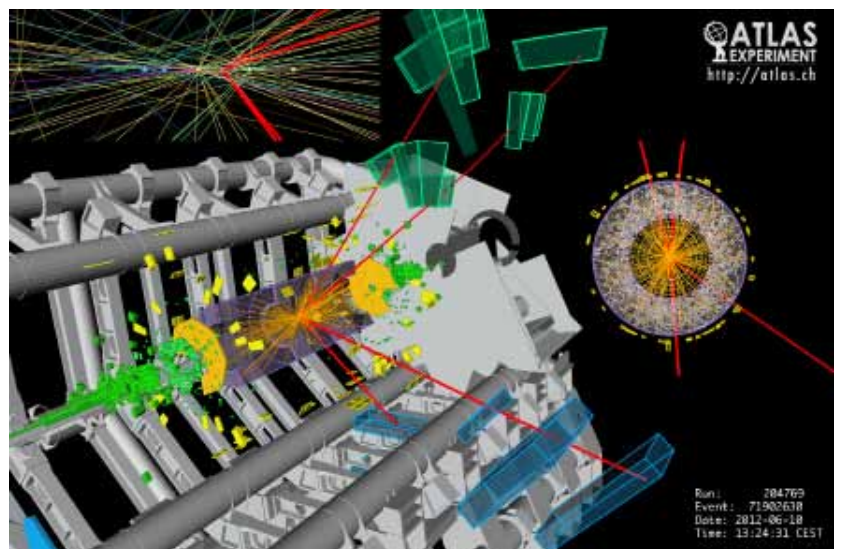
International collaborations with CERN, PSI and KEK have played a vital role in the group's accelerator research program. Support of the Australian Synchrotron, ANSTO, Berthold and DECTRIS been crucial to the effort.

#### DETECTORS AND INSTRUMENTATION

The Pilatus collaboration has now expanded considerably to include several other detector development projects. Internationally, we now play a major role in the characterisation of the detector and the design of upgrades. Successful measurements of the rate dependence of PILATUS2 at the Australian Synchrotron SAX/WAXS beam-line were carried out.

A differentiation between traditional integrated detectors such as CCD/CMOS devices and the newer single photon counting detectors such as PILATUS is their behaviour at high photon flux. We have identified that standard laboratory methods for correcting for the count-rate losses are insufficient and introduce significant errors at high flux. A preliminary monte carlo model which replicated the results was presented at the Synchrotron Radiation Instrumentation (SRI) conference in Lyon, France.

In collaboration with DECTRIS, the outcomes from this work have now been incorporated into a major upgrade of the detector. PILATUS3 now includes an





“instant retrigger” where the analogue readout behind the sensor monitors how the system is responding to flux and corrects on-the-fly for any perceived loss of counts. Critical tests of a pre-production prototype PILATUS3 are now being undertaken in collaboration with the SLS, ALS, and ESRF demonstrating the effectiveness of this cutting-edge readout technology. We have a strong and productive working relationship with both DETRIS and PSI in Switzerland and look forward to its continued development.

In the medical imaging domain, the exciting potential for non-invasive measurement of arterial blood radioactivity with the NIAM3 imaging system will progress to Phase0 medical trials, in collaboration with the Austin hospital PET Centre. The smaller footprint NIAM3 uses in-house developed position sensitive detector modules, based on state-of-the-art Silicon-PMT technology. Results from this work have been presented at the World Molecular Imaging Conference (WMIC) in Dublin, Ireland.

With an ARC linkage grant a program of atomic and condensed matter science with advanced X-rays in partnership with Bruker and DETECT Australia is underway.

## ACCELERATOR PHYSICS

The next generation e+e- linear collider design study from CERN is the CLIC Project with its associated test facilities (CTF3, ATF2, CESR-TA) and light sources collaborating on damping ring studies (SLS, AS, Diamond). Roger Rassool, Mark Boland and Kent Wootton were co-authors for the Conceptual Design Reports for CLIC [4-6], contributing to the modelling and measurements on the damping rings studying how to produce beams with emittances that are close the quantum limit as required at CLIC. In 2011 a world record for vertical emittance was set by Accelerator Group. In 2012 further improvements in emittance minimisation resulted in a mere 0.35 pm rad emittance with indications that the quantum limit has been reached. No existing diagnostics on the storage ring existed to measure accurately such small electron beams. Kent Wootton invented a new technique using an x-ray beamline in a novel vertical undulation mode which is now being refined to reach the sensitivities required to measure the new world record.

The detector expertise of the group led to collaborative development of accelerator beam diagnostics for the AS, CTF3 and LHC. To measure and control head-tail instabilities in the beam bunches, a multi-band instability monitor is being developed to measure signatures currently beyond the reach of conventional time-domain detectors. Masters student Thomas Lucas is building a detector for the picosecond bunches at the Australian Synchrotron storage ring. An improved version of the fill pattern monitor developed by the EPP group for the Australian Synchrotron is being installed at CTF3 to monitor the bunch charges at a 12 GHz repetition rate.

2012, marked the second year of CoEPP operation and was a time of discovery and achievement for the field of particle physics. It saw the International Conference

in High-Energy Physics 2012 (ICHEP2012) held in Melbourne, with the discovery of a Higgs-like boson, announced in a two-way link with CERN. This landmark discovery was fifty years in the making. CoEPP had deep involvement with both the discovery—via its work on the ATLAS experiment—and with the organisation of the conference itself. CoEPP researchers featured widely in the media during this time and were called upon to comment on the Higgs discovery, dark matter and neutrino mass in both the national and international arena. They appeared in front page stories in The Australian, Melbourne’s The Age and the Sydney Morning Herald, and in prominent multimedia features on the Fairfax and News Ltd networks of websites.

In 2012 CoEPP had 13 chief investigators, six partner investigators, 29 research staff and 50 research students across all four nodes. An experimental particle-physics team has been established in the Adelaide Node under the guidance of Dr Paul Jackson, and a theoretical particle physics team—led by Dr Archil Kobakhidze—is being established at the Sydney Node. These teams lead the way in collaborative research between the two areas of particle physics: theoretical and experimental. Whilst CoEPP experimentalists have a major interest in the ATLAS experiment, they are also involved with other leading international collaborations including the Collider Detector at Fermilab (CDF), Belle Collaboration; and the Compact Muon Solenoid experiment (CMS) at CERN.

Research outputs were high, with over 350 refereed journal papers published. A number of high-profile international visitors presented talks and colloquia to CoEPP researchers throughout the year; and similarly, CoEPP researchers traversed the globe to present their work to colleagues at leading universities. CoEPP also organized a number of workshops and symposia during the year, including the Large Hadron Collider Theory Workshop; the Australia–Italy Symposium (to promote and establish collaboration between Australian and Italian physicists); and the CoEPP workshop in Lorne where CoEPP researchers and partner institutions presented their latest findings.

CoEPP’s outreach program was strong and nationally-based. It included the July public lecture series where prominent international particle physicists spoke on high-energy physics. Speakers included Fabiola Gianotti (ATLAS spokesperson); Raman Sudrum (University of Maryland) and Young-Kee Kim (Fermilab). A well-attended high-school masterclass was held at the Australian Synchrotron in partnership with Australian Collaboration for Accelerator Science. In the masterclass students worked with Dr Martin White (ATLAS experiment), Dr David Barney (CMS experiment) and utilised real data from CERN. Other outreach activities included public exhibitions held at Scienceworks Museum, National Science Week events, the building and exhibition of a to-scale Lego model of the ATLAS experiment, high-school talks and public events.

## PROGRESS FOR ARC CENTRE OF EXCELLENCE FOR PARTICLE PHYSICS AT THE TERASCALE (COEPP)

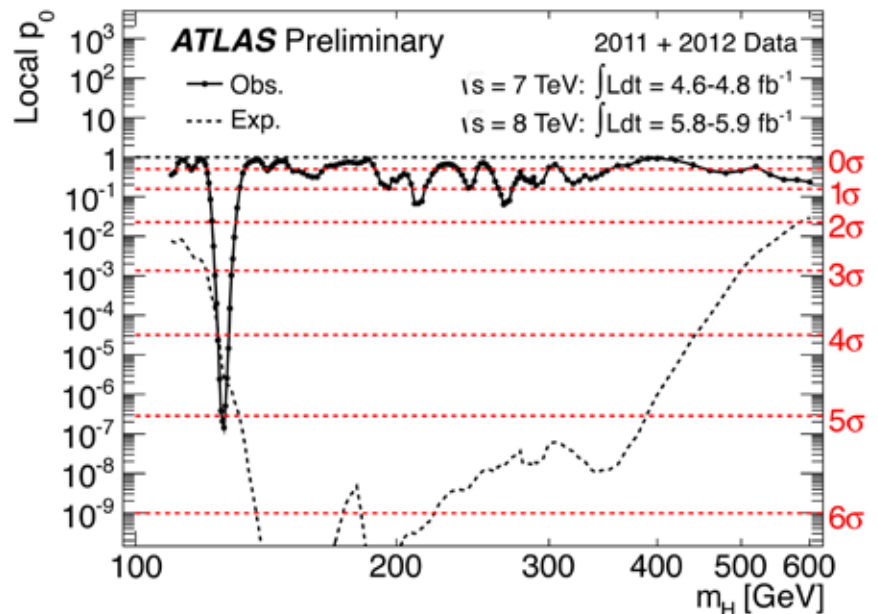
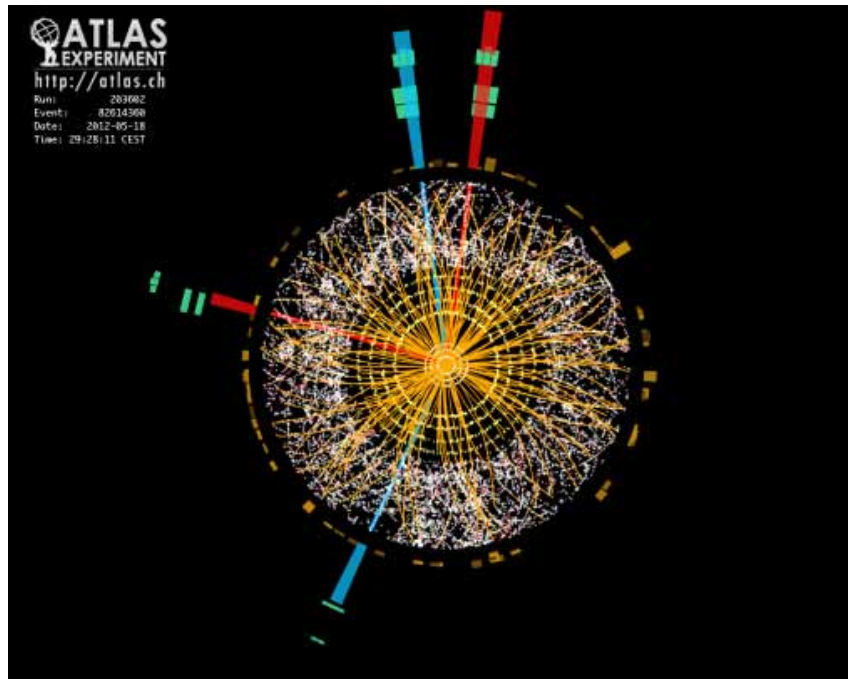
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# MICROANALYTICAL RESEARCH CENTRE (MARC) & ARC CENTRE OF EXCELLENCE FOR QUANTUM COMPUTATION AND COMMUNICATION TECHNOLOGY (CQC2T)

The Microanalytical Research Centre (MARC) has an extensive suite of advanced materials and device fabrication and characterization facilities and undertakes research principally in the areas of silicon and diamond materials and device development, with a particular focus on ion beam processing and ion beam analysis. Research activities in 2011-12 were dominated by the research themes of the Australian Research Council Centre of Excellence for Quantum Computation and Communication Technology (CQC2T) and the Bionic Eye project of Bionic Vision Australia. There were also key programs in single photon source development for applications in quantum communications, development of graphene devices, diamond detector development, and nano-diamond sensing.

The Melbourne node of CQC2T is lead by Prof. Lloyd Hollenberg with Prof. David Jamieson managing the experimental programs of the Centre. In 2011-12 CQC2T has enjoyed considerable international success with key papers including "A single-atom electron spin qubit in silicon", J. J. Pla et al., *Nature*, **489**, 541–545, (2012) demonstrating for the first time the fundamental building block for a silicon-based quantum computer. And, there are more papers to come in the near future as the Centre continues to produce world-leading research in solid-state quantum computation. Locally, the installation and development of the MARC group's dilution refrigerator with a unique 3D vector magnet and optical access will in the near future produce an important expansion of the group's ability to fabricate and measure quantum-device structures.

The diamond group lead by Prof. Steven Prawer is recognised internationally for its research in the field of diamond-based quantum optics and quantum computing and its involvement in the Bionic Vision Australia consortium to develop the bionic eye has been a major research focus in 2011-12. In a major development in 2012, Bionic Vision Australia researchers successfully performed the first implantation of a prototype bionic eye with 24 electrodes and the recipient was able to experience some vision. This augurs well for future developments in the project and it is testament to the hard work and dedication of the researchers in the program that such rapid progress has been made. In addition to the research highlights of the program several new key research infrastructure items have been added to the MARC group facilities through the bionic eye program including an optical profilometer, laser cutter, laser welder, indium evaporator and bonder.

The major research programs in the MARC group have continued to foster strong collaborations with other research groups in Australia including LaTrobe University, Royal Melbourne Institute of Technology University, University of New South Wales, University of Adelaide and The Australian National University, and internationally including Sandia National Laboratory, CEA Grenoble, University of Ulm, and University of Stuttgart. The strong research programs of the group continue to attract excellent postdoctoral fellows, students and international visitors. Space is tight but thus far we have been able to find everyone a home.

The Education Infrastructure Fund/Superscience Heavy Ion Accelerator Project, which is jointly managed between ANU and University of Melbourne, commenced funding in the latter half of 2009 and has provided \$1.3M over the time period 2009-12 to develop equipment and resources for the Pelletron laboratory. This important funding boost has allowed this core infrastructure to be revitalized and restored and for new equipment to be developed including a unique pixilated X-ray detector and related analysis chamber that will represent a major advance in micro-analysis when it comes on-line in 2013-14.



*The MMI held a public event giving political, technical and economic perspectives on water recycling. From left to right: Prof M. Porter (Deakin University), Prof P. Scales (University of Melbourne), Prof S. Prawer, Dr A. Bandt (The Greens MP) (credit: Casamento Photography)*



*Dr Georgina Such, The University of Melbourne (credit: L'Oréal Australia/sdpmmedia.com.au)*



# MELBOURNE MATERIALS INSTITUTE (MMI)

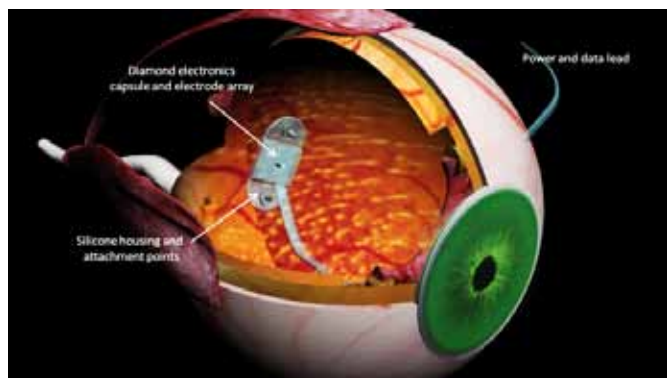
The School of Physics is the host department of the interdisciplinary Melbourne Materials Institute (MMI). The MMI is one of six interdisciplinary research institutes, established by the University to foster new research collaborations internally and externally to solve major social, economic and environmental challenges.

The MMI has brought together researchers across the faculties of Science, Engineering, MDHS and Arts through seed funding, networking events, and research workshops. The excellence of materials research at the University is exemplified by the highest citation rate in materials science in Australia<sup>1</sup> and two researchers in the Thomson Reuters ranking of Top 100 Materials Scientists (Professor Frank Caruso #17, Associate Professor Rachel Caruso #21). Early career materials researchers have also excelled, with Dr Georgina Such awarded a L'Oreal Women in Science Fellowship in 2011. PhD student Brandon MacDonald (Bio21 Institute) was selected as one of sixteen 2011 Fresh Scientists for his work to lower the cost of renewable energy by making solar cells from nanocrystal inks.

Over the last two years, the collective expertise of Melbourne researchers has resulted in funding success with over \$13.6 million in grants from the ARC. A further \$13.8 million was awarded by state and federal governments for research into materials processing for water treatment, carbon dioxide capture and printable solar cells.

The MMI supports materials research through the following themes: energy, materials conservation, materials for medicine, materials processing, and quantum and nanophotonic materials. Significant funding is provided through seed grants (\$430,000 provided by the MMI to 13 projects over 2011-2012), as well as financial and administrative support for workshops, publications and a visitor program. The visitor program has seen visits and new collaborations form with: A/Prof Eva Harth (Vanderbilt University), Prof Christ van de Walle (UCSB), Prof David Awschalom (UCSB), Dr Robert Miller (IBM), Prof Kenneth Dawson (University College Dublin) and Dr Xavier Sauvage (CNRS, France). An array of international experts visited the University in January 2012 as part of the MMI symposium on diamond photonics that was co hosted with Harvard University.

A highlight of the research program has been the successful implantation of an early prototype bionic eye by Bionic Vision Australian. The MMI and the School of Physics are members of this national consortium, fabricating a high-density diamond electrode array for the high acuity vision prototype.



*Artist's impression of the current generation of the BVA epiretinal device, tacked in positioned over the macular. (credit: David Garrett)*

[www.physics.unimelb.edu.au](http://www.physics.unimelb.edu.au)



MELBOURNE  
MATERIALS  
INSTITUTE

A major new pilot program to support materials research infrastructure was initiated by the MMI in 2012. The program provides technical support and academic leadership for key infrastructure platforms across the University, as well as at the Melbourne Centre for Nanofabrication (MCN). The University is a partner of the MCN and the MMI has facilitated increased utilisation of the facilities over the past 18 months.

The MMI is fostering the next generation of materials researchers through the MMI-CSIRO Materials Science PhD Scholarship Program. Through joint supervision with CSIRO, 14 students have received scholarship 'top-ups' to \$30,000p.a. The program provides increased collaboration between University researchers and the CSIRO as well as excellent training for the students.

The MMI public lecture series has covered a broad range of topics. In 2011 Associate Professor Eva Harth from Vanderbilt University presented on her work on nanosponges for targeted cancer treatment. Later in the year Professor Peter Scales spoke about the materials processing issues relating to water recycling as part of the public event on water recycling – From Toilet to Tap. He was joined by Greens MP Adam Bandt and Professor Michael Porter (Alfred Deakin Research Institute) who provided perspectives on the associated political and social issues. In 2012, the MMI held public lectures on diamonds for the quantum age (Professor David Awschalom, UCSB), medical bionics (Professor Robert Shepherd, Bionics Institute) and the science of conserving Indigenous Australian art (A/Professor Robyn Sloggett, Dr Petronella Nel from the University of Melbourne and Indigenous Australian artists from Warmun Art Centre).



Ngalangangpum School, Nancy Nodea. © Copyright in this artwork and text remains with the Artist and Warmun Art Centre respectively

# OPTICAL PHYSICS

Research into plasmonics and metamaterials, led by Ann Roberts and supported by Australian Research Council Discovery and Linkage Projects, has also led to the development of novel nanoscale photonic devices and metamaterials and plasmonic.

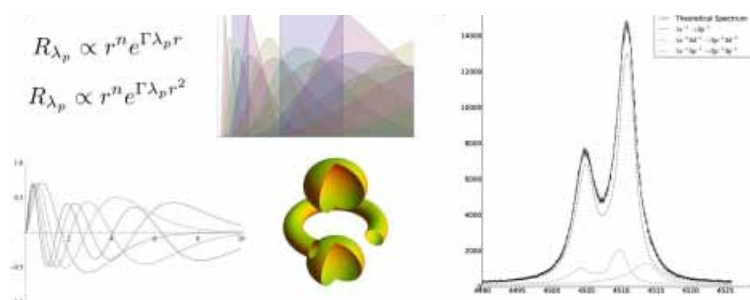
In collaboration with Dr Tim Davis from CSIRO particular focus during 2011 and 2012 has been on the development of active devices where a nanoantenna controls and shapes the radiation of light produced by emitters such as quantum dots or defects in diamond. Recent papers in Applied Physics Letters, Optics Express and Optical Materials Express have focussed on demonstrating designs for ultracompact optical devices including lenses and polarising elements.

Dr Tim James also started work as a research fellow on the nanoantenna project and has made outstanding contributions to the development of fabrication capability using the facilities of the Melbourne Centre for Nanofabrication.

The group was also joined in early 2011 by Dr Daniel Gomez, recipient of an ARC Australian Postdoctoral Fellowship, who is working toward the development of a SPASAR – devices for amplifying surface plasmons. In mid-2011, along with researchers from the Reserve Bank of Australia and Professor Paul Mulvaney from Bio 21 and the School of Chemistry, A/Prof Roberts was awarded a Linkage Project award from the ARC to develop novel plasmonic optical security devices.

Research into the developments of novel imaging techniques was boosted by the award of an ARC Discovery Early Career Researcher Award to Dr Shan Shan Kou who arrived in April 2012 and is leading work into the development of three-dimensional imaging techniques for live cell imaging. The collaboration with the University's Centre for Cultural Materials Conservation is also progressing with papers accepted in the Journal of the American Institute of Conservation and the Proceedings of LACONA IX.

The research team has also been awarded a grant through the University's Interdisciplinary Seed Funding scheme to look at climate control and physical changes in artworks in museums. The ultracold plasma cold electron experiment is a collaboration with the TCMP group (ARC Discovery Project High-resolution



Growing Tall Poppies Climate Change outreach project

electron diffraction imaging for the nanosciences; Allen, Nugent, Roberts and Scholten) and with the ARC Centre of Excellence in Coherent X-ray Science. Laser-cooled and trapped atoms are first excited with an on-resonant infrared laser, and the excited atoms are then photoionised with a blue laser pulse tuned precisely to the ionisation threshold. Electrons are released with almost zero excess energy, such that their temperature is only 10 Kelvin and their corresponding coherence length is 10 nanometres, sufficient for diffraction imaging of large biomolecules. The initial electron bunch can be created in arbitrary shapes by appropriate patterning of the excitation laser beam, and because the electrons are so cold, that pattern is retained during propagation (see *Nature Physics* 7 p785, 2011).

In other work as part of the electron diffraction imaging project, we unambiguously demonstrated coherent diffractive imaging with a high-coherence electron transmission microscope. The work led by Corey Putkunz used ptychographic methods to obtain atomic-resolution images of a boron nitride cone, with higher resolution than would otherwise be obtained for the microscope configuration (see *Physical Review Letters* 108 073901, 2012).

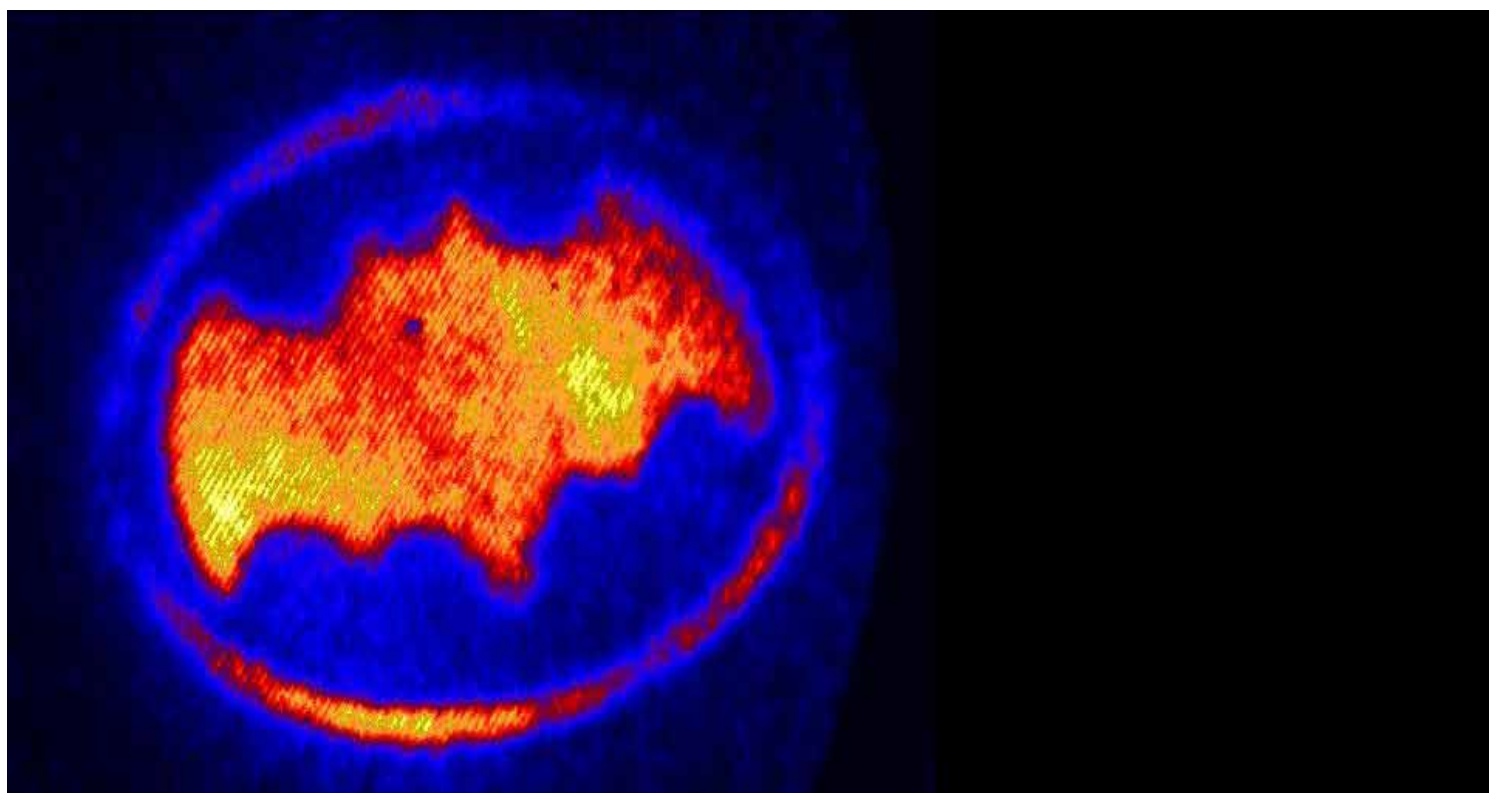
The group also continued its productive collaboration on diamond quantum sensors with Prof. Hollenberg. We have shown that diamond NV centre magnetometry has the sensitivity needed for non-invasively detecting electrical neural impulses (see *Nature Scientific Reports* 2 p401, 2012). A/Prof Scholten was awarded the 2011 David Syme Prize for his contributions to research with diamond NV centres and with ultracold electrons.

The X-ray optics, Synchrotron Science and Atomic Physics subgroup [Chris Chantler, Zwi Barnea] has had great success with

notable media highlights, an article in *Physical Review Letters* and major papers across several fields. Jay Bourke's PhD thesis was cited by the referee as one of the best to have crossed his desk, on the new fields of [photo-] electron IMFP measurement and theory which stem from our experimental work with Synchrotrons and our X-ray Extended Range Technique. We obtained first fruits of the field of measurement of the inelastic mean free path of the [photo-]electron through matter (Bourke and Chantler, *J Phys Chem A* 116, p 3202, 2012). In the last two years, a collaboration with Dr Stephen Best in the School of Chemistry and other institutions has led to a new approach to fluorescence XAFS and dilute systems but especially has enabled high precision and XAFS accuracy for 15 K cryostat cells – called the Hybrid technique. Students have developed the prototype experiments on non-destructive nanoroughness measurement using X-rays at the ANBF and at the Australian Synchrotron.

Our theoretical developments of relativistic atomic physics have led to great acclaim internationally, and we have been reported as a laboratory highlight for a theoretical project. (Chantler et al., *J Phys B* 46, 015001, 2012) Perhaps the biggest highlight was the first sign of a pattern of discrepancy of QED from the theoretical computation. Chantler et al., *Phys. Rev. Lett.* 109, 153001, 2012) which was also highlighted in *Physics Today*.

Members of the group continue to contribute to other organisations. Ann Roberts became President of the Australian Optical Society, an organisation devoted to the promotion of optical science and engineering in Australia.



*False-colour image of arbitrarily shaped cold electron bunch. An electron bunch was created in the bat shaped pattern and then detected after 24cm free-propagation distance. Because the electrons are very cold, the pattern is retained.*



## ARC CENTRE OF EXCELLENCE FOR COHERENT X-RAY SCIENCE (CXS)

2012 has been another great year for the ARC Centre of Excellence for Coherent X-ray Science. We continue to develop and diversify and our science continues to be outstanding. As will be discussed in more detail below, Professor Keith Nugent's time has been rather fractured with commitments to both a major sustainability program at the University of Melbourne for the first half of the year and a nominal 20% commitment to the Australian Synchrotron for the entire year. While this has been demanding, the leadership of CXS has been in very safe hands with Assistant Director Harry Quiney, Deputy Director Leann Tilley and Chief Operating Officer Tania Smith.

As part of our continuing development, we welcomed a new program into CXS from Monash University led by Associate Professor Martin Scanlon. This new aspect of our work is developing extremely well.

We will discuss some scientific achievements further along, but we think we have some non-scientific achievements to also be proud of. Chief Operating Officer Tania Smith was asked by the ARC to convene the inaugural meeting of COOs for all Centres of Excellence across Australia. This is a terrific recognition of the fact that CXS is recognised as being amongst the best run CoEs and that Tania is a major contributor of ideas as to how to manage what are rather idiosyncratic and diverse organisations. Efficient and nimble management is critical to a successful Centre of Excellence. We should also be delighted with the continued success of the Growing Tall Poppies program. This initiative continues to attract national attention and we were all delighted to see its Director, Dr Eroia Barone-Nugent, recognised as a finalist in the High School teacher section of the Eureka Prizes this year. Centres of Excellence, as the premier research structures supported by the Australian Research Council, are expected to take their outreach activities very seriously and our very outcome-focussed approach makes it is safe to claim that we do it better and more effectively than perhaps any other centre.

It is also a pleasure to note the recognition for CXS members including Dr Victor Streltsov being awarded a Japanese Society for the Promotion of Science Fellowship, Dr Ben Norton gaining second place in the Canon Extreme Imaging Competition with publicity via Cosmos and National Geographic. Dr Ved Mooga was awarded a poster Prize with the Melbourne Protein Group.

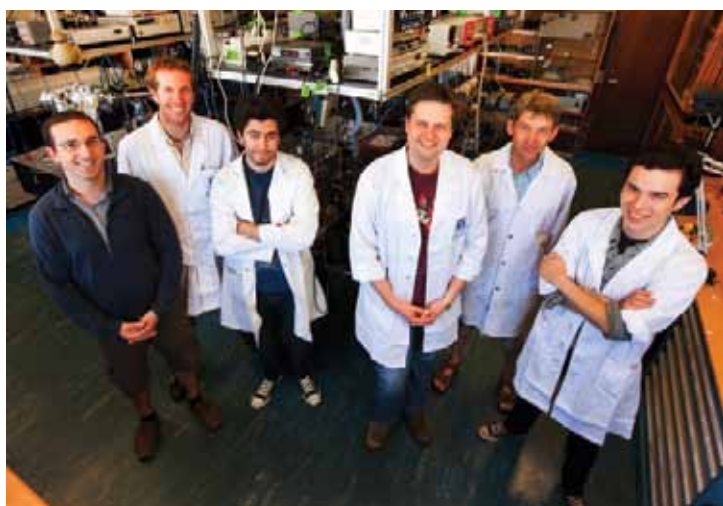
2013 sees the conclusion of the current funding round and we are now deeply engaged in planning what to do next. The relationships and collaborative links that characterise CXS are enormously valuable and we think establish the basis for a further world-leading research program. It is our view that, in particular, our work on the application of X-ray free electron lasers to structural biology is putting us in an excellent position to spearhead our national engagement in this new scientific frontier. The work of University of



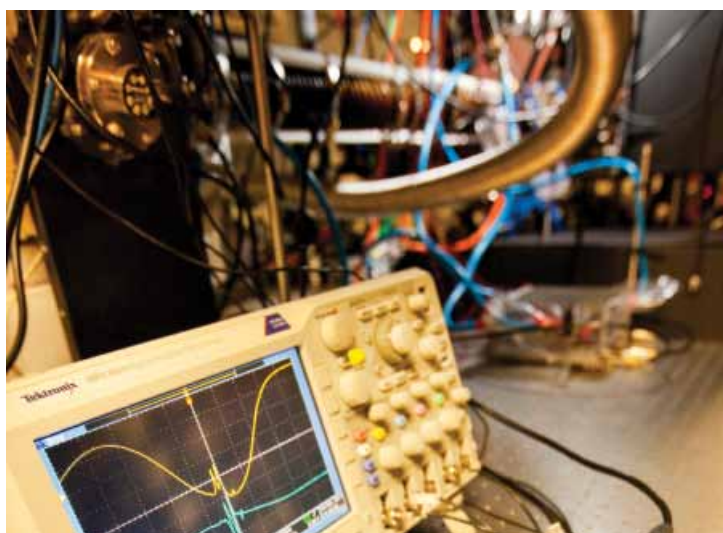
Melbourne alumnus and CXS Partner Investigator, Professor Henry Chapman, and his team continues to demolish potential barriers and continues to give a great deal of confidence that this important new approach to biomolecular structural determination is going to be profoundly important. And, while this area will remain the keystone, the other projects that are emerging as our discussions progress are also tremendously exciting.

The scientific goals for CXS are of course deeply integrated into the development of the Australian Synchrotron and it was important both for us and for the nation that the Australian Synchrotron continues to thrive and grow. The demands for expertise in the synchrotron has seriously depleted the staff of CXS with Professor Andrew Peele taking on the full-time role of Head of Science and with Professor Keith Nugent taking on the part-time role as Director, both commencing in 2011. 2011 was very much a year for groundwork with the Australian Synchrotron. Andrew has done a wonderful job at helping improve communications and structures internally and Keith concentrated on making sure that the external perceptions of the synchrotron were correct; that the Australian Synchrotron is recognised as a well-managed and highly productive facility that is delivering great science for Australia. With the perceptions sorted out and proven via a clear analysis of the performance, Keith and Andrew were in a position to make the case for ongoing funding. It was a bit of a roller-coaster ride but by the middle of the year it was clear that they were going to secure a budget of \$100M over four years from a range of stakeholders. This is a tight budget for the facility but will secure the operation for the next four years and allow the Australian Synchrotron to develop an ongoing base of funding and hopefully to develop the capital program, including the construction of more beamlines. We are delighted that ANSTO has stepped up to be the operator of the facility. The Australian Synchrotron has found its natural home with ANSTO and we are very confident about its future.

CXS can be proud of the role its members have played in this latest chapter of the development of the Australian Synchrotron. It is indicative of the esteem in which we are collectively held and we have played a national leadership role that has possibly been to the cost of our own scientific productivity. However, it has been tremendously important to have taken this on and CXS and the research it will have spawned over the years to come will be the beneficiary. The development of the soft X-ray imaging branch-line is just one important example.



*The Ultracold Plasma Source team*



*Science at work*



*CXS student office*

CXS continues to make major scientific contributions. We have led a major collaboration in the development of high-resolution soft X-ray imaging and we have, over the last seven years, developed a wide range of novel approaches and brought them to the point where they can be reliably applied. While we did experience some technical challenges with the development of our facility at the Advanced Photon Source, it has now been brought back to Australia and we are in the process of installing it at the branch line at the Australian Synchrotron. We hope that this will be an important scientific resource for the future of Australia. We have also had a major project in the development of the NADIA (Novel Algorithms for Diffraction Imaging Applications) software package that is to be made available to the international community. Professor Leann Tilley and colleagues had an article highlighted on the cover of Trends in Parasitology and a high profile paper in Physical Review Letters from a team led by Dr Corey Putkunz was reported as a highlight in the Asia Pacific Physics Newsletter.

We were also delighted that Dr Brian Abbey and colleagues gained the first access by an Australian team to the Linac Coherent Light Source X-ray free electron laser at the SLAC laboratory in Stanford. The results from this experiment are extremely exciting and we hope to announce their publication in next year's report.

CXS members have continued to play a role in the public eye. Professor Andrew Peele has been interviewed in the Canberra Times. Associate Professor Robert Sang and Professor Dave Kielpinski have appeared on the program Scope on Channel 10. Robert also undertook the Queensland branch of the Australian Institute of Physics Annual Youth Tour with lectures across Queensland.

We hosted Felix Frank, Jacob Taylor, Ron Steer, Paul Janssen and Jamie White as visitors over the year and we welcomed new members Andrew Martin, T'Mir Julius, Luke Formosa, Coralie Millet, Chen Xie, Rory Spiers, Richard Taylor, Aidan Jessen, Ashish Tripathi, Martin Scanlon, Martin Williams and Biswaranjan Mohanty.

Professor Keith Nugent has accepted a position as Deputy Vice-Chancellor and Deputy President (Research) at La Trobe University. The reasons for his decision to accept this position are complex but he steps down from his leadership of CXS with considerable regret. While he will continue to be an active member of CXS, he considers his role as its leader for the best part of eight years to have been a tremendous privilege. He is delighted, however, to be able to move to a senior position with La Trobe University as it has been an exemplary partner institution and the CXS Experimental Methods Program will have its home at La Trobe University from 2013. CXS is in good hands as Professor Leann Tilley steps up to the Director's role.

## THEORETICAL CONDENSED MATTER PHYSICS (TCMP)

In 2011-2012, the team led by Prof Lloyd Hollenberg (including researchers in the Centre for Quantum Computation and Communication Technology) conducted research into a diverse range of projects from quantum computing to quantum sensing. In quantum silicon electronics ab-initio work was conducted in collaboration with Prof. Russo (RMIT), and with the group of Prof. Klimeck (Purdue) and Prof. Simmons (UNSW) theory work underpinned the fabrication and measurement of nanowires a few atoms in width (Science 2012), and the first single atom transistor (Nature Nanotechnology 2012). Highlights in diamond based quantum sensing, include the world's first quantum measurement in a living cell (Nature Nanotechnology 2011), nanoscale electric field measurements (Nature Physics 2011), and proof-of-concept work towards neuronal imaging (Nature Scientific Reports 2012). In quantum computing, centre researchers developed a technique achieving the largest error threshold for quantum error correction and simulated a world record instance of Shor's quantum factoring algorithm.

ARC Australian Professorial Fellow Les Allen delivered invited talks at the XXII Congress and General Assembly of the International Union of Crystallography in 2011 and at the European Microscopy Conference in 2012. He was an invited lecturer at the 5th Summer School on Aberration Corrected STEM organized by the SuperSTEM facility in the UK. His student, Dr Adrian D'Alfonso was a recipient of the Bragg medal for the best PhD in physics in Australia in 2011. A research highlight for the subgroup led by Prof. Allen was a paper published with researchers in Spain and France in the high profile journal *Angewandte Chemie* and in which the chemical imaging at atomic resolution of the structure industrially important catalytic nanocrystals was determined. A paper was also published in *Applied Physics Letters* on determining ferroelectric polarity at the nanoscale, which was highlighted in *Virtual Journal of Nanoscale Science & Technology*. An invited review paper was published in the *Materials Research Society Bulletin* on chemical mapping at atomic resolution using energy-dispersive x-ray spectroscopy. A major advance was reported in *Physical Review Letters* where atom-scale ptychographic electron diffractive imaging (of boron nitride cones) was demonstrated.

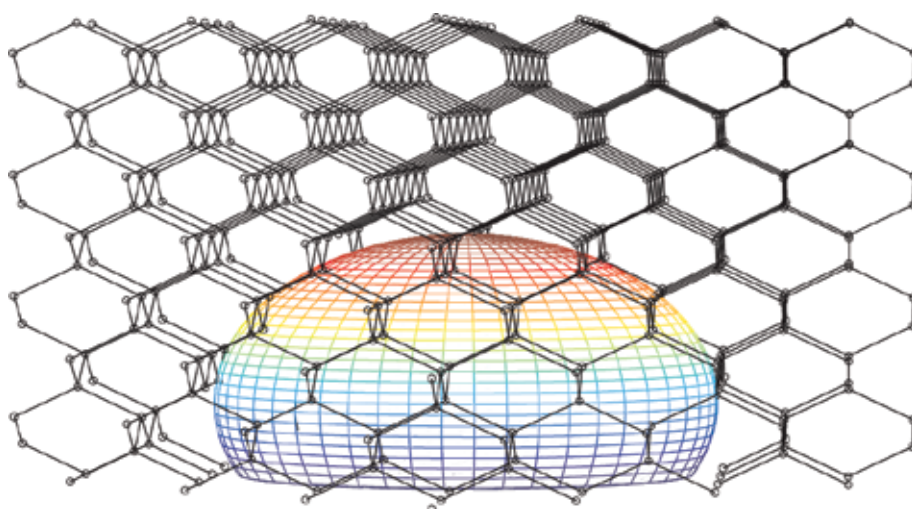
In 2011-2012, researchers in the subgroup of Dr Andy Martin conducted research into a diverse range of areas from the study of the properties of ultracold gases and the emergence of domain structures in early universe dynamics, to the properties of coupled atom cavity systems and the accumulation of measurable geometric phases in rotating nitrogen-vacancy defects. Specifically, in the area of ultracold gas research, this group, in collaboration with Prof T.M. Fromhold (University of Nottingham, U.K.), Dr T.E. Judd (Tubingen University, Germany) and Dr R.G. Scott (University of Trento, Italy), showed that thin dielectric films can be used to enhance the performance of passive atomic mirrors. This work was selected to appear in the 2011 special highlights edition of *New Journal of Physics*. Additional highlights in the field of ultracold gas research included: (i) the design of an atom interferometer using adiabatic passage protocols for a dilute gas Bose-Einstein condensate in a three well system; (ii) in collaboration with Dr D.H.J. O'Dell (McMaster University, Canada), Prof S.J.J.M.F. Kokkelmans (Eindhoven University of Technology, The Netherlands) and Dr N.G. Parker (Newcastle University, U.K.), the determination of the stability regimes of a Bose-Einstein condensate in a synthetic magnetic field; (iii) in collaboration with Assoc. Prof. Harry Quiney, new universal thermodynamic properties of strongly interacting rotating ultracold gases. Work carried out in collaboration with Prof Lloyd Hollenberg and Dr Andrew Greentree (RMIT) demonstrated the possibility of a new class of dynamic quantum metamaterials, based on the quantum properties of coupled atom-cavity arrays. Further work in this field demonstrated the possibility of new strongly correlated states of light, which have analogies with the fractional quantum Hall effect. Also, in collaboration with Dr Andrew Greentree (RMIT), the emergence of domain structures in early universe dynamics were studied. Finally, in collaboration with Prof. Lloyd Hollenberg, the group of Dr Andy Martin demonstrated that the internal magnetic states of a single nitrogen-vacancy defect, within a rotating diamond crystal, acquire geometric phases. The analysis also provides the basis for quantifying geometric phase shift effects in the use of nanodiamonds as high precision translational and rotational sensors.



Assoc. Prof. Harry Quiney was appointed to a continuing position as Senior Lecturer in TCMP in July 2011 and was promoted to Reader in October 2012. He is also Deputy Director of the ARC Centre of Excellence for Coherent X-ray Science (CXS) and the leader of its Theory and Modelling Group. He has led the development of methods to exploit the brightness of X-ray Free-Electron Laser sources in the imaging of biomolecules and in the use of partially-coherent light sources in coherent diffractive imaging applications. He collaborates closely with the Allen subgroup on the development of new imaging algorithms and with the Martin subgroup on the realization of advanced many-body theories for ultra-cold Fermi gases. He is continuing earlier work on the development of relativistic electronic structure theories for the interpretation of high-precision atomic and molecular spectroscopy and has recently developed collaborations with Dave Kielpinski (Griffith) and Jeff Davis (Swinburne) to model time-dependent electronic phenomena. Recent highlights include the publication of a dynamical theory describing the interaction of a biomolecule with femtosecond X-ray pulses (Nature Physics) and the experimental demonstration of broadband X-ray imaging using a modal analysis of partially coherent sources (Nature Photonics).

ARC Australian Research Fellow Dr Snjezana Tomljenovic-Hanic joined TCMP in 2010, a PhD student, Kelvin Chung, commenced in February 2011 and a PhD student Asma Khalid commenced in February 2012.

In 2011 her team invented a new hybrid approach for inducing a high-Q cavity only by the presence of nanodiamonds, which was invited for inclusion in a special issue of Optics Express: "Collective phenomena in photonic, plasmonic and hybrid structures". Two hybrid diamond structures have been investigated in 2011. Studies of hybrid diamond-tellurite glass structures have been pioneered in collaboration with the University of Adelaide. This work has already been recognised internationally and nationally as an important step towards achievement of scalable and practical quantum devices. In collaboration with the BIO21 institute the subgroup investigated a new hybrid quantum platform, zinc oxide and nanodiamond. The discovery of the first single photon emitter in ZnO, along with quantum characterisation has been performed and published in the prestigious journal Nano Letters. In 2011-2012 Dr Tomljenovic-Hanic has initiated three new projects including a number of new collaborations with Tufts University in Boston, the University of Sydney, Hong Kong University, the Australian National University, the University of Technology Sydney and the Department of Chemical and Biomolecular Engineering at the University of Melbourne. Tomljenovic-Hanic served as a Guest Editor for: "Optical Waveguides and Resonant Cavities" in Advances in Optoelectronics, 2011.



*Schematic of the strong coupling sphere enclosing a nitrogen-vacancy centre in a diamond lattice, used in the calculations of lattice spin-bath induced decoherence in the central-spin problem (L. Hall et al).*

## THEORETICAL PARTICLE PHYSICS (TPP)

2011 was a momentous year for TPP and particle physics in Australia in general as it saw the inauguration in March of the ARC Centre of Excellence for Particle Physics at the Terascale (CoEPP). A Melbourne-led consortium with the University of Adelaide, Monash University and the University of Sydney, CoEPP was officially launched in June by the Hon. Kim Carr, the Federal Minister for Science. The substantial funding awarded to the Centre, and its long-term (7 year) nature, allows both a significant expansion in personnel and the scope for pursuing new and more ambitious projects. As well as bringing together four institutions, it also features theorists and experimentalists working together closely, usually for the first time. For the theory part of the Melbourne node, CoEPP funding has permitted us to make level B appointments for Dr Robert Foot and Dr Archil Kobakhidze, with two new level A postdoctoral fellows joining us in September: Dr Anibal Medina and Dr Michael A. Schmidt. They have broad experience in supersymmetry, extra dimensions and neutrino physics. A further two level A appointments will be made in 2012.

CoEPP is focused on TeV-scale research associated with the Large Hadron Collider. This is an important part of our work, but there are also research areas outside this domain that are just as significant, especially in particle astrophysics, particle cosmology and deeper theoretical topics. To that end, we also welcomed the arrival of Dr James Barnard as a level A postdoc, funded by Tony Gherghetta's ARC Federation Fellowship. James is an expert in Seiberg duality, supersymmetry and solitons.

We bid a fond farewell to PhD student Thomas Jacques, who completed his thesis under the supervision of Nicole Bell. He is now a postdoc at Arizona State University in Lawrence Krauss's research group. Professor Krauss visited Melbourne as a Miegunyah Fellow for about one month this year. His visit here was extremely successful in terms of cementing research collaboration with Nicole and her students, and also through the many high-profile outreach activities he engaged in. We also said goodbye to postdoc Nicholas Setzer, who moved on to Granada University in Spain for his

second postdoc. Masters students Paul Angel, Amelia Brennan, Jackson Clarke and Peter Cox completed their degrees in 2012.

There are many research highlights to report:

Tony Gherghetta, working with postdocs Benedict von Harling and Nicholas Setzer, completed a major piece of work that combines some of the features of supersymmetry and warped extra dimensions in a vision for how the critical gauge hierarchy problem might ultimately be solved. The gauge hierarchy problem is the generic expectation that low energy scale physics is driven up to high energy scales by quantum effects. The potential effect to be avoided is that the W and Z boson masses become many orders of magnitude higher than they need to be in order to fit with what we know about the weak interaction responsible for beta decay. Their model allows important experimental constraints to be obeyed while retaining just the right new physics at a scale of a few 100s of GeV to solve the gauge hierarchy problem. This paper was published in the Journal of High Energy Physics.

Nicole Bell, postdoc Kallia Petraki and myself worked with Ian Shoemaker of Los Alamos to invent a scenario termed "pangeneses", which hypothesises a common cosmological origin for both ordinary and dark matter, thus explaining their very similar observed densities in the present-day universe. This Physical Review D paper reports on a way of doing this within supersymmetric theories through the use of a well-known dynamical phenomenon called the Affleck-Dine mechanism. Subsequent work (Journal of High Energy Physics) by Petraki, myself and Professor Mark Trodden (University of Pennsylvania) explored a different mechanism (bubble nucleation from a first-order phase transition) to achieve the same outcome. Professor Trodden is a Partner Investigator on CoEPP.

Nicole Bell with her students Ahmad Galea and Thomas Jacques, and international collaborators James Dent, Lawrence Krauss (both of Arizona State University) and Thomas Weiler (Vanderbilt University), pursued studies of "electroweak bremsstrahlung" in the process of dark matter annihilation. This annihilation process is crucial as it sets the dark matter density in a certain wide class of dark matter models. Nicole and her collaborators have discovered that an effect that naively looks

# POSTGRADUATE PHYSICS STUDENT SOCIETY

subdominant – electroweak bremsstrahlung, the radiation of W and Z bosons – will actually be the dominant channel for dark matter annihilation in many models.

2012 was another great year for particle physics research in the group, and in Australia generally. In terms of creating international visibility, the 4 July announcement of the discovery of a “Higgs-like” particle jointly at CERN and the University of Melbourne-hosted International Conference on High Energy Physics (ICHEP) 2012, is likely to never be exceeded. The storm of media interest all over the world was intense. It is not often one wakes to a headline such as the “Origin of Universe Revealed” effort by The Age on July 5! Going beyond the mere organisation of a conference, it is very important to appreciate that researchers within CoEPP played substantial roles in the scientific analysis behind the announcement.

During the year we congratulated Nicole Bell and Archil Kobakhidze on being awarded the very competitive Future Fellowships by the Australian Research Council.

This year saw the departures of research fellows Donatello Dolce, Benedict von Harling (to his second postdoc, at SISSA, Trieste, Italy) and Kalliopi Petraki (to her second postdoc, at NIKHEF, Amsterdam, The Netherlands), and the PhD completion of Jayne Thompson. We also said a partial goodbye to research fellow Archil Kobakhidze, who is now a Senior Lecturer at CoEPP partner the University of Sydney. We look forward to continued collaboration with Archil as he pioneers theoretical particle physics at that institution. These departures were balanced by the arrivals of Yi Cai and Andrew Spray as new CoEPP research fellows, and Tirtha Sankar Ray as a postdoc working under Tony Gherghetta.

Research conducted in 2012 saw Tony Gherghetta with collaborators and students continuing to explore supersymmetric models and theories involving extra dimensions of space. Ray Volkas and associates worked on discovering the origins of neutrino mass at the LHC, domain-wall brane models involving one or two extra dimensions of space, and asymmetric dark matter. Nicole Bell and coworkers continued their in-depth studies of dark matter through indirect detection of astrophysical signals and in colliders through electroweak bremsstrahlung.

Participation in the PPSS for 2011/2012 was at typical levels for the last few years. All officer positions were easily filled, and a core group of students showed enthusiasm for involvement in the PPSS. School committee representation continues and is an important and valued role of the PPSS.

Feedback received regarding the MSc program has been overwhelmingly positive. The two-year timeframe, in contrast to the one-year honours program, is much appreciated as it gives the students a chance to absorb the coursework content more thoroughly, and spend more time undertaking their research projects. The MSc theses are generally seen as being of a higher standard than the honours theses due to the increased amount of time available for the writing up of the projects. It seems that students are also more likely to have a paper published during or soon after completion of the MSc.

Extra-curricular activities continued to be supported by the School and the Graduate Student Association (GSA), which is much appreciated by the student body. The pool competition was held as usual, which provided a welcome chance to take a well-earned break from study and research, and to interact with others in the building.

Trivia night is always the highlight of the physics social scene, and in 2012 it was considered to be one of the more successful trivia nights of recent years. Participation in the organisation of these events was great and much appreciated.

As always, the finishing MSc students presented a great array of talks for their final assessment. A new initiative in 2012 was the presentation of MSc talk prizes, which will hopefully continue to run in years to come.

The Geoff Opat Seminar Series (GOSS) and associated food and drinks following have continued to be well organised and maintained, and provided a great way to cap off each week with a presentation of the work of our peers, as well as a chance to interact socially in the common room. Talks covered a wide variety of subjects from large-scale simulations of the universe to the physics of Frisbees.





## ALUMNI & FRIENDS

WE HIGHLY VALUE THE SUPPORT WE RECEIVE FROM OUR ALUMNI FOR PRIZES AND AWARDS THAT SUPPORT OUR STAFF AND STUDENTS AS WELL AS OUR POTENTIAL BUILDING PROJECTS IN THE FUTURE

THE SCHOOL OF PHYSICS HOPES TO RECONNECT WITH ITS ALUMNI AND HAS STARTED A ROLLING PROGRAM OF ALUMNI REUNIONS

### CLASS OF 1960-69

In August 2011 the School of Physics hosted a reunion for Physics honours and postgraduate students from the 1960s.

It was a wonderful occasion and a delight to have so many alumni from that period together. Those who attended enjoyed the opportunity to renew acquaintances and share recollections.



*Geoff Hudson*



*David Webb and George Dracoulis*

## LABY IDEAS CENTRE

### A NEW LEARNING CENTRE FOR THE SCHOOL OF PHYSICS

On October 18 2012, the School of Physics opened the Laby IDEAS Centre for undergraduate students who will use the facility to Interact, Discuss, Explore, and Analyse Scientific ideas.

The centre was named in recognition of the strong connection between the University and the legacy of Professor Thomas Laby (1880-1946) and his family.



It consists of three zones designed to meet different learning needs: an informal area with couches, discussion and meeting areas, and computer labs.

The Provost Professor Margaret Sheil (below) officially opened the space on 18 October.

Faculty of Science Dean Professor Robert Saint said the new centre, with its flexible mix of study, discussion and computer spaces would provide a great space for undergraduate students to work and interact.

"It is a great space, befitting the highly talented students we attract to our physics courses," he said.

Head of the School of Physics Professor David Jamieson explained how the space developed from the legacy of the Laby family.

"Continuing the long involvement of the Laby family in the history of the School of Physics, including the Laby lecture theatre, the Laby Foundation made a generous bequest to create the Laby IDEAS Centre," he said.

"Judging by the crowds and the impassioned speech from student representative Jasmine Hughes at the opening, the new centre is a great success."

Third-year Physics student Jasmine Hughes said the new space would be more than a comfortable study space and meeting place for physics students.

"The new centre will serve a different purpose for every physics student who enters it. It's not just a study area or classroom, but a home for those who love physics," she said.

The centre is part of a multi-tier redevelopment of the David Caro building, which also includes new spaces for the University's new Australian Research Council Centres of Excellence in Physics at the Terascale and All-sky Astrophysics.



*Laby Foundation Trustees: David Jamieson, David Hughes, Peter Watmuff and family friend & representative of the Laby family Diana Cerini*

INTERACT  
DISCUSS  
EXPLORE  
ANALYSE  
SCIENTIFIC  
IDEAS

# OUTREACH PROGRAMS

## 2011 JULY LECTURES - 100 YEARS OF SUPERCONDUCTIVITY

8 July	Professor David Jamieson, The University of Melbourne	<i>Absolutely No Resistance</i>	The strange discovery of superconductivity Since the discovery in 1911 that frozen mercury would conduct electricity with absolutely no resistance when cooled to very low temperature, humanity has struggled to explain the phenomenon. It took nearly 50 years to explain the 1911 discovery but this explanation was challenged by new high temperature superconductors discovered in 1986. This lecture looks at the past and promise of this remarkable phenomenon.
15 July	Dr Cathy Foley, CSIRO	<i>Superconductivity: How it touches your life</i>	Applications of superconductivity are ubiquitous in modern technology. From ultra-sensitive probes that can map brain waves to mobile phone base-stations and medical scanners, superconducting devices have enhanced our lives. This lecture looks at these applications and the important role Australian scientists have had in these innovations.
22 July	Professor Ray Volkas, University of Melbourne	<i>The Superconducting Universe: Breaking symmetry</i>	Could the entire universe be a superconductor? Some of the ideas used to explain superconductivity have had a surprising cross over into fundamental particle physics and our understanding of deep symmetries in the structure of matter at the most fundamental scale. Breaking these symmetries leads to the idea of the Higgs boson and the origin of mass. This lecture looks at the wide frontiers of superconductivity.
29 July	A/Prof Andrew Melatos, University of Melbourne	<i>Superconductivity in Space: neutron stars and gravity waves</i>	Along with its strange cousin, superfluidity, superconductivity governs the behaviour of matter at the extreme conditions found inside supernova remnant neutron stars. Glitches in the crust of the neutron star and the super-strong magnetic field from the stars promise floods of gravity waves that one day soon we may be able to detect on Earth.

## 2012 JULY LECTURES - "AN EVENING WITH THE WORLD'S LEADERS IN HIGH ENERGY PHYSICS"

The 2012 July Lecture Program once again showed the great interest in Physics from the people of Melbourne and beyond. Just two days after the Higgs was announced, this panel of physicists from the International Conference in High Energy Physics presented their personal experiences of the great discovery and fielded questions from the overflow audience in the Spot Theatre. The evening concluded with an insightful question from a school student that draw applause from the rest of the audience! Visiting the campus, CERN Director and University honorary Doctor of Laws laureate, Professor Rolf Dieter Heuer captured the moment: 'Just two days ago, we announced in conjunction with this University, the discovery of a new particle that is set to have a profound influence on our understanding of the fundamental nature of matter.' The audiences of our 2012 July Lecture program clearly appreciated being part of the action.

6 July	A panel of physicists from the International Conference in High Energy Physics	<i>An evening with the world's leaders in high energy physics</i>	The world's leaders in high energy physics met Melbourne to unveil the latest results in particle physics. Where is the Higgs boson? Is supersymmetry dead? Do we need an even Larger Hadron Collider? What is dark energy and the new cosmology? This special Physics July Lecture, presented a panel of theoretical and experimental physicists to discuss the most recent developments at the LHC and what it means for 'future physics'.
10 July	Leader of ATLAS, one of the world's largest experiments	<i>A conversation with Professor Fabiola Gianotti (CERN)</i>	ATLAS is a particle physics experiment at the Large Hadron Collider at CERN. The ATLAS detector is searching for new discoveries in the head-on collisions of protons of extraordinarily high energy. ATLAS is learning about the basic forces that have shaped our Universe since the beginning of time and that will determine its fate. Fabiola Gianotti is the overall coordinator of the ATLAS Collaboration which consists of 3000 scientists from 38 countries. In this lecture she will discuss the challenges and goals of the Large Hadron Collider, the ATLAS experiment and its latest results, and the impact of particle physics on society.
13 July	Professor Jeremy Mould, Swinburne University	<i>Understanding the Cosmos</i>	In recent years, astronomical observations have provided a remarkable basis for our understanding of the large-scale structure of the universe. Jeremy Mould discusses observations of dark matter, the expanding and accelerating universe and direct remnants of the big bang to give us an understanding of the cosmos.
20 July	Professor Raymond Volkas, University of Melbourne	<i>Particle Physics meets Cosmology</i>	Physics of the very small (high-energy particle physics) and the physics of the very large (cosmology) have come together to provide an amazingly unified view of the universe. Our understanding has evolved to an unprecedented level of precision, but also leaves major unanswered questions, such as the nature of dark matter and dark energy. This lecture discusses astrophysics and particle physics in combination and provides insight into astronomical observation and high-energy particle collider experiments.
27 July	Associate Professor Elisabetta Barberio, University of Melbourne	<i>Big Science at the Frontier: future facilities for answering big questions</i>	The understanding of our universe from the largest to the smallest has progressed significantly in recent decades. Large complex and expensive facilities have been essential in the pursuit of knowledge of the fundamental structure, constituents and forces in nature; and the demand to make observations, measurements and analyses has driven technological advancement. Following a presentation on the facilities at each of the frontiers, specifically the Large Hadron Collider (LHC) and the Square Kilometer Array (SKA), a panel discussion will be opened to take questions from the audience.



# 2011 NOVEMBER INSERVICE

## VCE PHYSICS IN THE MODERN WORLD

David Ottaway, University of Adelaide	<i>Einstein and gravitational waves</i>	Einstein predicted Gravity waves, but their detection has proven elusive. Of the experiments proposed to detect them, this orbiting observatory, LIGO (Laser Interferometer Gravitational Wave Observatory) is the newest and most sophisticated. Dr David Ottaway of Adelaide University will explain the creation of gravity waves and how LIGO is designed to detect them
Dr Peter Seligman, Melbourne Energy Institute	<i>Renewable energy</i>	His recent book Australian Sustainable Energy - by the numbers provides a clear account of Australia's renewable energy potential. Peter has analysed a raft of available technologies, and offers a blueprint of a nationwide renewable energy system based on the most efficient mix of technology, societal and habitual changes.
Dr Roger Rassool, University of Melbourne	<i>Inspiration for teachers</i>	Physics is engaging, stimulating and exciting. In this session Dr Roger Rassool introduces two inspirational teachers Carolyn Hutchens and Kim Northmore, who recently visited the Large Hadron Collider in Switzerland as part of the ACAS/CERN Summer School. They will share the highlights of their experience and relate how it has motivated and changed their teaching.
Nick Nicola, University of Melbourne	<i>Laboratory equipment and Demonstrations</i>	Nick Nicola, designer-of-equipment extraordinaire, will display a number of demonstrations that are relevant to the VCE Physics study. Nick developed, and is curator of, the Physics museum.
Professor Jim Jury, Trent University	<i>Nuclear power: how reactors work, and what can go wrong</i>	The failure of the Fukushima reactor earlier this year raised many questions about the safety of nuclear power. VCE study design includes nuclear power as a topic, and Prof Jim Jury of Trent University in Canada will discuss nuclear reactor design and safety considerations.
Dr Graeme O'Keefe, Austin Hospital	<i>Nuclear physics and medical diagnosis</i>	In the modern world, nuclear techniques have revolutionised methods of medical diagnosis. It is therefore not surprising that the VCE study design includes topics on the nucleus, ionizing radiation and medical applications. Dr Graeme O'Keefe directs the department of Nuclear Medicine and PET services at the Austin Hospital and will talk on nuclear physics and medical diagnosis.

# 2012 NOVEMBER INSERVICE

## PHENOMENAL PHYSICS

<i>Landing 'Curiosity' on Mars</i>	Prof. David Jamieson is head of the School of Physics at Melbourne University and past president of the Australian Institute of Physics. He is an experimental physicist, with more than 200 published research papers. Amongst his current interests is the Research Centre for Quantum Computer Technology. Importantly for this meeting, he is an outstanding lecturer, and will discuss the technology of the amazing feat of landing the "Curiosity" rover on Mars.
<i>Finding the Higgs boson</i>	The confirmation of the Higgs boson in August was a seminal event in particle physics. The data was taken at CERN using a proton beam from Large Hadron Collider, and the huge ATLAS detector. Prof. Geoff. Taylor and his research group were major contributors to the construction of this detector. He will discuss the ATLAS detector, the role of the Higgs in the standard model, and how elementary particles acquire mass by interaction with its field.
<i>VCE Study design</i>	The VCE Study design for physics is of critical importance to high-school teachers and university academic staff. Changes, both minor and major, are always topics of discussion and often of concern. Dr. Syd. Boydell is currently chair of the VCE Physics exam-setting panel, and brings to that position, and to this meeting, many years of experience in physics education. He will comment on the current situation of the teaching and examination of physics in this state.
<i>The Square Kilometre Array</i>	In a major boost to Astronomy in Australia it was recently announced that a major part of the SKA (Square Kilometre Array) will be located in Australia. This distributed array of some 3000 dish receivers and thousands of dipole antennas is expected to answer some of the most fundamental questions in astronomy. Dr. Lisa Harvey-Smith is a research astronomer at CSIRO's Astronomy and Space Science Division in Sydney, and was part of the team that secured Australia's role. She works on the SKA Pathfinder project, tasked to deliver the science-ready telescope.
<i>Inspiring your students</i>	Not all students that we teach have enrolled in physics because it is their first love. Encouraging those with low interest, whilst stimulating the committed ones is one role of the physics teacher. Frank de la Rambelya, science co-ordinator at South Oakleigh Secondary College will outline his teaching philosophy.

# RESEARCH SEMINAR SERIES

## SPEAKERS AND VISITORS AFFILIATED WITH THE SCHOOL GAVE THE FOLLOWING COLLOQUIA AND SEMINARS DURING 2011 AND 2012.

UNLESS INDICATED ELSEWHERE, THE LECTURES TOOK PLACE IN THE LABY OR HERCUS THEATRES

### COLLOQUIA 2011

1-Feb	Prof Wieslaw Krolikowski	Laser Physics Centre, Research School of Physics and Engineering, Australian National University	<i>Managing light in nonlinear disordered media</i>
22-Feb	Dr Paul Lasky	Eberhard Karls University of Tübingen in Tübingen, Germany	<i>How right was Einstein?</i>
1-Mar	Prof Sven Rogge	ARC Future Fellow, Centre for Quantum Computation and Communication Technology, School of Physics, University of New South Wales	<i>Transport through a single atoms in a silicon transistor</i>
8-Mar	Dr Jonathan Carroll	Special Research Centre for the Subatomic Structure of Matter (CSSM), Department of Physics, University of Adelaide	<i>The radius of the proton; devil in the details</i>
9-Mar	Dr Paul Jackson	SLAC (ATLAS Group), CERN, Geneva	<i>Searches for supersymmetry and exotic meta-stable particles with the ATLAS experiment</i>
15-Mar	Assoc Prof David Liley	Brain Sciences Institute, Swinburne University of Technology	
18-Mar	Prof Allan Clark	CERN, Geneva, Switzerland	<i>Status report on the CERN LHC and ATLAS</i>
22-Mar	Prof Victor Galitski	University of Maryland, USA	<i>Exotic quantum phenomena and topological phases in spin-orbit-coupled systems</i>
29-Mar	Dr Patrick Kluth	Department of Electronic Materials Engineering, Research School of Physics and Engineering, Australian National University	<i>Ion tracks: from the earth's crust to space travel</i>
5-Apr	Dr Michael J. Biercuk	School of Physics, University of Sydney	<i>Science at the yocto-scale: force detection at the limits of the SI system</i>
12-Apr	Dr Yana Izdebskaya	Nonlinear Physics Centre, Research School of Physics and Engineering, Australian National University	<i>Guiding and bending light at will in liquid crystals</i>
19-Apr	Dr Andrew G. White	Department of Physics, University of Queensland	<i>Quantum biology, chemistry, maths and physics</i>
3-May	Assoc Prof Adam Micolich	Associate Professor and ARC Future Fellow, University of New South Wales	<i>Spinning in a straight line – quantum wires as a platform for spintronics</i>
10-May	Dr Kerry Hinton	ARC Special Centre for Ultra-Broadband Information Networks, University of Melbourne	<i>Addicted to data: the Internet's "energy bottleneck"</i>
16-May	Prof Chris G. Van de Walle	Materials Department, University of California, USA	<i>Quantum computing with defects</i>

24-May	Dr Mary Beilby	Biophysics Department, University of New South Wales	<i>Electrical characteristics of plant cell membrane</i>
31-May	Dr Matthew Hole	Department of Theoretical Physics, Research School of Physics and Engineering, Australian National University	<i>The physics of burning plasmas</i>
7-Jun	Assoc Prof Jeff McCallum	School of Physics, University of Melbourne	<i>Extracting light from silicon</i>
14-Jun	Dr Tim Garoni	School of Physics, University of Melbourne	<i>Criticality, combinatorics and computing</i>
5-Jul	Dr Andrea Morello	School of Electrical Engineering & Telecommunications, University of New South Wales	<i>The dawn of silicon quantum computing: coherent control and single-shot readout of single electron and nuclear spins</i>
13-Jul	Prof Stefan Estreicher	Physics Department, Texas Tech University, USA	<i>Non-equilibrium dynamics of localized phonons in semiconductors: isotope effects</i>
19-Jul	Dr Andrew Truscott	College of Physical and Mathematical Sciences, Australian National University	<i>Correlations: what they tell us about quantum gases</i>
26-Jul	Dr Jeremy Sumner	School of Mathematics and Physics, University of Tasmania	<i>Lie Markov Models</i>
2-Aug	Dr Daniel Shaddock	Department of Quantum Science, Australia National University	<i>The GRACE follow-on mission</i>
23-Aug	Dr Scott Power	Senior Principal Research Scientist, National Climate Centre, Bureau of Meteorology	<i>Can we predict climate over coming decades?</i>
30-Aug	Prof Fulvio Melia	Department of Physics & Steward Observatory, University of California, USA	<i>The cosmic spacetime</i>
6-Sep	Assoc Prof Eric Hudson	Department of Physics and Astronomy, University of California, USA	<i>Molecular ions: a new addition to the quantum toolbox</i>
13-Sep	Assoc Prof Michael Steel	Department of Physics, Macquarie University	<i>Engineering single photon and photon pair generation in nanophotonic structures</i>
27-Sep	Prof Les Allen	School of Physics, University of Melbourne	<i>A hitch-hiker's guide to some recent research in atomic resolution imaging</i>
4-Oct	Dr Jenni Adams	Department of Physics and Astronomy, University of Canterbury, New Zealand	<i>Cosmic accelerators</i>
11-Oct	Prof Geoff Spinks	School of Mechanical, Materials & Mechatronic Engineering, Intelligent Polymer Research Institute, University of Wollongong	<i>Building bionic muscles</i>
18-Oct	Prof David Kielpinski	Australia Attosecond Science Facility, Griffith University	<i>Quantum microscopy of trapped ions: the shadow of a single atom</i>
19-Oct	Prof Mahananda Dasgupta	Department of Nuclear Physics, Australian National University	<i>Nuclear collisions – many-body quantum dynamics in action</i>
25-Oct	Prof Marvin Cohen	Condensed Matter Physics and Materials Science, Department of Physics, Berkeley University, USA	<i>Einstein, nanoscience and superconductivity</i>
15-Nov	Prof Mikhail Kostylev	School of Physics, University of Western Australia	<i>Microwave dynamics in magnetic multi-layers and nanostructures for magnonic and spintronic applications</i>
22-Nov	Dr Orsola de Marco	Department of Physics, Macquarie University	<i>How common envelope binary interactions change the life of stars and planets</i>
30-Nov	Prof Bennett Link	Department of Physics, Montana University, USA	<i>Superfluid turbulence in neutron stars</i>
6-Dec	Assoc Prof Victor Gurarie	Department of Physics, University of Colorado, USA	<i>Non-Abelian particles in a two dimensional world</i>





6-Mar	Prof Min Gu	Faculty of Engineering & Industrial Sciences, Swinburne University of Technology	<i>Nanophotonics: transformational technology and cutting-edge science</i>
13-Mar	Dr Karen Kheruntsyan	School of Mathematics and Physics, The University of Queensland	<i>Measurement of atom number fluctuations: a new fundamental tool in ultracold atom research.</i>
20-Mar	Dr Adrian Sheppard	Department of Applied Mathematics Physics Education Centre, ANU	<i>Capturing the Complexity of Multiphase Flow in Sand, Soil and Stone</i>
27-Mar	Prof Bernd Meyer	Faculty of Information Technology, Monash University	<i>Mavericks required --- understanding collective decision making through diffusion modelling</i>
3-Apr	Prof Greg Tallents	York Plasma Institute, Department of Physics, University of York	<i>Extreme ultra violet and x-ray laser interactions with high energy density materials</i>
24-Apr	Assoc Prof Timothy Schmidt	School of Chemistry, The University of Sydney	<i>Photonic Alchemy: Turning Red into Gold for Improved Solar Energy Conversion</i>
1-May	Dr Bram Slagmolen	Centre for Gravitational Physics, The Australian National University	<i>The pendulum in the detection of Gravitational Waves</i>
8-May	Prof Joe Wolfe	School of Physics, University of New South Wales	<i>Acoustics of the voice: registers and resonances in singing</i>
15-May	Dr Cormac Corr	Research School of Physics and Engineering, Australian National University Canberra	<i>At the edge: Plasma-surface science for future fusion reactors</i>
29-May	Dr Sean Farrell	School of Physics, The University of Sydney	<i>Bridging the Gap Between Stellar Mass and Supermassive Black Holes</i>
12-Jun	Assoc Prof Dragomir Neshev	Nonlinear Physics Centre, Research School of Physics and Engineering, Australian National University Canberra	
19-Jun	Prof Shunsuke Ohtani	University of Electro-Communications, Japan	<i>Research Activity at the Tokyo-EBIT facility</i>
3-Jul	Assoc Prof Warwick Bowen	School of Mathematics and Physics, University of Queensland	<i>Optomechanical sensing</i>
24-Jul	Dr Greg Iane	Department of Nuclear Physics, ANU Canberra	<i>Nuclear state lifetimes as probes of exotic nuclei</i>
31-Jul	Prof Debra Bernhardt	School of Biomolecular and Physical Sciences, Griffith University Brisbane	<i>Fluctuation Theorems and the Dissipation Function</i>
7-Aug	Prof Elaine M. Sadler	School of Physics, University of Sydney	<i>Black holes and galaxy evolution modelling</i>
14-Aug	Dr David Abbott	Brain Research, Florey Neuroscience Institutes, Melbourne Brain Centre	<i>Simultaneous functional Magnetic Resonance Imaging (fMRI) and Electroencephalography (EEG) of Epilepsy</i>
21-Aug	Dr Irene Suarez-Martinez	NRI, Curtin University of Technology WA	<i>Modelling thermal conductivity of carbon materials</i>
28-Aug	Prof Kostya (Ken) Ostrikov	CSIRO, Sydney	<i>Plasma nanoscience for a sustainable future: small energy for small things</i>
4-Sep	Prof Howard Wiseman	Centre for Quantum Dynamics, Griffith University Queensland	<i>Quantum jumps in atoms: what's new after 100 years?</i>
11-Sep	Prof David Paganin	School of Physics, Monash University	<i>Twist and burn: Screwed-up waves, caustical rays and the singularity hierarchy</i>
18-Sep	Prof Alex Hamilton	School of Physics, University of NSW	<i>Unexpected behaviour of electrons and holes in nanoscale quantum transistors</i>
2-Oct	Dr Matthew Davis	School of Mathematics and Physics, University of Queensland	<i>Quantum gases far from equilibrium</i>
9-Oct	Prof Elisabetta Barberio	School of Physics, University of Melbourne	<i>The Higgs boson at the Large Hadron Collider</i>
16-Oct	Dr Gary Hill	University of Adelaide	<i>Exploring the mysteries of the high energy universe with Antarctic neutrino detectors</i>

23-Oct	Dr Boris Kuhlmei	CUDOS/IPOS/School of Physics, The University of Sydney	<i>Drawing the invisible: fibres for hyperlenses and the emperor's clothes</i>
30-Oct	Dr John Daniels	School of Materials Science and Engineering, University of New South Wales	<i>Exotic Mechanical Materials: The realms of physical possibilities and potential applications</i>
13-Nov	Prof Joanne Etheridge	Department of Materials Engineering, Monash University	<i>The Modern Fast Electron - new developments and applications</i>
20-Nov	Dr Charlene Lobo	School of Physics and Advanced MAterials, University of Technology Sydney	<i>Kinetics of electron beam induced etching and deposition</i>
27-Nov	Prof Jeffrey R. Reimers	School of Chemistry, The University of Sydney	<i>Non-trivial quantum effects in biology: some basic science with a view to device applications</i>

## COMPLETION SEMINARS/ GOSS\* 2011

25-Mar	Liam McGuinness	<i>Nanoscale quantum sensing using coherence of Nitrogen-Vacancy centers in diamond</i>
1-April	Anthony van Eysden	<i>Determining properties of bulk nuclear matter from pulsar glitch recovery</i>
8-April*	Evan Curwood	<i>Determining biomolecular structures: overcoming X-ray damage</i>
8-April*	Mark Bennett	<i>A backhanded method for detecting gravitational waves</i>
15-April	Alastair Stacey	<i>Surface engineering for quantum information processing in NV diamond</i>
29-April	Jinghua Fang	<i>Fabrication, characterisation and applications of anodic aluminum oxide (AAO)</i>
6-May*	Ahmad Galea	<i>Late decaying dark matter and the disruption of small scale structure</i>
6-May*	Chris Magoulas	<i>The 6dFGS fundamental plane: maximum likelihood fitting and peculiar velocities</i>
13-May*	Guido Cadenazzi	<i>What is rational drug design?</i>
13-May*	Andrew McCulloch	<i>The sound of music</i>
20-May	Nathan Lugg	<i>New developments in scanning transmission electron microscopy</i>
27-May	Sebatian Saliba	<i>A coherent electron source for diffractive imaging</i>
3-Jun	Daniel Drumm	<i>Physics of low-dimensional nanostructures</i>
10-Jun	Jason Smith	<i>Modelling flocking phenomena through physics</i>
22-Jul*	Bradley Greig	<i>Power spectrum forecasts for baryon acoustic oscillation experiments using the Lyman-alpha forest</i>
22-Jul*	Loren Bruns Jr	<i>Ly<sub>α</sub> galaxies as a probe of galaxy formation and reionization history</i>
29-Jul	Xiao Ming Goh	<i>Nanometric near-resonant apertures in metallic films for lens and beaming applications</i>
5-Aug	David Wang	<i>Simulations of Shor's algorithm with matrix product states</i>
12-Aug	Sudhir Raskutti	<i>Measuring the thermal signature of the first galaxies</i>
19-Aug	Jayne Thompson	<i>Symmetries</i>
26-Aug	Jessica van Donkelaar	<i>The fabrication and application of single atom arrays in silicon</i>
2-Sept	Marcus Doherty	<i>Unravelling the mystery of the nitrogen-vacancy colour centre in diamond</i>
9-Sept	T'mir Julius	<i>A final measurement of <math>B \rightarrow \pi^0 \pi^0</math> at the Belle Experiment</i>
16-Sept	Andrew Hayward	<i>Artificial Magnetic Fields in Cavity QED</i>
23-Sept	Anja Schubert	<i>Sensor modelling for the next generation of medical detectors</i>
7-Oct	Deborah Lau	<i>The Raman spectroscopy of artists materials: advances in characterisation and analysis</i>
14-Oct	James Quach	<i>Solid light physics: quantum emulation to quantum metamaterials</i>
28-Oct	Andrea Ruff	<i>The broad emission line region of quasars</i>
4-Nov	Tony Shao	<i>The search for the Higgs at the LHC</i>
11-Nov	Christina Magoulas	<i>Fitting the near-infrared fundamental plane relation of early-type galaxies</i>
13-Dec	Guido Cadenazzi	<i>Developments in partially coherent x-ray diffraction microscopy</i>

## COMPLETION SEMINARTS/ GOSS\* 2012

23-Mar	Angela Torrance	Using X-Ray Ptychography To Characterise Disordered Materials
30-Mar*	Iason Baldes	Proton Decay
20-Apr*	Chris Bradly & Bikram Ravi	N-Particle Ctap
27-Apr	Nadine Pesor	Soft Supersymmetry Breaking From Stochastic Superspace
4-May	Loren Bruns Jr	Lyman-Alpha Emitting Galaxies: A Probe of Galaxy Formation And Ionization History
11-May*	Sead Djalalian-Assi & Nina Eikenberg	Subwavelength Plasmonic Structures
18-May*	Benjamin Forbes	The Aerodynamics of Flying Discs
25-May*	Brendan Mulkerin	Ultracold Fermi Gases In The Unitary Limit
27-Jul	Evan Curwood	Towards Imaging Single Biomolecules at Femtosecond X-Ray Lasers
3-Aug	Andrew McCulloch	Electron Diffraction from a Cold Atom Electron Source
10-Aug	Andrew Morgan	Direct Coherent Diffractive Imaging: at and Beyond the Nano-Scale
24-Aug	Ahmad Galea	Electroweak Bremsstrahlung Processes, and the Detection of Dark Matter at The LHC
31-Aug*	David Jennens & KG Tan	Understanding The Reconstructed Energy of Tau Leptons At ATLAS
7-Sep	Benjamin Callen	Domain-Wall Braneworld Phenomenology in Five and Six Dimensions
14-Sep*	Kent Wootton	Turning an Undulator on its Side Turns the Storage Ring on its Head
5-Oct*	Laurence Deam & Jennifer Riding	Erbium-Doped Silicon Nanocrystal-Sensitised Silicon Slot Waveguides: Towards an Understanding of Quantum Interlayers (And Photonic Disconnects)
12-Oct	Stefanie Elbracht-Leong	Development of a State-of-the-Art X-Ray Imaging Detector
26-Oct	Mark Bennett	Neutron Star Interior Flows and Oscillations
9-Nov	Liam Hall	Quantum Decoherence Imaging of Life at the Nanoscale
23-Nov	Bradley Greig	Probing the Nature of Dark Energy using Large-Scale Structure Simulations of the Universe

## PHYSICS PUBLIC LECTURES 2011

9-May	Prof Michael S. Turner	University of Chicago, USA	<i>The dark side of the universe: beyond stars and the starstuff we are made of</i>
18-May	Prof David Cahen	Weizmann Institute of Science, Israel	<i>The energy challenge: what is the problem and what is the role of basic science?</i>
24-Jun	Prof Byoungcho Lee	Seoul National University, Korea	<i>Plasmonic diffractive optics</i>
22-Jul	Prof Leonard C Feldman	Rutgers the State University, Vanderbilt University, USA	The materials revolution
10-Aug	Prof Lawrence Krauss	Arizona State University, USA	<i>Quantum man: Richard Feynman's life in science</i>
19-Aug	Assoc Prof Jeffrey McCallum	School of Physics, University of Melbourne	<i>Rutherford and the atomic Nucleus: The 100th Anniversary of a Remarkable Discovery</i>
18-Nov	Prof Robert P Kirshner	Harvard University, USA	<i>Exploding stars and the accelerating cosmos: Einstein's blunder undone</i>
8-Dec	Prof Rudolf Grimm	University of Innsbruck, Austria	Quantum matter at absolute zero: cool and fascinating

## ASTROPHYSICS SEMINARS 2011

2-Feb	Dr Paul Lasky	Eberhard Karls University of Tübingen, Germany	<i>Magnetic fields in strongly magnetized neutron stars</i>
7-Mar	Dr James Dent	Arizona State University, USA	<i>Warm DBI inflation</i>
16-Mar	Dr Matthew Baring	Rice University, Texas, USA	<i>The gamma-ray pulsar paradigm as viewed by Fermi</i>
13-April	Pietro Procopio	Istituto Nazionale di Astrofisica (INAF), Italy	<i>The Simultaneous Medicina-Planck Experiment (SiMPIE) Northern sample: data acquisition, reduction and first results</i>
20-April	Dr Chris Lidman	Australian Astronomical Observatory	<i>Cosmology with type Ia supernovae: recent results and future directions</i>
18-May	Dr Michael Brown	Monash University	<i>The ubiquitous radio continuum emission from early-type galaxies</i>
16-Nov	Michele Trenti	University of Colorado, USA	<i>From the first stars to the first galaxies</i>



## THEORETICAL PARTICLE PHYSICS SEMINARS

25-Jan	Kara Hoffman	University of Maryland, USA	<i>South pole neutrino telescopes</i>
7-Mar	James Dent	Arizona State University., USA	<i>Warm DBI inflation</i>
16-Mar	Matthew Dolan	Durham University, UK	<i>Implications of initial LHC searches for supersymmetry</i>
28-Mar	Prof Joaquim Gomis	University of Barcelona, Spain	<i>Lifshitz and Schroedinger Algebras and some of their dynamical realisations</i>
1-Jun	Assoc Prof David Hutchinson	University of Otago, New Zealand	<i>Effects of disorder in ultracold atomic gases</i>
20-Jun	Dr David Curtin	Cornell University, USA	<i>Supersymmetry-breaking via nonperturbative monopole dynamics</i>
2-Aug	Prof Keiichi Akama	Saitama Medical University, Japan	<i>General solution of the braneworld with the Schwarzschild ansatz</i>
21-Sept	Juan Carlos D'Olivo	The National University of Mexico	<i>Transition radiation by an active neutrino</i>
21-Nov	Dr Jong Soo Kim	Univerisity of Adelaide	<i>Light stop searches at the LHC in events with two b-Jets and missing energy</i>

## OPTICS & CONDENSED MATTER PHYSICS SEMINARS 2011

10-Mar	Bartosz Kaczmarek	Nottingham University, UK	<i>Search of non-Abelian statistics in fractional quantum hall states</i>
24-Mar	Prof Victor Galitski	University of Maryland, USA	<i>A general theory of spin-relaxation in two-dimensional semiconductors</i>
22-April	Richard Haglund	Vanderbilt University, USA	<i>Reconfiguring plasmonic metamaterials using vanadium dioxide</i>
22-Jun	Dr Ivan Maksymov	Australian National University	<i>Optical nanoantennas for near- and far-field control of light enhancement</i>
8-Jul	Prof Daniel Arovas	University of California, USA	<i>What can we learn from quantum entanglement spectra?</i>
27-Jul	Dr Hong Wei	Institute of Physics, Chinese Academy of Sciences, China	<i>Plasmons propagating on silver nanowires</i>

\* *Geoff Opat Seminar Series*





## RESEARCH INCOME

### RESEARCH INCOME FROM CONTINUING GRANTS

PROJECT DESCRIPTION	AMOUNT
CC_ARC COE 05/10 - NUGENT	\$1,995,790.50
ARC FF 06/11- NUGENT	\$348,107.00
ARC DP 07/11- HOLLENBERG	\$91,065.00
ARC DP 07/11- WYITHE	\$61,999.00
ARC LE 07/11- TAYLOR	\$270,000.00
ARC LP 07/11- NUGENT	\$55,041.00
ARC IP (Herma) 07/11- NUGENT	\$16,000.00
ARC FF 07/12- GHERGHETTA	\$353,632.00
ARC DP 08/12- TAYLOR	\$149,333.00
ARC DP 08/12- GREENTREE	\$213,223.00
ARC DP 09/11 - BOLTON	\$95,205.00
ARC DP 09/11 - HOLLENBERG	\$169,252.00
ARC DP 09/11 - VOLKAS	\$100,493.00
ARC DP 09/11 - VOLKAS DP0988343	\$121,364.91
ARC DP (Shared-ANU) 09/11- McCALLUM	\$48,747.45
ARC DP (Shared-ANU) 09/11- MELATOS	\$43,333.00
ARC LP (Shared-UNSW) 09/12- PRAWER	\$110,000.00
ARC DP 10/12 - BELL	\$62,210.00
ARC DP 10/12 - MOULD	\$2,097.00
ARC LP 10/12 - PRAWER	\$196,997.00
ARC DP 10/14 - PRAWER	\$186,628.00
ARC DP 10/12 - NUGENT	\$259,207.00
ARC DP 10/12 - LIMOSANI	\$98,500.00
ARC DP 10/12 - BARBERIO	\$93,314.00
ARC DP 10/12 - GHERGHETTA	\$93,314.00
ARC IP (HP LAB) 10/12 - PRAWER	\$209,954.18
ARC 10/13 - WYITHE	\$94,262.00
ANU 10/13 - MCCALLUM	\$300,000.00
UW (ARC NON LEAD) 10/12 - JAMIESON	\$10,000.00
CC_ARC 10/13 - PRAWER	\$979,275.75
SUT (ARC MIA) 09/11 - NUGENT	\$35,000.00
ARC DP 11/13 - ROBERTS	\$172,678.00
TOTAL	\$7,036,022.79

### RESEARCH INCOME FROM NEW GRANTS 2011

PROJECT DESCRIPTION	AMOUNT
ARC DP 11/13 - GOMEZ	\$140,174.00
ARC DP 11/13 - CHANTLER	\$182,835.00
ARC DP 11/15 - ALLEN	\$182,835.00
ARC DP 11/13 - MELATOS	\$111,733.00
ARC-11/17 - TAYLOR	\$3,656,701.00
ARC CE (NON-LEAD UNI-SYD) 11/17 - WYITHE	\$365,411.00
ARC (NON-LEAD UNI-UNSW) 11/17 - HOLLENBERG	\$520,625.00
ANSTO 11/13 - RASSOOL	\$60,000.00
ARC LP 11/14 - ROBERTS	\$59,938.00
SIEF 11/14 - WYITHE	\$17,000.00
ARC ALF 11/16 - WYITHE	\$261,315.00
TIPF 2011 - NUGENT	\$20,000.00
ARC DP (CSIRO PORTION) 11/13 - CHANTLER	\$11,250.00
TOTAL	\$5,589,817.00

## RESEARCH INCOME FROM CONTINUING GRANTS

PROJECT DESCRIPTION	AMOUNT
82184 ARC DP 11/15 - ALLEN	\$805,735.00
82168 ARC DP 10/12 - BARBERIO	\$290,986.00
82162 ARC DP 10/12 - BELL	\$186,813.00
82151 ARC DP 09/12 - BOLTON	\$293,260.00
82177 CC_ARC 10/13 - PRAWER	\$3,285,931.00
82183 ARC DP 11/13 - CHANTLER	\$499,285.00
82204 IARPA (NON-LEAD RAYTHEON BBN TECH) 11/12 - FOWLER	\$324,949.10
82126 ARC FF 07/12- GHERGHETTA	\$2,099,277.00
82169 ARC DP GHERGHETTA	\$300,219.00
82182 ARC DP 11/13 - GOMEZ	\$519,914.00
82133 ARC DP 08/12- GREENTREE	\$919,713.00
82105 ARC DP 07/12- HOLLENBERG	\$653,684.00
82152 ARC DP 09/12 - HOLLENBERG	\$519,101.00
82188 ARC (NON-LEAD UNI-UNSW) 11/17 - HOLLENBERG	\$3,384,062.50
82167 ARC DP 10/12 - LIMOSANI	\$300,405.00
82156 ARC DP (Shared-ANU) 09/11- McCALLUM	\$190,000.00
82174 ANU 10/13 - MCCALLUM	\$1,200,000.00
82160 ARC DP (SHARED-ANU) 09/11- MELATOS	\$140,000.00
82185 ARC DP 11/13 - MELATOS	\$343,795.00
82163 ARC DP 10/12 - MOULD	\$184,419.00
82087 COE 05/13 - NUGENT	\$15,123,074.50
82099 ARC FF 06/11- NUGENT	\$1,678,261.00
82155 ARC LE 2009 - NUGENT	\$500,000.00
82161 ARC LP (SHARED-UNSW) 09/12- PRAWER	\$330,000.00
82164 ARC LP 10/12 - PRAWER	\$674,642.00
82165 ARC DP 10/14 - PRAWER	\$826,629.00
82172 ARC IP (HP LAB) 10/12 - PRAWER	\$300,000.00
82181 CSIRO 11/15 - PRAWER	\$300,000.00
82180 ARC DP 11/13 - ROBERTS	\$511,320.00
82190 ARC LP 11/14 - ROBERTS	\$349,534.00
82191 ARC IP 11/14 - ROBERTS	\$0.00
82166 ARC DP 10/12 - NUGENT	\$778,387.00
82114 ARC LE 07/12- TAYLOR	\$1,350,000.00
82131 ARC DP 08/12- TAYLOR	\$719,209.00
82186 ARC CoE-11/17 - TAYLOR	\$26,441,053.00
82153 ARC DP 09/12 - VOLKAS	\$296,352.00
82106 ARC DP 07/12- WYITHE	\$423,499.00
82173 ARC 10/13 - WYITHE	\$290,038.00
82187 ARC CE (NON-LEAD UNI-SYD) 11/17 - WYITHE	\$2,622,662.48
82192 SIEF 11/14 - WYITHE	\$51,000.00
82193 ARC ALF 11/16 - WYITHE	\$2,753,721.00
TOTAL	\$72,760,930.58

## RESEARCH INCOME FROM NEW GRANTS 2012

PROJECT DESCRIPTION	AMOUNT
82211 ARC FT 12/16- BELL	\$559,631.00
82199 ARC DECRA 12/14 - CERVENKA	\$379,617.00
82202 ARC LP 12/14 - CHANTLER	\$237,521.00
82198 ARC FT 12/15 - GIBSON	\$692,024.00
82212 ARC (NON LEAD UNI-ADEL) 12/15 - GIBSON	\$60,000.00
82201 ARC DECRA 12/15 - KOU	\$379,617.00
82200 ARC DECRA 12/15 - MACK	\$379,617.00
82207 CSIRO 12/13 - MCCALLUM	\$24,500.00
82209 ARC (NON LEAD ANU) 12/15 - MCCALLUM	\$210,000.00
82206 CSIRO 12/15 - PRAWER	\$51,000.00
82210 NECTAR 12/14	\$718,200.00
TOTAL	\$3,691,727.00



## STAFF PROFILE & VISITORS

### TEACHING & RESEARCH STAFF

#### HEAD OF DEPARTMENT AND PROFESSOR OF PHYSICS

David Jamieson

#### DEPUTY HEAD AND ASSOCIATE PROFESSOR

Ann Roberts

#### ARC FEDERATION FELLOW & LAUREATE PROFESSOR

Keith Nugent

#### ARC FEDERATION FELLOW

Tony Gherghetta

#### PROFESSORS

Leslie Allen

Elisabetta Barberio

Christopher Chantler

Lloyd Hollenberg

Steven Prawer

Geoffrey Taylor

Raymond Volkas

Rachel Webster

#### ARC AUSTRALIAN PROFESSORIAL FELLOWS

Leslie Allen (2012)

Lloyd Hollenberg (2011)

Geoffrey Taylor (2011)

#### ARC QUEEN ELIZABETH II FELLOW

Andrew Greentree

Stuart Wyithe

#### ARC LAUREATE FELLOW

Stuart Wyithe (2012)

#### ASSOCIATE PROFESSORS & READERS

Harry Quiney

Andrew Melatos

Robert Scholten

#### ASSOCIATE PROFESSORS

Michelle Livett

Jeffrey McCallum

Martin Sevier

#### SENIOR LECTURERS

Nicole Bell

Andrew Martin

Roger Rassool

### RESEARCH-ONLY STAFF

#### ARC FUTURE FELLOW

Nicole Bell (2012)

Brant Gibson (2011)

#### SENIOR RESEARCH FELLOW

Ruben Dilanyan

Daniel Mitchell

Laurens Willems van Beveren

#### AUSTRALIAN RESEARCH FELLOW

Snjezana Tomljenovic-Hanic

#### AUSTRALIAN POSTDOCTORAL FELLOW

James Bolton

Daniel Gomez

Antonio Limosani

#### ARC SUPER SCIENCE FELLOW

Hansik Kim

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James Barnard

Akin Budi

Jiri Cervinka

Bo Chen

Adrian D'Alfonso

Sara Diglio

Dontatello Dolce

Robert Foot

Austin Fowler

Kate Fox

David Garrett

Shrihari Gopalakrishna

Kenji Hamano

Guilherme Hanninger

Charles Hill

Timothy James

Dansha Jiang

Tim Karle

Archil Kobakhidze

Takashi Kubota

Jessica Kvansakul

Hermine Landt

Paul Lasky

Desmond Lau

Kin Lee

Ling Lin

Anibal Medina

Kalliopi Petraki

Bart Pindor

Corey Putkunz

Gary Ruben

Michael Schmidt

Nicholas Setzer

David Sheludko

David Simpson

Paul Spizzirri

Edoardo Tescari

Chiara Tonini

David Vine

Matteo Volpi

Benedict Von Harling

Martin White

Changyi Yang

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Anthony Klein

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#### PROFESSORIAL FELLOWS

Allan Clark

Tien Kieu

Bruce McKellar

Fulvio Melia

Jeremy Mould

Colin Norman

Gerard Milburn

## PRINCIPAL FELLOWS WITH THE TITLE ASSOCIATE PROFESSOR

Ken Amos  
David Cookson  
Timothy Davis  
Trevor Finlayson  
Norman Frankel  
Girish Chandra Joshi  
James Jury  
Tomas Kron  
George Legge  
Edmund Muirhead  
Chris Ryan  
Alan Charles Spargo  
Maxwell Thompson  
John Wignall

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Valery Gurarie  
Shane Huntington  
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Gareth Moorhead  
Graeme O'Keefe  
Salvy Russo

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Stefania Castelletto  
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Roland Crocker  
Jason Doukas  
Nicoleta Dragomir  
Rohan Dowd  
Matthew Downton  
Barbara Etschmann  
Adrian Flitney  
David Floyd  
Paul Fraser  
Moshi Geso  
Faruque Hossain  
David Hoxley  
Sasikaran Kandasamy  
Steven Karataglidis  
Jamie Laird  
Robert McLeod  
Steven Melnikoff  
Martin Meyer  
Julius Orwa  
Alicia Oshlack  
Christopher Pakes  
Donald Payne  
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Carlos Peralta  
Olena Ponomarenko  
Andrew Rawlinson  
Peter Robertson  
Robert Sault  
Manoj Sridhar  
Juris Svenne  
Ben Toner  
Maurizio Toscano  
Steven Trpkovski  
Lincoln Turner  
Phillip Urquijo  
Dirk van der Knijff  
Cameron Wellard

## PROFESSIONAL STAFF

### ADMINISTRATION

Diana Bell  
Sandy Bell  
Cheryl Burrell  
Hayley Campbell  
Marie Christodoulaki  
Eliza Drake  
Anita George  
Cilla Gloger  
Kristine McDonald  
Sehan Selvadurai  
Kirsty Waring  
Dave Wolf

### RESEARCH AND ARC CENTRE OF EXCELLENCE SUPPORT

Darren (Dief) Alexander  
Nicole Anderson  
Rosslyn Ball  
Lucien Boland  
Gabrielle Bright  
Tania Carrubba  
Sean Crosby

Kim Dorrell  
Kumaravelu Ganesan  
Patricia Gigliuto  
Caroline Hamilton  
Ying Hu  
Joanna Huang  
Winnie Huang  
Irving Liaw  
Akina Mikami  
Anabelle Pontvianni  
Chris Schroen  
Tania Smith  
Paul Spizzirri  
Roland Szymanski  
Lilian Tan  
Samuel Thompson

### INFORMATION TECHNOLOGY

Sean Hooley  
Kathryn Sparks  
Linh Vu

### LIBRARIAN

Shirley Wong

### TECHNICAL AND ELECTRONIC SUPPORT

Ashley French  
Stephen Gregory  
Jonathan (Wayne) Powrie  
Sandor Szilagyi  
Evonne Tan  
Michael Zammit

### LABORATORY SUPPORT

Steven Damen  
Colin Entwisle  
Philip Lyons  
Stephen Marshall  
Jude Prezens  
Geoff Shute



# VISITORS

EACH YEAR THE SCHOOL OF PHYSICS PROUDLY HOSTS A RANGE OF VISITORS INCLUDING HIGHLY DISTINGUISHED SPEAKERS, VISITING ACADEMICS, STUDENTS AND INDUSTRY CONTACTS

## 2011 (DURATION OF STAY 2 WEEKS OR MORE)

Mr Aldo Besmer, BSc(Hons) Switzerland, MSc student from University of Bern working at Monash University

Mr Jonathan Bittner, BSc(Hons) Yale, PhD student from Cambridge University, United States

Dr James Dent, BSc PhD USA, Department of Physics and School of Earth and Space Exploration, Arizona State University

Mr Mark Edmonds, BSc(Hons) La Trobe, PhD student from La Trobe University, School of Physics

Prof Eliezer (Laser) Finkman, BSc MSc DSc Israel, Department of Electrical Engineering, Technion - Israel Institute of Technology

Mr Jacopo Forneris, BSc(Hons) MSc Italy, PhD student from Dipartimento di Fisica Sperimentale, Torino, Italy

A/Prof Victor Gurarie, BSc MSc PhD Princeton, Department of Physics, University of Colorado

Prof Richard Haglund, BA MA PhD USA, Department of Physics and Astronomy, Vanderbilt University, USA

Mr Stefan Kaufmann, DipPhys DipEd ETH Zurich, Postdoctoral Fellow from Swiss Federal Institute of Technology, Zurich on a year's Swiss fellowship to work on a project with Lloyd Hollenberg (1 year only and then employed 1 year by CQ2CT)

Prof Lawrence Krauss, BSc(Hons) Canada PhD MIT Miegunyah Fellow of the University of Melbourne and Professor at School of Earth and Space Exploration, Department of Physics, and Beyond Center for Fundamental Concepts in Science, Arizona State University, USA

Prof Mark Kruse, BSc(Hons) MSc New Zealand PhD USA, Department of Physics, Duke University, Durham visiting Geoff Taylor

Dr Paul Lasky, BSc(Hons) PhD Monash, Theoretical Astrophysics, Eberhard-Karls-Universitat, Germany

Dr Daniel Mitchell, BSc(Hons) PhD USyd, Harvard-Smithsonian Center for Astrophysics, USA

Mr Shota Nagayama, UQCC Japan, Student from the Graduate School of Media and Governance, Keio University, Japan

Mr Alimohammad Rabbani (Esfahani), Undergraduate Occupational trainee from Sharif University of Technology, Tehran, Iran

Mr Joost Ridderbos, BSc The Netherlands, Masters student from University of Twente in The Netherlands

Mr Keving Rietwyk, BSc(Hons) La Trobe, PhD student from La Trobe University

Mr Ashely Rozario, Intern student from Temasek Polytechnic in Singapore

Mr Frank Rudzik, Mech Eng Germany, Student from the University of Freiberg, Germany

Mr Steffen Steinert, DiplIng Germany, University of Stuttgart, Germany

Prof Viktor Struzhkin, BA MA PhD Russia, Professor from Geophysical Laboratory, Carnegie Institution of Washington

## 2012 (DURATION OF STAY 2 WEEKS OR MORE)

Dr George Becker, Kavli Fellow, Kavli Institute for Cosmology and Institute of Astronomy, Cambridge, United Kingdom

Prof Stephen Collins, BSc(Hons) PhD Melb, Victoria University, School of Engineering and Science

Prof Eliezer (Laser) Finkman, BSc MSc DSc Israel, Department of Electrical Engineering, Technion - Israel Institute of Technology

Mr Hadar Genish, PhD MSc BSc, PhD student from Bar-Ilan University, Israel

A/Prof Victor Gurarie, BSc MSc PhD Princeton, Department of Physics, University of Colorado

Prof Arthur Hebecker, PhD Germany, Professor of Theoretical Particle Physics and Cosmology, University of Heidelberg, Germany

Dr Damien Hicks, Physicist, Lawrence Livermore National Laboratory, USA

Dr Shunsaku Horiuchi, BA MA MSc Cambridge PhD Tokyo, JSPS Postdoctoral Fellow and McCue Fellow, University of California

Mr Stefan Kaufmann, DipPhys DipEd ETH Zurich, Postdoc from Swiss Federal Institute of Technology, Zurich on a year's Swiss fellowship

Prof Wen Biao Liu, BSc MSc PhD China, China Scholarship Council Visiting Scholar, School of Physics, Beijing Normal University, China

Prof James White, BA Med PhD USA, Department of Physics, Juniata College, USA

Ms Nor Azah Abdul Aziz

Mr Tim Dyce, BSc(Hons) Melb

Mr Mark Edmonds, BSc(Hons) La Trobe, PhD student from La Trobe University, School of Physics

Mr Kevin Finelli, BSc USA, PhD student from Duke University, USA

Mr Paul Janssen, Masters student from Eindhoven University of Technology in The Netherlands

Mr Guenter Kewes, BSc(Hons) Dip Germany, Student from Humboldt University on a DAAD scholarship

Mr Nader Kidwani, BSc(Hons) Egypt

Ms Katharina Koenig, BSc Freiberg, Masters student from Technical University Freiberg

Ms Agnieszka Leyko, BSc Germany ME Poland, PhD student from the University of Bonn

Mr Andreas Moll, PhD student from International Max-Planck Research School, Germany

Mr Maxim Priymak, BSc(Hons) Melb

Mr Daniel Pyke, BSc(Hons) Melb, PhD student from ANU

Mr Joost Ridderbos, BSc The Netherlands, Masters student from University of Twente in The Netherlands

Mr Ashley Roazario, Student from Temasek Polytechnic in Singapore doing a Diploma in Biotechnology

Mr Florian Soutschek, Undergraduate student from Ludwig Maximilian University of Munich



# SUBJECTS OFFERED



## FIRST YEAR SUBJECTS

PHYC10001/2	Physics 1/2: Advanced
PHYC10003	Physics 1
PHYC10004	Physics 2: Physical Science & Technology
PHYC10005	Physics 1: Fundamentals
PHYC10006	Physics 2: Life Sciences & Environment
PHYC10007	Physics for Biomedicine

## SECOND YEAR SUBJECTS

PHYC20009	Thermal & Classical Physics
PHYC20010	Quantum Mechanics & Special Relativity
PHYC20011	Electromagnetism & Optics

## THIRD YEAR SUBJECTS

PHYC30018	Quantum Physics
PHYC30019	Astrophysics
PHYC30016	Electrodynamics
PHYC30014	Laboratory Work A
PHYC30011	Sub-atomic Physics
PHYC30012	Computational Physics
PHYC30013	Principles & Applications of Sensors
PHYC30014/5	Laboratory Work A/B
PHYC30017	Statistical Physics
PHYC30020	Quantum Systems

## MASTER OF SCIENCE

Students can select seven from the following:

- Quantum Mechanics
- Quantum Field Theory
- General Relativity
- Statistical Mechanics
- Physical Cosmology
- Particle Physics
- Condensed Matter Physics
- Optics
- Experimental Methods

Advanced Seminars in:

- Astrophysics/Physical Cosmology
- Particle Physics
- Condensed Matter
- Optics

Students must undertake one of the following Professional Tools:

- Critical Analysis in Science
- e-Science
- Ethics in Science
- Systems Modelling and Simulation
- Thinking and Reasoning with Data
- Science and Communication
- Science in Context
- Money, People and Projects

# TOP 20 CITED PUBLICATIONS

FURTHER DETAILS OF PUBLICATIONS CAN BE FOUND BY SEARCHING FOR AN INDIVIDUAL AT:

[www.findanexpert.unimelb.edu.au](http://www.findanexpert.unimelb.edu.au)

## 2011

Search for squarks and gluinos using final states with jets and missing transverse momentum with the ATLAS detector in  $\sqrt{s}=7$  TeV proton-proton collisions, Aad G, Barberio L, Davey W, Davidson N, Diglio S, Felzmann CU, Nunes Hanninger GNH, Kazi S I, Kubota T, Limosani A, Moorhead GF, Phan A, Seviar M, Shao Q, Taylor G, Volpi M, White MJ, Zwalinski L, Physics Letters B (98)

Electric-field sensing using single diamond spins, Dolde F, Fedder H, Doherty M, Nobauer T, Rempp F, Balasubramanian G, Wolf T, Reinhard F, Hollenberg LC, Jelezko F, Wrachtrup J, Nature Physics (58)

Dynamical decoupling of a single-electron spin at room temperature, Naydenov B, Dolde F, Hall L, Shin C, Fedder H, Hollenberg LC, Jelezko F, Wrachtrup J, Physical Review B (52)

Quantum measurement and orientation tracking of fluorescent nanodiamonds inside living cells, McGuinness LP, Yan Y, Stacey AD, Simpson DA, Hall L, Maclaurin D, Praver S, Mulvaney P, Wachtrup J., Caruso F, Scholten R, Hollenberg LC, Nature Nanotechnology (51)

Measurement of the centrality dependence of  $J/\psi$  yields and observation of Z production in lead-lead collisions with the ATLAS detector at the LHC, Aad G, Barberio L, Davey W, Davidson N, Diglio S, Felzmann CU, Limosani A, Kazi S I, Moorhead GF, Phan A, Seviar M, Shao Q, Taylor G, White MJ, Zwalinski L, Physics Letters B (51)

A search for new physics in dijet mass and angular distributions in pp collisions  $\sqrt{s}=7$  TeV measured with the ATLAS detector, Aad G, Barberio L, Davey W, Davidson N, Diglio S, Felzmann CU, Hanninger GN, Kazi S I, Limosani A, Moorhead GF, Phan A, Seviar M, Shao Q, Taylor G, Volpi M, White MJ, Zwalinski L, 2011, New Journal of Physics (50)

Search for supersymmetry in pp collisions at  $\sqrt{s}=7$  TeV in final states with missing transverse momentum and b-jets, Aad G, Barberio L, Davey W, Davidson N, Diglio S, Felzmann CU, Hanninger GN, Kazi S I, Limosani A, Moorhead GF, Phan A, Seviar M, Shao Q, Taylor G, Volpi M, White MJ, Zwalinski L, Physics Letters B (43)

Surface code quantum computing with error rates over 1%, Wang D, Fowler AG, Hollenberg LC, Physical Review A (42)

Measurement of the differential cross-sections of inclusive, prompt and non-prompt  $J/\psi$  production in proton-proton collisions  $\sqrt{s}=7$  TeV, Aad G, Barberio L, Davey W, Davidson N, Diglio S, Felzmann CU, Hanninger GN, Kazi S I, Kubota T, Limosani A, Moorhead GF, Phan A, Seviar M, Shao Q, Taylor G, White MJ, Volpi M, Zwalinski L, Nuclear Physics, Section B (40)

Surface Plasmon Resonances in Strongly Coupled Gold Nanosphere Chains from Monomer to Hexamer, Barrow S, Funston AF, Gomez DE, Davis TD, Mulvaney P, Nano Letters (39)

Search for quark contact interactions in dijet angular distributions in pp collisions at  $\sqrt{s}=7$  TeV measured with the ATLAS detector, Aad G, Barberio L, Davey W, Davidson N, Diglio S, Felzmann CU, Kazi S I, Kubota T, Limosani A, Moorhead GF, Phan A, Seviar M, Shao Q, Taylor G, Zutshi V, Physics Letters B (37)

Charged-particle multiplicities in pp interactions measured with the ATLAS detector at the LHC, Andrei V, Barberio L, Davey W, Davidson N, Diglio S, Felzmann CU, Hanninger GN, Kazi S I, Limosani A, Moorhead GF, Phan A, Seviar M, Shao Q, Taylor G, Volpi M, White MJ, Zwalinski L, New Journal of Physics (36)

Search for stable hadronising squarks and gluinos with the ATLAS experiment at the LHC, Aad G, Barberio L, Davey W, Davidson N, Diglio S, Felzmann CU, Nunes Hanninger GNH, Kazi S I, Kubota T, Limosani A, Moorhead GF, Phan A, Seviar M, Shao Q, Taylor G, Volpi M, White MJ, Zwalinski L, Physics Letters B (34)

The simple survey: observations, reduction, and catalog, Damen M, Labbe I, van Dokkum P.G., Franx M, Taylor EN, Brandt W.N., Dickinson M, Gawiser E, Illingworth G.D., Kriek M, Marchesini D, Muzzin A, Papovich C, Rix H.-W., Astrophysical Journal (33)

Measurement of the production cross section for W-bosons in association with jets in pp collisions at  $\sqrt{s}=7$  TeV with the ATLAS detector, Aad G, Barberio L, Davey W, Davidson N, Diglio S, Felzmann CU, Hanninger GN, Kazi S I, Kubota T, Limosani A, Moorhead GF, Phan A, Shao Q, Seviar M, Taylor G, Volpi M, White MJ, Zwalinski L, Physics Letters B (31)

Limits on Anomalous Trilinear Gauge Couplings in  $Z\gamma$  Events from pp Collisions at  $\sqrt{s}=1.96$  TeV, Aaltonen T, Limosani A, Zucchelli S, Physical Review Letters (30)

Detection of extended He II reionization in the temperature evolution of the intergalactic medium, Becker G.D., Bolton JS, Haehnelt M.G., Sargent W.L., Monthly Notices of the Royal Astronomical Society (29)

Search for supersymmetric particles in events with lepton pairs and large missing transverse momentum in  $\sqrt{s}=7$  TeV proton-proton collisions with the ATLAS experiment, Aad G, Barberio L,

Davey W, Davidson N, Diglio S, Felzmann CU, Hanninger GN, Kazi S I, Kubota T, Limosani A, Moorhead GF, Phan A, Seviar M, Shao Q, Taylor G, Volpi M, White MJ, Zwalinski L, European Physical Journal C (29)

Measurement of inclusive jet and dijet cross sections in proton-proton collisions at 7 TeV centre-of-mass energy with the ATLAS detector, Aad G, Barberio L, Davey W, Davidson N, Diglio S, Felzmann CU, Hanninger GN, Kazi S I, Kubota T, Limosani A, Moorhead GF, Phan A, Seviar M, Shao Q, Taylor G, Volpi M, Zutshi V, European Physical Journal C (27)

Search for heavy long-lived charged particles with the ATLAS detector in pp collisions at  $\sqrt{s} = 7$  TeV, Aad G, Barberio L, Davey W, Davidson N, Diglio S, Felzmann CU, Hanninger GN, KAZI S I, Kubota T, Limosani A, Moorhead GF, Phan A, Seviar M, Shao Q, Taylor G, Volpi M, White MJ, Zwalinski L, Physics Letters B (26)

## 2012

Review of Particle Physics, Beringer, Gherghetta T, Zhu, Physical Review D (664)

A single-atom transistor, Fueschsle M, Miwa J.A., Mahapatra S, Ryu H, Lee S, Warschkow O, Hollenberg LC, Klimeck G, Simmons M.Y., Nature Nanotechnology (55)

Search for new physics in the dijet mass distribution using  $1 \text{ fb}^{-1}$  of pp collision data at  $\sqrt{s} = 7$  TeV collected by the ATLAS detector, Aad G, Barberio L, Davey W, Davidson N, Diglio S, Felzmann CU, Hanninger GN, Kubota T, Limosani A, Moorhead GF, Phan A, Seviar M, Shao Q, Taylor G, Volpi M, White MJ, Zwalinski L, Physics Letters B (37)

Search for New Phenomena in  $t\bar{t}$  Events with Large Missing Transverse Momentum in Proton-Proton Collisions at  $\sqrt{s} = 7$  TeV with the ATLAS Detector, Aad G, Barberio L, Davey W, Davidson N, Diglio S, Felzmann CU, Hanninger GN, Kubota T, Limosani A, Moorhead GF, Phan A, Seviar M, Shao Q, Taylor G, Volpi M, White MJ, Zwalinski L, Physical Review Letters (26)

Measurement of the top quark pair production cross section in pp collisions at  $\sqrt{s} = 7$  TeV in dilepton final states with ATLAS, Aad G, Barberio L, Davey W, Davidson N, Diglio S, Felzmann CU, Hanninger GN, Kubota T, Limosani A, Moorhead GF, Phan A, Seviar M, Shao Q, Taylor G, Volpi M, White MJ, Zwalinski L, Physics Letters B (22)

Combined search for the Standard Model Higgs boson in pp collisions at  $\sqrt{s} = 7$  TeV with the ATLAS detector, Aad , Barberio L, Davidson N, Diglio S, Nunes Hanninger GNH, Kubota T, Limosani A, Moorhead GF, Phan A, Seviar M, Shao Q, Taylor G, Volpi M, White MJ, Zwalinski, Physical Review D (22)

Measurement of the azimuthal anisotropy for charged particle production in  $\sqrt{s_{NN}} = 2.76$  TeV lead-lead collisions with the ATLAS detector, Aad , Barberio L, Davidson N, Diglio S, Nunes Hanninger GNH, Kubota T, Limosani A, Moorhead GF, Phan A, Seviar M, Shao Q, Taylor G, Volpi M, White MJ, Zwalinski, Physical Review C (21)

First Observation of the P-Wave Spin-Singlet Bottomonium States  $h_b(1P)$  and  $h_b(2P)$ , Adachi I, Barberio LMB, Julius T, Seviar ME, Zupanc A, Physical Review Letters (20)

Time-resolved protein nanocrystallography using an X-ray free-electron laser, Aquila A, Martin AV, Chapman H.N., Optics Express (19)

Search for gravitational waves from low mass compact binary coalescence in LIGO's sixth science run and Virgo's science runs 2 and 3, Abadie J, Chung CT, Melatos A, Sammut L, Zweizig J, Physical Review D (17)

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Authorised by Professor David Jamieson  
Published by the School of Physics, August 2013

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