DEPARTMENTS

The Research School of Physical Sciences and Engineering is comprised of eight research departments:

- Applied Mathematics
- Atomic and Molecular Physics
- Electronic Materials Engineering
- Laser Physics
- Nonlinear Physics
- Nuclear Physics
- Plasma Research
- Theoretical Physics

A brief description of each department is detailed in the following pages as well as a list of staff dedicated to that area. Note that centres, networks and other associations are often formed by teams of scientists undertaking a common research activity and can span across various national and international institutions. Detailed reporting of their activities would, in most cases, be available in their respective Annual Reports.
Applied Mathematics

The Department of Applied Mathematics (AM) performs research on fundamental and applied topics in colloid, surface and polymer science, largely in measurement of surface forces; on self-assembly of organic and inorganic structures at mesoscopic scales; and on disordered materials, mostly on micron-scale morphology, granular materials and transport in porous structures and on complex systems.

Although condensed matter and materials research dominates the Department’s efforts, individual programs are diverse; for example, studies of wettability in plant capillaries, modelling of multiphase flow properties of oil-bearing rocks, tomographic imaging of fossils and studies of networks and analysis of economic data are part of the group’s ongoing research programs.

A large part of the Department’s effort has been funded by the ARC Cooperative Research Centre for Functional Communications Surfaces (CRC SmartPrint) which focuses mainly on fundamental research on surface physics and material structure with applications to the paper industry.

**Staff List**

**Professor and Head of Department**
Mark Knackstedt BSc Columbia, PhD Rice

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Dr J Jansen, Roskilde University, Denmark
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Professor S Marcelja
Professor K Mecke, Universität Erlangen-Nurnberg, Germany
Professor Y Nagai, University Waseda, Japan
Dr M Nicodemi, Universita degli Studi Napoli, Italy
Emeritus Professor B Ninham
Dr M Saddatar, Trinity College Dublin, Ireland
Dr G Schroder-Turk, Friedrich-Alexander Universität, Germany
Ms C Testa, University of Rome, Italy
Mr J Valbuena, University Venezuela, Venezuela
Professor D Weaire, Trinity College Dublin, Ireland
Atomic and Molecular Physics

The Atomic and Molecular Physics Laboratories (AMPL) are engaged in a broad range of experimental and theoretical studies of the interaction of electrons, positrons, and photons with atoms, molecules, and solids, in order both to further our knowledge of fundamental physical and chemical processes, and to provide essential information that is critical to applications in other scientific disciplines, technology, and the environment.

Experimental and theoretical studies are originally carried out in three specific areas, the Electron Physics Group, the Ultraviolet Physics Unit and the Atom Manipulation Project however over time the lines of distinction between the research directions changed and are now divided into nine research activities: Atom Manipulation, Atomic and Molecular Fragmentations Studies, Australian Positron Beamline Facility, Chemical Reaction/Photodissocation Dynamics, Helium BEC Project, High Energy Electrons Scattering in Solids, Low Energy Electron Physics, Planetary Atmospheres, Photon Collisions, Radiation Effects and Theoretical Studies.

The Department is also host to two Australian Research Council Centres of Excellence – the Centre for Quantum-Atom Optics (ACQAO) which plays a leading role in the study of the quantum properties of Bose-Einstein condensates and atom lasers via insights gained from quantum optics; and the Centre for Antimatter-Matter Studies (CAMS) whose experimental and theoretical program is based around the study of the interaction of positrons with matter. Both centres activities are reported in their respective annual reports.

Staff List

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Research Fellows
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Robert Dall BSc Queensland
Igor Ivanov PhD DSc Moscow
Mitsuhiko Kono MSc KyotoIT, PhD GUAS Tokyo
Franklin Mills BSE Princeton, MS PhD Caltech (jointly with CRES)
Stan Newman BSc PhD Manchester

Postdoctoral Fellows
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Technical Staff
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Professor G Garcia, Instituto de Matematicas y Fisica Fundamental, Spain
Professor H Lefebvre, Université Paris-Sud, France
Professor E Weigold
Electronic Materials Engineering

The Department of Electronic Materials Engineering (EME) undertake world-class interdisciplinary research into the growth, structure, properties, processing and applications of electronic materials and related structures and devices. The Department’s diverse research program is underpinned by core expertise, a strong network of national and international collaborators, and a comprehensive suite of state-of-the-art equipment and facilities.

The department also hosts two networks, the Australian Research Council Nanotechnology Network (ARCNN) and the Australian Research Network for Advanced Materials (ARNAM) as well as the ACT node of the NCRIS fabrication facility.

Staff List

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Professor M Petravic, University of Rijeka, Croatia
Dr M Premaratne, Monash University
Associate Professor G Stewart, University of New South Wales
Dr H Timmers, University of New South Wales
The Department of Laser Physics (LP) undertakes research and training at the highest international level on a range of topics with a balance between fundamental, strategic and applied laser-based research.

The research program spans many of the most exciting aspects of contemporary laser physics and quantum electronics. Generally fundamental question have been addressed in studies of the interaction of intense laser light with matter; nonlinear processes involving atoms; and ultra-high resolution spectroscopy of solids.

Research of more strategic nature includes work on photorefractive devices; on the properties of solitons and other nonlinear waves; on nonlinear optical materials for photonics; and aspects of solid-state physics for quantum computing. Applied research includes the development of novel high power lasers, parametric oscillators and amplifier; techniques for waveguide, photonic crystal and other photonic devices.

Laser Physics also hosts the Australian Research Council Centre of Excellence for Ultrahigh Bandwidth devices for Optical Systems (CUDOS) and Australian Research Network for Advanced Materials (ARNAM) highlights.

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Marek Samoc PhD DSc Wroc

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Steve Madden PhD Imperial College
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Rong Ping Wang PhD CAS

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Nonlinear Physics

The Nonlinear Physics Centre (NLPC) is engaged in interdisciplinary research, both theoretical and experimental, in a number of diverse topics unified by the general concepts of nonlinear physics and nonlinear photonics. The Centre's structure is defined by five major research directions and activities.

The experimental nonlinear photonics group is led by Dr Dragomir Neshev and research includes the experimental study of linear and nonlinear properties of light propagation and self-trapping in integrated and optically-induced photonic structures including waveguide arrays, photonic lattices, photonic crystals; polychromatic light, nonlinear patterns and self-focusing; singular optics and vortices.

The theoretical nonlinear photonics group is led by Dr Andrey Sukhorukov and the group's activity is based on our expertise in the study of nonlinear waves and optical solitons, and currently involves the development of theoretical models and numerical simulations of light propagation in nonlinear photonic structures with close collaboration with the experimental group (eg the generation of ideas, the study of visibility and experimental parameters, etc). More recently this included the development of novel concepts such as the physics of slow light, optical Bloch oscillations, light transmission in complex and quasi-periodic media, self-trapping of polychromatic light generated by a supercontinuum source.

The singular photonics and optical vortices group is led by Dr Anton Desyatnikov. This is the newest group recently awarded three ARC grants. The major research topics include the theoretical studies of the complex light with angular momentum, phase dislocation and optical vortices, optical polarization singularities, and vortex lattices.

The nonlinear matter waves and quantum-atom optics group is led by Dr Elena Ostrovskaya and is closely associated with the ARC Centre of Excellence on Quantum-Atom Optics, and involves the development of novel theoretical models, analytical and numerical studies of matter waves and nonlinear atom-optics problems, cold atoms, Bose-Einstein condensates in optical lattices and magnetic waveguides, atom lasers, quantum optics of nonclassical and squeezed light.

The composite structures and left-handed metamaterials group is led by Dr Ilya Shadrivov and is a new direction that involves the study of composite metamaterials with the property of negative refraction, with the emphasis on our pioneering results on nonlinear metamaterials and left-handed superlattices. One target of this group is the experimental verification for the first time in Australia of the basic phenomena of left-handed propagation and negative refraction for microwaves.

NPC continues to play an important role in two Centres of Excellence funded by the Australian Research Council: the ARC Centre of Excellence for Ultra-high Bandwidth Devices for Optical Systems (CUDOS) and the ARC Centre of Excellence for Quantum-Atom Optics (ACQAO). The Centre also hosts a Student Chapter of the Optical Society of America.
**Staff List**

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**Senior Fellow**
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Alexander Zharov DSc Russia (October–December)

**Fellow**
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**Research Fellows**
Anton Desyatnikov PhD Moscow
Vladimir Denisenko PhD Kiev (August–October)
Libin Fu BSc PhD Lanzhou (April–June)
Elena Ostrovskaya MSc Moscow, PhD ANU
Vladlen Shvedov PhD Ukraine (September–December)
Andrey Sukhorukov MSc Moscow PhD ANU
Denis Sych PhD Moscow (January–March)
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Andrey Miroshnichenko PhD Dresden
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Professor M Trippenbach, Warsaw University, Poland
Professor A Volyar, Taurida National University, Ukraine
Dr N Zharova, Russian Academy of Sciences, Russia
Nuclear Physics

The Department of Nuclear Physics (NP) carries out research into experimental Nuclear Physics and applications of nuclear techniques and other accelerator-based research. The Heavy Ion Accelerator Facility, maintained, developed and operated by the Department provides a range of energetic heavy-ion beams produced with a suite of ion sources and accelerated by a 15 million-volt Pelletron and a superconducting linear accelerator. Beams are delivered to ten separate beam-lines, each dedicated to specialised detector instrumentation.

The facilities are used by staff and students of the Department as well as external users from other Australian universities and institutions, and international scientists from a number of laboratories. Scientists from the United Kingdom, for example, have formal access to the facilities through the ANU-EPSRC agreement.

The Department and its facilities constitute the main laboratory in Australia for accelerator-based research and training in Nuclear Physics as well as specialised workshops in radiation physics and accelerator techniques. A Master of Nuclear Science by coursework was instituted in 2007.

To complement the research carried out on the local facilities, Department members conduct research in collaboration with international scientists at major overseas experimental facilities.

Current nuclear research areas cover nuclear spectroscopy and the study of exotic nuclear quantum states, heavy-ion reaction dynamics including nuclear fusion and nuclear fission, and the study and use of hyperfine interactions for moment measurements and nuclear structure. Both nuclear techniques and heavy-ion techniques are used in a range of materials science applications including materials modification and characterisation, while the technique of Accelerator Mass Spectrometry is applied extensively. It covers both applications and basic research in archaeology, hydrology, climate change, soil erosion and trace isotopic analyses applied to environmental pollution studies, both nuclear and non-nuclear.

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Departmental Administrator
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Dr T Esat, ANSTO
Dr Q Guo, Peking University, China
Emeritus Professor J Newton
Dr P Nieminen, Academy of Finland
Dr H Timmers, University of New South Wales
Plasma Research

The Plasma Research Laboratory (PRL) is comprised of two research areas – the Toroidal Plasma and the Space Plasma, Power and Propulsion (SP³) groups.

The Toroidal Plasma group, led by Dr Boyd Blackwell, embraces a range of pursuits associated with the physics of magnetised plasma; the physics of fluids, electromagnetics, remote sensing and inverse methods. The group operates the National Plasma Fusion Research Facility based on the H-1 heliac, an innovative plasma confinement device with flexible geometry allowing exploration of basic plasma physics, advanced configurations and remote measurement systems for fusion power plants. The Plasma Configurations group, led by Dr Blackwell has developed datamining techniques on H-1 which are being applied to stellarators in Japan, Spain and Germany, to unravel the mode structure of plasma instabilities. A precision magnetic surface mapping technique has revealed magnetic islands structure, and some interesting effects on plasma confinement. The BushLAN project, a research-led teaching project led by Dr Borg, aims to provide Internet connectivity beyond the reach of conventional fibre networks using new wireless communications protocols.

Pioneering optical technologies developed by Prof Howard’s Advanced Imaging and Inverse Methods group underpin collaborations on prototype fusion devices in the US, Europe and Asia, and with Bluescope, on steel production. With Chalmers University in Sweden, the group is adapting inverse techniques, initially developed for plasma diagnostics, to microwave imaging of human tissue. The Physics of Fluids group led by Dr Shats focuses on studies of waves, turbulence and nonlinear phenomena in fluids, important for the physics of weather phenomena, and for improving plasma confinement. A recent discovery, enabled by our high resolution velocimetry techniques, was the suppression of turbulence by shear decorrelation of turbulent eddies.

The Space Plasma, Power and Propulsion (SP³) group, led by Professor Rod Boswell, conducts work on both basic and applied plasma physics. The core research areas involve experimental and theoretical aspects of expanding radiofrequency helicon plasmas applied to space science, space propulsion and hydrogen fuel cells.

The discovery of current free double layers and of the Helicon Double Layer Thruster led to a contract with EADS/ASTRIUM, Europe's largest Space company. Experimental work includes thrust measurement, prototype optimisation and plasma detachment. In addition, the group has a major program to simulate and model the double layer phenomena observed in the laboratory plasma. Furthermore, the laboratory double layers are being applied to understanding space plasma physics such as the magnetic funnels of the solar corona. Other research on space plasma physics includes studying high-beta plasmas and wave-plasma interactions.

Funded by an Australian Research Council Discovery grant until 2009, SP³ is using dry plasma processing techniques to produce fuel cell electrodes and membranes. Employing carbon nanofibers in the electrodes the group has reduced the amount of catalyst while maintaining the fuel cell efficiency. A new plasma system will deposit new plasma polymer membranes.
Staff List

Professor and Head of SP3 Group
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Head of Toroidal Plasma Group
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Dr D Mather, University of New South Wales
Professor J O’Connor, University of Newcastle
Professor R Storer, Flinders University
Dr K Takahashi, Tohoku University, Japan
Theoretical Physics

The Department of Theoretical Physics (TP) is one of the university's founding departments. The core research areas involve theoretical aspects of mathematical physics, plasmas and fluids, condensed matter physics and optical sciences.

Research in the mathematical physics group is centred on two related areas of activity. These are string theory and integrable models. The string theory team is led by Professor Peter Bouwknegt. The main area of research focusses on the mathematical structures underlying string theory, in particular on duality symmetries and generalizations of geometry. This involves studying non-commutative and non-associative C*-algebras, generalised geometries (in the sense of Hitchin) and T-dualities between these structures.

The integrable model team is led by Professors Murray Batchelor and Vladimir Bazhanov. Research is based on the development of theoretical models and methods of analysis for the exact physical description of fundamental interacting systems in statistical mechanics and quantum field theory. It includes the study of phase transitions and magnetic ordering in low-dimensional spin systems and cold atomic gases and the development of new approaches and applications in quantum geometry.

The plasmas and fluids group is led by Professor Robert Dewar with the major research topic in complex, nonequilibrium systems. The area spans plasma physics, atmospheric physics, bushfire dynamics and other complex physical systems applications. Much of the research is focused on the fundamental physics and the modelling of magnetic confinement fusion energy devices. The group has active research links with CSIRO, Princeton Plasma Physics Laboratory, UKAEA Fusion, among others. Dr Matthew Hole is Chair of the Australian ITER Forum.

Research activity in the condensed matter theory group includes the theory of electron transport and noise in mesoscopic systems, high-temperature superconductivity, density functional theory of disordered systems, strongly correlated electrons, spintronics and semiconductor devices.

The optical sciences group is led by Professors John Love and Nail Akhmediev and involves studies in nonlinear optics and soliton theory. The group develops basic theory of solitons for optical systems that includes modern all-optical information transmission lines and ultra-short pulse lasers. The group is strongly linked to experimental photonics groups within the School, across campus, and to international research laboratories.

The Department is host to the ARC Research Network on Complex Open Systems (COSNet) led by Professor Dewar, and the Centre for Complex Systems (CCS) led by Professor Batchelor.
Staff List

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