

RSPHysSE Annual Report 2005

Department of Applied Mathematics

The Department of Applied Mathematics 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 and transport in porous structures.

The research activities of the Department remain very diverse, encompassing researchers with very different backgrounds and often very different approaches to research. It is fitting then that this year our founder, Professor Barry Ninham, be awarded the David Craig medal for his lasting contributions to the broad science he has made over the past 50 years. As reflected in Barry's contributions this also remains the Department's great strength. In reality it is much like a physics, chemistry, biology, mathematics, materials and chemical engineering department all rolled into one. Work in the Department continues to include experimental work as well as theory and simulation.

The research interests in condensed matter can be broadly classified into three main areas:

- (a) soft matter systems (polymers, liquid crystals, surfactants);
- (b) surface science – particularly systems involving colloidal and soft materials;
- (c) porous and disordered materials.

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 Groups' ongoing research programs.

A large part of the Department's effort has been funded by the ARC Cooperative Research Centre, SmartPrint, which focuses mainly on fundamental research on surface physics and material structure with applications to the paper industry (Knackstedt, Senden and Craig). A joint research project with companies in the oil and gas industry is now being undertaken. In both cases the Department has been able to forge solid research consortia, where industry is being driven by the application of pure research. So successful have these relationships been that the partners are in fact championing the development of ANU technology in the global setting. Largely, progress continues to be open science, although a number of commercial opportunities have presented themselves. In supporting open research the collaborating industry partners are recognising the role universities play in providing the broad and basic training that their industry draws upon.

The Department has grown to its largest now comprising over 50 people, and in terms of academic staff is the largest in the Research School. It continues to grow, thanks mainly to the support of the Australian Research Council (ARC) in terms of fellowships, the Co-operative Research Centre (CRC) and industry-related grants.

During 2005 the research of the Department continued much as in recent years. Of particular note was the commencement of the Federation Fellowship awarded to Professor Stephen Hyde. His research program underlines the breadth of the Department; his interest include self-assembly of molecular and macromolecular amphiphiles and lipids in solution into liquid crystals, formation of inorganic materials in biological and abiotic conditions. His work also includes characterisation and enumeration of geometric networks in various spaces, including two-dimensional hyperbolic networks and higher-dimensional euclidean networks. To great fanfare, Stephen, Vanessa Robins and Stuart Ramsden initiated the 'Euclidean Patterns in Non-Euclidean Tilings' (EPINET) project, which explores 2D hyperbolic (H^2) tilings as a source of crystalline frameworks (or networks) in 3D euclidean (E^3) space.

Just as the Atomic Force Microscope (AFM) facility has been extended to ANU researchers as an open access facility, the X-ray Micro-tomography facility has also provided support to researchers outside the Department. Some of these innovative projects include quantifying the neural capacity of bees, exploring the sensory systems of 270 Million year old fossil fish and the arrangement of wood fibre composites.

Staff List

Professor and Head of Department

Mark Knackstedt, BSc Columbia, PhD Rice (ARC QEII Fellowship)

Professor

Stephen Hyde, BSc PhD Monash (ARC Federation Fellowship)

Senior Fellows

Tomaso Aste, DipHons Genova, PhD Milan (EU, Marie Curie Fellowship)

Vince Craig, BSc PhD ANU (ARC Fellowship)

Tiziana Di Matteo, BSc(Hons) PhD Salerno (ARC QEII Fellowship)

Tim Senden, BSc PhD ANU (ARC Fellowship)

Adrian Sheppard, BSc Adel, PhD ANU (ARC Fellowship)

David Williams, BSc Sydney, PhD Cambridge (ARC Fellowship)

Research Fellows

Christoph Arns, Dipl-Phys Aachen, PhD UNSW (ARC Postdoctoral Fellowship)

Mika Kohonen, BAppSc BSc(Hons) PhD ANU

Ankie Larsson, Ma Sc Lic PhD Lund, Doc Stockholm

Nobuo Maeda, BSc PhD ANU

Chiara Neto, BSc(Hons) PhD Florence (ARC Fellowship)

Shannon Notley, BSc(Hons) PhD ANU

Drew Parsons, BSc(Hons) PhD Karpov, DipEd UNSW

Vanessa Robins, BSc ANU, PhD Colorado

Arthur Sakellariou, BSc PhD Melbourne
Rob Sok, BSc PhD Groningen

Postdoctoral Fellows

Fabrice Bauget, PhD Paris VI
Amit Goel, BEng Roorkee, PhD Minnesota
Ernesto Hernandez-Azpata, BSc PhD Mexico
Shio Inagaki, BSc Tokyo IT, MSc Ibaraki, PhD Tokyo
Christian Kugge, PhD KTH Stockholm
Ray Roberts, BSc(For) PhD ANU
Mohammad Saadatfar, BSc Mazandaran, MSc IASBS, PhD ANU (from October)
Gerd Schroeder, Dipl Phys Cologne, PhD ANU (February to August)
Pär Wedin, MSc KTH Stockholm, PhD Karlstad (from April)
Xuehua Zhang, BE Dalian, ME PhD Shanghai (from September)

Visiting Fellows

Olaf Delgado-Friedrichs, Arizona State University, USA (November to December)
Susan Gunner, South Australia (July to December)
Stjepan Marcelja, Dip Ing Zagrep, PhD Roch, FAA, ANU (Emeritus Professor)
Mario Nicodemi, Universitario di Monte S. Angelo, Italy (from November)
Barry Ninham, MSc WA, PhD Maryland, DTech (hon causa) KTH Stockholm, D Phil (hon causa) Lund, FAA (Visiting Professor, University of Florence, Italy), ANU (Emeritus Professor)
Magnus Norgren, Mid Sweden University, Sweden (until June)
Christoph Oguey, Université de Cergy-Pontoise, France (April)
Ewa Radlinska, Australian National University (from February)
Enricho Scalas, Università del Piemonte Orientale, Italy (November to December)

Senior Technical Officers

Anthony Hyde, Assoc IE Aust
David King (from August)
Tim Sawkins

Consultants and Other Staff

Holger Averdunk, BSc(Hons) Biochemistry, BSc Computer Science
Richard Corby
Stuart Ramsden, GardDip Film & Television Swinburne
Paul Veldkamp (from July)

Departmental Administrators

Jan James (CRC Administrator)
Jenny Smith

Publications

Legend: * *External to the University*

Member of another area of this University other than this School

Publications in Refereed Journals

Akbulut, M.*, Chen, N.*, Maeda, N., Israelachvili, J.*, Grunewald, T.* and Helm, C.A.*
Crystallization in Thin Liquid Films Induced by Shear
Journal of Physical Chemistry B **109** (2005) 12509-12514

Arns, C.H., Knackstedt, M.A. and Martys, N.S.*
Cross-property Correlations and Permeability Estimation in Sandstone
Physical Review E **72** (2005) 046304-1-12

Arns, C.H., Bauget, F.*, Limaye, A., Sakellariou, A., Senden, T.J., Sheppard, A.P., Sok, R.M., Pinczewski, W.V.*, Bakke, S.*, Berge, L.I.*, Øren, P.-E.* and Knackstedt, M.A.
Pore-scale Characterization of Carbonates Using X-ray Microtomography
SPE Journal December 2005 (2005) 475-484

Arns, C.H., Mecke, J.*, Mecke, K.* and Stoyan, D.*
Second-order Analysis by Variograms for Curvature Measures of Two-phase Structures
European Physical Journal B **47** (2005) 397-409

Aste, T., Saadatfar, M. and Senden, T.J.
Geometrical Structure of Disordered Sphere Packings
Physical Review E (Statistical, Nonlinear and Soft Matter Physics) **71** (2005) 061302-1-15

Aste, T. and Valbusa, U.*
Ripples and Ripples: From Sandy Deserts to Ion-sputtered Surfaces
New Journal of Physics **7** (2005) 122/1-22

Aste, T. and Di Matteo, T.
The 13th Problem
Australian Mathematical Society, Gazette **32** (2005) 314-316

Aste, T.
Variations around Disordered Close Packing
Journal of Physics: Condensed Matter **17** (2005) S2361-S2390

Bauduin, P.*, Touraud, D.*, Kunz, W.*, Savelli, M.-P.*, Pulvin, S.* and Ninham, B.
The Influence of Structure and Composition of a Reverse SDS Microemulsion on Enzymatic Activities and Electrical Conductivities
Journal of Colloid and Interface Science **292** (2005) 244-254

Boström, M.* and Ninham, B.
Energy of an Ion Crossing a Low Dielectric Membrane: The Role of Dispersion Self-free Energy

Biophysical Chemistry 114 (2005) 95-101

Boström, M.*, Kunz, W.* and Ninham, B.
Hofmeister Effects in Surface Tension of Aqueous Electrolyte Solution

Langmuir 21 (2005) 2619-2623

Boström, M.*, Tavares, F.W.*, Bratko, D.* and Ninham, B.
Specific Ion Effects in Solutions of Globular Proteins: Comparison between Analytical Models and Simulation

Journal of Physical Chemistry B 109 (2005) 24489-24494

Boström, M.*, Tavares, F.W.*, Finet, S.*, Skouri-Panet, F.*, Tardieu, A.* and Ninham, B.

Why Forces between Proteins Follow Different Hofmeister Series for pH above and below pI

Biophysical Chemistry 117 (2005) 217-224

Christy, A.G., Senden, T.J. and Evans, P.D.*
Automated Measurement of Checks at Wood Surfaces

Measurement 37 (2005) 109-118

Di Matteo, T., Aste, T. and Gallegati, M.*
Innovation Flow through Social Networks: Productivity Distribution in France and Italy
European Physical Journal B **47** (2005) 459-466

Di Matteo, T., Aste, T., Hyde, S.T. and Ramsden, S.J.
Interest Rates Hierarchical Structure

Physica A 355 (2005) 21-33

Edwards, S.A. and Williams, D.R.M.
Stretching a Single Diblock Copolymer in a Selective Solvent: Langevin Dynamics Simulations

Macromolecules 38 (2005) 10590-10595

Eriksson, T.*, Mellergård, A.*, Nordblad, P.*, Larsson, A.-K., Felton, S.*, Höwing, J.*, Gustafsson, T.* and Andersson, Y.*

Magnetic Short-range Order in the New Ternary Phase $Mn_8Pd_{15}Si_7$

Journal of Alloys and Compounds 403 (2005) 19-28

García-García, F.J.* and Larsson, A.-K.
X-ray Powder Diffraction and Electron Diffraction Studies of the $Ni_{1-y}Ge_{1-x}P_x$ System

Journal of Solid State Chemistry 178 (2005) 742-754

- Giorgi, R.*, Bozzi, C.*, Dei, L.*, Gabbiani, C.*, Ninham, B. and Baglioni, P.*
Nanoparticles of Mg(OH)₂: Synthesis and Application to Paper Conservation
Langmuir **21** (2005) 8495-8501
- Huh, J.*, Ahn, C.-H.*, Jo, W.H.*, Bright, J.N. and Williams, D.R.M.
Constrained Dewetting of Polymers Grafted onto a Nonadsorbing Surface in Poor Solvents: From Pancake Micelles to the Holey Layer
Macromolecules **38** (2005) 2974-2980
- Kabla, A., Debrégeas, G.*, Di Meglio, J.-M. and Senden, T.J.
X-ray Observation of Micro-failures in Granular Piles Approaching an Avalanche
Europhysics Letters **71** (2005) 932-937
- Knackstedt, M.A., Arns, C.H. and Pinczewski, W.V.*
Velocity-porosity Relationships: Predictive Velocity Model for Cemented Sands Composed of Multiple Mineral Phases
Geophysical Prospecting **53** (2005) 349-372
- Knackstedt, M.A., Arns, C.H., Saadatfar, M., Senden, T.J., Sakellariou, A., Sheppard, A.P., Sok, R.M., Schrof, W.* and Steininger, H.*
Virtual Materials Design: Properties of Cellular Solids Derived from 3D Tomographic Images
Advanced Engineering Materials **7** (2005) 238-243
- Knüfing, L., Schollmeyer, H.*, Riegler, H.* and Mecke, K.
Fractal Analysis Methods for Solid Alkane Monolayer Domains at SiO₂/Air Interfaces
Langmuir **21** (2005) 992-1000
- Kugge, C., Bellander, H.* and Daicic, J.*
Pressure Filtration of Cellulose Fibres
Journal of Pulp and Paper Science **31** (2005) 95-100
- Lo Nostro, P.*, Ninham, B., Lo Nostro, A.*, Pesavento, G.*, Fratoni, L.* and Baglioni, P.*
Specific Ion Effects on the Growth Rates of Staphylococcus Aureus and Pseudomonas Aeruginosa
Physical Biology **2** (2005) 1-7
- Lonetti, B.*, Lo Nostro, P.*, Ninham, B. and Baglioni, P.*
Anion Effects on Calixarene Monolayers: A Hofmeister Series Study
Langmuir **21** (2005) 2242-2249
- Mclean, S.C.*, Lioe, H.*, Meagher, L.*, Craig, V.S.J. and Gee, M.*
Atomic Force Microscopy Study of the Interaction between Adsorbed Poly(ethylene oxide) Layers: Effects of Surface Modification and Approach Velocity
Langmuir **21** (2005) 2199-2208

Mecke, K.* and Arns, C.H.

Fluids in Porous Media: A Morphometric Approach

Journal of Physics: Condensed Matter **17** (2005) S503-S534

Miller, I.C.B.#, Keentok, M.*, Pereira, G.G.* and Williams, D.R.M.

Semiflexible Polymer Condensates in Poor Solvents: Toroid versus Spherical Geometries

Physical Review E (Statistical, Nonlinear and Soft Matter Physics) **71** (2005) 031802-1-9

Nagai, Y.*, Maddess, T.# and Hyde, S.T.

The Oscillatory Features of Triangular and Square Prism Oscillator Networks

Memoirs of the Kokushikan University Centre for Information Science **26** (2005) 1-16

Neto, C., Evans, D.R., Bonaccorso, E.*, Butt, H.-J.* and Craig, V.S.J.

Boundary Slip in Newtonian Liquids: A Review of Experimental Studies

Reports on Progress in Physics **68** (2005) 2859-2897

Neto, C., Bonini, M.* and Baglioni, P.*

Self-assembly of Magnetic Nanoparticles into Complex Superstructures: Spokes and Spirals

Colloids and Surfaces A: Physicochemical and Engineering Aspects **269** (2005) 96-100

Ninham, B. and Boström, M.*

Building Bridges between the Physical and Biological Sciences

Cellular and Molecular Biology **51** (2005) 803-813

Norgren, M. and Bergfors, E.*

Sorption of Kraft Lignin from Spent Liquors on Pulp Fibres

Wood Science and Technology **39** (2005) 512-520

Pashley, R.M.#, Rzechowicz, M.#, Pashley, L.R. and Francis, M.J.#

De-gassed Water is a Better Cleaning Agent

Journal of Physical Chemistry B **109** (2005) 1231-1238

Pinna, M.C.*, Bauduin, P.*, Touraud, D.*, Monduzzi, M.*, Ninham, B. and Kunz, W.*

Hofmeister Effects in Biology: Effect of Choline Addition on the Salt-induced Super Activity of Horseradish Peroxidase and its Implication for Salt Resistance of Plants

Journal of Physical Chemistry B **109** (2005) 16511-16514

Pinna, M.C.*, Salis, A.*, Monduzzi, M.* and Ninham, B.

*Hofmeister Series: The Hydrolytic Activity of *Aspergillus Niger* Lipase Depends on Specific Anion Effects*

Journal of Physical Chemistry B **109** (2005) 5406-5408

Pinna, M.C.*, Salis, A.*, Monduzzi, M.* and Ninham, B.*
Reply to Comments on 'Homeister Series: Hydrolytic Activity of Aspergillus Niger Lipase Depends on Specific Effects'
Journal of Physical Chemistry B **109** (2005) 14752-14754

Roberts, R. and Evans, P.D.*
Effects of Manufacturing Variables on Surface Quality and Distribution of Melamine Formaldehyde Resin in Paper Laminates
Composites Part A-Applied Science and Manufacturing **36** (2005) 95-104

Robins, V., Ramsden, S.J. and Hyde, S.T.
A Note on the Two Symmetry-preserving Covering Maps of the Gyroid Minimal Surface
European Physical Journal B **48** (2005) 107-111

Rode, A.V., Gamaly, E.G., Christy, A.G., Fitz Gerald, J.[#], Hyde, S.T., Elliman, R.G., Luther-Davies, B., Veinger, A.I.*, Androulakis, J.* and Giapintzakis, J.*
Strong Paramagnetism and Possible Ferromagnetism in Pure Carbon Nanofoam Produced by Laser Ablation
Journal of Magnetism and Magnetic Materials **290-291** (2005) 298-301

Saadatfar, M., Arns, C.H., Knackstedt, M.A. and Senden, T.J.
Mechanical and Transport Properties of Polymeric Foams Derived from 3D Images
Colloids and Surfaces A: Physicochemical and Engineering Aspects **263** (2005) 284-289

Seemann, R.*, Herminghaus, S.*, Neto, C., Schlagowski, S.*, Podzimek, D.*, Konrad, R.*, Mantz, H.* and Jacobs, K.*
Dynamics and Structure Formation in Thin Polymer Melt Films
Journal of Physics: Condensed Matter **17** (2005) S267-S290

Sheppard, A.P., Arns, J.-Y.*, Knackstedt, M.A. and Pinczewski, W.V.*
Volume Conservation of the Intermediate Phase in Three-phase Pore-network Models
Transport in Porous Media **59** (2005) 155-173

Tumminello, M.*, Aste, T., Di Matteo, T. and Mantegna, R.N.*
A Tool for Filtering Information in Complex Systems
Proceedings of the National Academy of Sciences of the United States of America **102** (2005) 10421-10426

Wang, G.M.[#], Reid, J.C.[#], Carberry, D.M.[#], Williams, D.R.M., Sevick, E.M.[#] and Evans, D.J.[#]
Experimental Study of the Fluctuation Theorem in a Nonequilibrium Steady State
Physical Review E (Statistical, Nonlinear and Soft Matter Physics) **71** (2005) 046142-1-11

Yoshida, M.*, Fresco, Z.M.*, Ohnishi, S. and Fréchet, J.M.J.*
Efficient Divergent Synthesis of Dendronized Polymers with Extremely High Molecular Weight: Structural Characterization by SEC-MALLS and SFM and Novel Organic Gelation Behavior
Macromolecules **38** (2005) 334-344

Zebaze, R.M.D.*, Jones, A.C., Welsh, F.*, Knackstedt, M.A. and Seeman, E.*
Femoral Neck Shape and the Spatial Distribution of its Mineral Mass Varies with its Size: Clinical and Biomechanical Implications
Bone **37** (2005) 243-252

Refereed Conference Proceedings

Arns, C.H., Sheppard, A.P., Sok, R.M. and Knackstedt, M.A.
NMR Petrophysical Predictions on Digitized Core Images
SPWLA 46th Annual Logging Symposium, New Orleans, USA (2005) MMM1-16

Aste, T., Di Matteo, T., Tumminello, M.* and Mantegna, R.N.*
Correlation Filtering in Financial Time Series
Noise and Fluctuations in Econophysics and Finance, Austin, USA (2005) 100-109

Aste, T. and Senden, T.J.
The Hierarchical Properties of Contact Networks in Granular Packings
The 5th International Conference on Micromechanics of Granular Media, Stuttgart, Germany (2005) 37-40

Ghous, A., Bauget, F., Arns, C.H., Sakellariou, A., Senden, T.J., Sheppard, A.P., Sok, R.M., Pinczewski, W.V.*, Harris, R.G.*, Beck, G.F.* and Knackstedt, M.A.
Resistivity and Permeability Anisotropy Measured in Laminated Sands via Digital Core Analysis
SPWLA 46th Annual Logging Symposium, New Orleans, USA (2005) VVV1-14

Notley, S.M. and Wågberg, L.*
Direct Measurement of Attractive Van der Waals Forces and Repulsive Electrostatic Forces between Regenerated Cellulose Surfaces in an Aqueous Environment
13th Fundamental Research Symposium, Cambridge, UK (2005) 1337-1350

Saadatfar, M., Turner, M.L., Arns, C.H., Averdunk, H., Senden, T.J., Sheppard, A.P., Sok, R.M., Pinczewski, W.V.*, Kelly, J.* and Knackstedt, M.A.
Rock Fabric and Texture from Digital Core Analysis
SPWLA 46th Annual Logging Symposium, New Orleans, USA (2005) ZZ1-16

Saadatfar, M., Kabla, A., Senden, T.J. and Aste, T.

The Geometry and the Number of Contacts on Monodisperse Sphere Packs Using X-ray Tomography

The 5th International Conference on Micromechanics of Granular Media, Stuttgart, Germany (2005) 33-36

Atomic and Molecular Physics Laboratories

As recognised by the Division of Atomic, Molecular, and Optical Physics of the American Physical Society, "Atomic, molecular, and optical (AMO) physics is an enabling science that supports many other important areas of science and technology". Indeed, students graduating in AMO physics acquire a breadth of knowledge and skills, enabling them to contribute to many areas of science, technology, and society. AMO physicists have also appeared prominently among Nobel laureates in recent times. The Atomic and Molecular Physics Laboratories 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.

During the year, the Department bade farewell to Alice Duncanson and Jun Matsumoto. We thank them for their service. Three new graduate students, Alan Heays, Violaine Vizcaino, and Mostyn Gale, were welcomed and Linda Uhlmann had her PhD degree conferred. Finally, congratulations are due to Anatoli Kheifets who was deservedly promoted to Professor during the year.

Members of the Department were again successful in winning grants during the year. Five successes in the ARC Discovery round (Vos, Baldwin, Buckman, Gibson, and Bellm) resulted in new funding on the order of \$500,000 per annum. In addition, Ken Baldwin was a partner on a successful ARC Linkage proposal. Most importantly, Steve Buckman was successful in his bid for an ARC Centre of Excellence, winning on the order of \$7,000,000 over 5 years for his Centre of Antimatter-Matter Studies. Together with our existing role in the ARC Centre for Quantum Atom Optics (Baldwin, Truscott), this gives the Department a significant profile in the ARC Centre of Excellence program.

The international research profile of the Department remains strong, as evidenced by continuing invitations to speak at international conferences, and an ongoing commitment to 30 collaborative projects, most involving international collaborators. Of 53 refereed departmental publications this year, nearly 70% have international coauthors.

Staff List

Professor and Head of Laboratories

Brenton Lewis, PhD DSc Adel, C Phys, FInstP, FAPS, FOSA, FAIP

Professors

Stephen Buckman, BSc PhD Flind, FAPS, FAIP

Adjunct Professors

Lewis Chadderton, DSc Dur, MA PhD Camb, C Phys, FInstP, FAIP

Robert McEachran, MSc PhD UWO, C Phys, FInstP

Robert Robson, BSc Qld, DipMet, PhD, FRMS, FAPS, FAIP (ARC Centre for Matter-Anti-Matter Studies, from November)

Senior Fellows

Ken Baldwin, MSc ANU, DIC PhD Lond, FAIP, FOSA
Stephen Gibson, BSc PhD Adel
Anatoli Kheifets, BSc PhD St Pet (jointly with Theoretical Physics)
Maarten Vos, MSc PhD Grön

Fellows

Julian Lower, BSc PhD Flind
Andrew Truscott, BSc PhD Qld (ARC Centre for Quantum Atom Optics) (ARC Fellowship)

Research Fellows

Mitsuhiko Kono, MS Kyoto IT, PhD Grad U Adv Sci
Igor Ivanov, BSc PhD Moscow (jointly with Theoretical Physics)
Franklin Mills, BSE Princ, MS PhD Caltech (jointly with CRES)
James Sullivan, BSc PhD ANU (ARC Fellowship)

Postdoctoral Fellows

Susan Bellm, BSc PhD Flind
Steven Cavanagh, BSc PhD Griff
Robert Dall, BSc CQld (ARC Centre for Quantum Atom Optics)
Jun Matsumoto, MSc PhD Tokyo Met (until September)
Michael Went, BSc Newcastle, PhD Griff

ARC Linkage International Fellow

Michael Lange, Dipl- Phys Dr rer nat Heid

Research Assistants

Alan Heays, MSc Auck (from July)
Linda Uhlmann, B App Sci CQld

Visiting Fellows

Robert Crompton, AM, FAA, FInstP, FAPS, HonFAIP (Emeritus Professor), ANU
Erich Weigold, FAA, FTSE, FAPS, FAIP, Australian Research Council

Technical Staff

Stephen Battisson, AssocDipMechEng CIT
Graeme Cornish, AssocDipMechEng CIT
Colin Dedman, AssocDipSciInst Bdgo CAE
Gary Picker, AssocDipMechEng CIT
Kevin Roberts, MechTechCert SAIT

Departmental Administrator

Alice Duncanson (until November)

Publications

Legend: * *External to the University*

Member of another area of this University other than this School

Book Chapters

Buckman, S.J., Brunger, M.J.*, Campbell, L.*, Jelisavcic, M. and Petrovic, Z.Lj.*
Electron Collisions in our Atmosphere – How the Microscopic Drives the Macroscopic
in **Atomic and Molecular Data and their Applications**, American Institute of Physics,
New York, USA (2005) 91-100

Chatzidimitriou-Dreismann, C.A.*, Abdul-Redah, T.*, Krzystyniak, M.* and Vos, M.
Attosecond Effects in Scattering of Neutrons and Electrons from Protons
in **Decoherence, Entanglement and Information Protection in Complex Quantum Systems**, Springer-Verlag, UK (2005) VI-1-20

Publications in Refereed Journals

Baldwin, K.G.H.
Metastable Helium: Atom Optics with Nano-grenades
Contemporary Physics **46** (2005) 105-120

Bellm, S.M., Davies, J.A.*, Whiteside, P.T.*, Guo, J.*, Powis, I.* and Reid, K.L.*
An Unusual π^ Shape Resonance in the Near-threshold Photoionization of S_1 Para-difluorobenzene*
Journal of Chemical Physics **122** (2005) 224306-1-10

Berdinsky, A.S.*, Fink, D.*, Yoo, J.B.*, Chun, H.G.*, Chadderton, L.T. and Petrov, A.V.*
Conducting Properties of Planar Irradiated and Pristine Silicon-fullerite-metal Structures
Applied Physics A: Materials Science and Processing **80** (2005) 1711-1715

Berdinsky, A.S.*, Chadderton, L.T., Yoo, J.B.*, Gutakovsky, A.*, Fedorov, V.*, Mazalov, L.* and Fink, D.*
Structural Changes of MoS_2 Nano-powder in Dependence on the Annealing Temperature
Applied Physics A: Materials Science and Processing **80** (2005) 61-67

Chen, C., Gale, M.N., Kheifets, A.S., Vos, M. and Went, M.R.
Spectral Momentum Densities of Vanadium and Vanadium Oxide as Measured by High Energy ($e, 2e$) Spectroscopy
Journal of Physics: Condensed Matter **17** (2005) 7689-7704

Cruz, S.A.* and Chadderton, L.T.
Theoretical Study of Pressure Effects on Fission Fragment Track Registration Lengths in Apatite

Radiation Measurements 40 (2005) 765-769

Czasch, A.*, Schöffler, M.*, Hattass, M.*, Schössler, S.*, Jahnke, T.*, Weber, T.*, Staudte, A.*, Titze, J.*, Wimmer, C.*, Kammer, S.*, Weckenbrock, M.*, Voss, S.*, Grisenti, R.*, Jagutzki, O.*, Schmidt, L.Ph.H.*, Schmidt-Böcking, H.*, Dörner, R.*, Rost, J.M.*, Schneider, T.*, Liu, C.-N.*, Bray, I.*, Kheifets, A.S. and Bartschat, K.*
Partial Photoionization Cross Sections and Angular Distributions for Double Excitation of Helium up to the $N=13$ Threshold

Physical Review Letters 95 (2005) 243003-1-4

Dorn, A.*, Kheifets, A.S., Schröter, C.D.*, Höhr, C.*, Sakhelashvili, G.*, Moshhammer, R.*, Lower, J.C.A. and Ullrich, J.*

Reply to Comment on 'Appearance and Disappearance of the Second Born Effects in the $(e, 3e)$ Reaction on He'

Physical Review A 71 (2005) 026702-1-3

Fink, D.*, Alegaonkar, P.S.*, Petrov, A.V.*, Wilhelm, M.*, Szimkowiak, P.*, Behar, M.*, Sinha, D.*, Fahrner, W.R.*, Hoppe, K.* and Chadderton, L.T.

High Energy Ion Beam Irradiation of Polymers for Electronic Applications

Nuclear Instruments and Methods in Physics Research B 236 (2005) 11-20

Fink, D.* and Chadderton, L.T.

Ion-solid Interaction: Status and Perspectives

Brazilian Journal of Physics 35 (2005) 735-740

Fink, D.* and Chadderton, L.T.

Ion-solid Interactions: Current Status, New Perspectives

Radiation Effects and Defects in Solids 160 (2005) 67-83

Guinea, W.E.*, Hanne, G.F.*, Went, M.R., Daniell, M.L.*, Stevenson, M.A.*, Bartschat, K.*, Payne, D.*, MacGillivray, W.R.* and Lohmann, B.*

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Department of Electronic Materials Engineering

The Electronic Materials Engineering (EME) Department undertakes world-class interdisciplinary research into the growth, structure, properties, processing and applications of electronic materials and related structures and devices. It also plays an important role in the training of undergraduates, postgraduates and other early career researchers. 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 has grown considerably in recent years, largely due to its success in competitive grant schemes. This year EME welcomed two new staff members, Mr Simon Ruffell and Ms Rui Rao, who will be working on projects supported by a departmental start-up company, Wriota, and ten new graduate students: Ragu Lakshmanasamy, Ian McKerracher, Hannah Joyce, David Oliver, Tae-Hyun Kim, Supakit Charnvanichborikan, Raquel Giulian, Alexey Glushenkov, Mykhaklo Lysevych and Hua Chen. This brings the total number of EME staff/students to well over 60, including 26 research staff, 8 general staff and 25 MPhil/PhD students. The Department's equipment base was also expanded this year, with the installation of a new multi-target sputter depositions system, and funding approved for the purchase of an electron-beam lithography system, which will be purchased in 2006.

The Department's impressive research record continued in 2005, as measured by a broad range of performance indicators, including the number and quality of its publications, success in competitive research funding schemes, the ability to attract and train high-quality early career researchers, and awards presented to staff and students. For example, in 2005 staff and students published around 70 papers in high-quality peer-reviewed journals and conference proceedings, and presented 24 invited or keynote talks at national or international conferences — an outstanding effort by any measure. The Department also continued its success in the ARC Discovery round, with two new ARC Discovery grants and one new Linkage Project grant awarded in the 2004/2005 round, and another six Discovery Grants and one Linkage grant awarded for commencement in 2006. The latter including an ARC Australian Research Fellowship awarded to Dr Lan Fu and a Postdoctoral Fellowship awarded to Dr Michael Gao.

In other significant awards, Professor Jagadish was elected to Fellowship of the Australian Academy of Science and Dr Ying Chen was elected to Fellowship of the Australian Institute of Physics. The contributions of the Department's PhD students were also recognised, with Mr Michael Fraser receiving a one-year Fulbright Scholarship to study at Stanford University in the USA, and Mr Alexey Glushenkov and Mr Marc Spooner receiving conference awards for best student presentations.

The Department's commitment to research training was once again evident in 2005, with Dr Chris Glover and Dr Manuel Forcales completing postdoctoral appointments and Mr Zohair Hussain and Mr David Brett completing graduate degrees during the year. The Department also hosted a wide range of visitors and visiting scholars, with over 30

visiting academics from eight countries, and nine visiting scholars from five countries, spending periods of up to six months in the Department during 2005.

With a strong experimentally-based research program, the Department relies very heavily on the efficient and effective operation of its experimental equipment and facilities. These are installed, maintained and developed by the Department's technical staff, with support from School service areas. The contributions of Michael Aggett, Martin Conway, Tom Halstead, Fred Johnson, Bernie King, and David Llewellyn to the overall research program cannot be overstated. Equally important is the contribution made to the smooth-running of the Department's administrative affairs and its overall social ambience. This is a role admirably performed by our Departmental Administrator, Renee Vercoe. The important role played by other general staff in the School, including both workshop and administrative staff, is also acknowledged.

Staff List

Professor and Head of Department

Rob Elliman, BAppSci, MAppSci RMIT, PhD DSc Salf, FAIP, FIP

Professors

Chennupati Jagadish, BSc MSc (Tech) MPhil PhD, FAA, FTSE, FAIP, FIP, FIoN, FIEEE, FAPS, FOSA (ARC Federation Fellowship)

Jim Williams, BSc PhD NSW, FAIP, FIEAust, FTSE

Senior Fellows

Mark Ridgway, BSc McM, MSc PhD Queen's

Ying Chen, BSc CAS, MSc Tsinghua, PhD Paris

Fellows

Mladen Petracic, MSc Zagreb, PhD ANU

Yong Kim, PhD KAIST (from February)

ARC QEII Fellow

Hoe Tan, BE Melb, PhD ANU

Jenny Wong-Leung, BSc Bristol, PhD ANU

Research Fellows

Manuela Buda, PhD Eindhoven (until July)

Postdoctoral Fellows

Jodie Bradby, BApSc RMIT, PhD ANU

Yong Jun Chen, MSc USTB, PhD Tsinghua

Tessica Dall, BSc QUT, PhD ANU

Rakesh Dogra, BSc MSc PhD Panjab (jointly with Nuclear Physics)

Manuel Forcales, PhD Amsterdam (until October)

Lan Fu, MSc UTSC, PhD ANU

Qiang Gao, MS BSc Northeastern China, PhD ANU (from April)
Chris Glover, BSc Newcastle, PhD ANU (until July)
Patrick Kluth, Dipl. Phys. Dusseldorf, PhD Julich
Susan Kluth, BSc BEng PhD Leuven
Bill Chi Pui Li, BEng MPhil PhD City UHK, MIEAust, MAIP
Rui Rao, MSc WUST, PhD HUST (from June)
Simon Ruffell, MEng Surrey UK, PhD Western Ontario (from March)
Hongzhou Zhang, PhD Rice

Visiting Fellows

Leandro Araujo, Porto Alegre, Brazil
Stuart Campbell, ADFA, UNSW
Neville Fletcher, FIP, FAIP, FAAS, FTSE, FAA, AM (Professor), ANU
Michael Swain, University of Otago, NZ
Heiko Timmers, ADFA, UNSW (jointly with Nuclear Physics)
Li Yuguo, Shandong Normal University, China (until September)

Senior Technical Officers

Michael Aggett, AssocDipMechEng CIT
Tom Halstead, ElectCommCert Canb TAFE
Fred Johnson, MechEngCertCanbTAFE, DipAppSciCCA
Bernie King, ONC UK

Laboratory Technicians

Martin Conway

Research Assistant

Raquel Giulian, MSc UFRGS (from March)
David Hirschausen (part-time, March to June)
David Llewellyn, (Electron Microscopy Unit, RSBS)
Marc Spooner, BSc Ottawa, MSc Western Ontario, PhD ANU

Departmental Administrator

Renee Vercoe

Publications

Legend: * *External to the University*

Member of another area of this University other than this School

Publications in Refereed Journals

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Laser Physics Centre

The Laser Physics Centre is engaged in laser-based research on topics spanning fundamental and applied physics and engineering. Research in the Centre covers many of the most exciting aspects of contemporary laser physics. The activities can be broadly divided into the following areas: laser matter interaction physics; nonlinear optical phenomena; nonlinear and nanostructured materials; quantum information processing; laser spectroscopy; and photonics. Research in photonics is partly supported by the Australian Research Council Centre of Excellence for Ultrahigh Bandwidth Devices for Optical Systems (CUDOS).

Research highlights for 2005 include: the development of a radical new method of storing optical signals where a crystal first absorbs the light and then the time evolution of the stored coherence is reversed using an electrical signal which results in stimulated re-emission of the optical wave (Alexander, Longdell, Sellars and Manson); the demonstration of drift-free ion beam milling of nano-phonic devices in chalcogenide glass films and in collaboration with colleagues at the University of Sydney the first observation of optical coupling into defect waveguides in these structures (Freeman, Luther-Davies, Krolikowska, Madden, Grillet and Eggleton); demonstration of 3-D optical data storage using two-photon induced photodarkening inside chalcogenide glass (Rode, Samoc, Luther-Davies, Juodkazis, Kondo and Misawa); discovery of a unique liquid crystal system (containing a newly developed boron closo-cluster) which forms spontaneously a second-order nonlinear optical (NLO) active structure (Samoc, Humphrey and Miniewicz); the first demonstrations of the attraction of dark solitons in nonlocal media and of two-dimensional Zener tunneling in optically induced lattices as well as the observation of negative refraction with nonlinearity induced beam localisation and steering (Krolikowski, Rosberg, Neshev, Sukhorukov, Desyatnikov and Kivshar); and new understanding of the processes leading to nanoparticle formation in laser-ablated plumes (Madsen, Rode, Gamaly and Luther-Davies).

During 2005 the Centre benefited from strong levels of funding from the Australian Research Council (ARC) with major grants supporting CUDOS; Professor Luther-Davies's Federation Fellowship; six Discovery grants and two Linkage grants as well as significant funding from DARPA (USA), AOARD (USA), DOD (Australia) and DSTO. Two new ARC Discovery grants were awarded for commencement in 2006 and one new ARC Linkage grant commenced in July 2005.

The Centre congratulates Yinlan Ruan, Elliott Fraval and Eleni Notaras on the award of their PhDs and Roger McMurtie and Brendan Hanna for their Masters degrees. Amrita Prasad and Robert Fisher joined as a new PhD students and Matthew Cheung as a Masters student. At the end of 2005 two long serving staff members retired, namely Mr Mike Pennington and Mr Ian McRae. Both had provided superb technical support to the Centre over many years and are heartily thanked for their efforts.

Staff List

Professor and Head of Department

Barry Luther-Davies, BSc PhD S'ton, SIEE, FAIP (ARC Federation Fellowship)

Professors

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Wieslaw Krolikowski, MSc PhD Wars

Senior Fellows

Andrei Rode, MSc PhD Mosc

Marek Samoc, PhD DSc Wroc

Research Fellow

Duk Yong Choi, PhD Seoul

Andrzej Miniewicz, MSc PhD Wroc (from September)

Matthew Sellars, BSc PhD ANU

Rong Ping Wang, PhD China

Postdoctoral Fellows

Ruth Jarvis, BE BSc PhD ANU

Congji Zha, BE Jingdezheng, ME WUT, PhD Sydney

Vesselin Kolev, PhD ANU

Visiting Fellows

Graham Atkins, RSPHysSE, ANU

Robbie Charters, RPO Pty Ltd

Ben Cornish, RSPHysSE, ANU

Eugene Gamaly, RSPHysSE, ANU

Graham Gordon, RSPHysSE, ANU

Mark Humphrey, RSC, ANU

Dax Kukulj, RPO Pty Ltd

David Pulford, DSTO

Head Technical Officer

Ian McRae

Senior Technical Officers

Craig Macleod, AssocDipMechEng CIT

Mike Pennington, AssocDipAppSci&Inst CIT

Anita Smith, BSc Flinders

Technical Officers

John Bottega

Maryla Krolikowska

Departmental Administrator

Belinda Barbour (part-time)

Publications

Legend: * *External to the University*

Member of another area of this University other than this School

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Nonlinear Physics Centre

The Nonlinear Physics Centre is one of the most active and productive research teams in the School engaged into interdisciplinary (theoretical and experimental) research that covers a number of diverse topics.

Currently, the Centre's structure is defined by the following four major research directions and activities.

Experimental Nonlinear Photonics (Group leader: Dr Dragomir Neshev)

The research topics of this Group include the experimental study of linear and nonlinear optical properties of integrated and optically-induced photonic structures including waveguide arrays, photonic lattices, photonic crystals; optics of polychromatic and white light, nonlinear patterns and self-focusing in gases; singular optics and vortices.

Theoretical Nonlinear Photonics (Group leader: Dr Andrey Sukhorukov)

The activity of this Group is based on our deep expertise in the study of nonlinear waves and solitons, and currently it involves the development of theoretical models and numerical simulations of light propagation in nonlinear photonic structures with close collaboration with the experimental group (e.g. 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.

Nonlinear Matter Waves and Quantum-atom Optics (Group leader: Dr Elena Ostrovskaya)

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

Composite Structures and Metamaterials (Group leader: Dr Ilya Shadrivov)

This is a new and very successful 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 of the targets 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.

Research highlights for 2005 include a number of important theoretical and experimental results, presented in many research publications including four papers in Physical Review Letters, the top-ranked journal in physics. The most remarkable results include the prediction of a novel type of self-trapped states of matter waves in

Bose-Einstein condensates (Alexander and Ostrovskaya); the first experimental generation of the reduced-symmetry photonic gap solitons in optically-induced lattices (Fischer, Neshev and Sukhorukov); the first observation of Bloch oscillations and Zener tunneling in two-dimensional photonic lattices (Fischer, Krolikowski and Neshev), the prediction of a number of novel nonlinear effects in left-handed metamaterials (Shadrivov); the analysis of nonlinear resonant Fano effects (Miroshnichenko) and beaming effect in photonic crystals (Morrison); and the experimental demonstrations of interesting properties of defocusing nonlinear waveguides (Rosberg and Neshev), performed in collaboration with the Group of Professor W. Krolikowski from the Laser Physics Centre. Added to our important milestones for 2005 was the publication of the Russian edition of the book on optical solitons (Kivshar) and the publication of two comprehensive review papers in the famous book series "Progress in Optics", on optical vortices and vortex solitons (Desyatnikov, Torner and Kivshar) and multi-step parametric interactions in nonlinear optics (Saltiel, Sukhorukov and Kivshar).

The Centre continues to play an important role in the two Centre's of Excellence funded by the Australian Research Council announced at the end of 2002, namely 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). In view of our earlier success with ARC funding, we have a limited ability to attract additional funding from the ARC. Nevertheless, Dr Tristram Alexander received one of the highly-competitive Australian Postdoctoral Fellowship grants in 2005.

Staff List

Professor and Head of Department

Yuri Kivshar, PhD Kharkov UKR, FAIP, FOSA, FAA (ARC Federation Fellowship)

Professor

Alexander Zharov, PhD, DSc Nizhny Novgorod (September to December)

Senior Fellow

Miklos Gulacsi BSc MSc Cluj, PhM PhD Trieste (from December)

Research Fellows

Anton Desyatnikov, BSc MScPhD Moscow

Michael Feise, MSc PhD Pullman (until January)

Maxim Gorkunov, PhD Moscow TU (July to August)

Dragomir Neshev, MSc PhD Sofia, BG (ARC Research Fellowship)

Elena Ostrovskaya, MSc Moscow, PhD ANU (ARC Postdoctoral Fellowship)

Vladlen Shvedov, PhD Taureda V Vernadsky (April to July)

Andrey Sukhorukov, BSc Moscow, PhD ANU

Postdoctoral Fellows

Tristram Alexander, BSc Darwin, PhD ANU

Chaohong Li, PhD China

Andrey Miroshnichenko, PhD Dresden
Ilya Shadrivov, MSc Nizhny Novgorod, PhD ANU

Visiting Fellows

Jim Bashford, University of Tasmania (January to February)
Evgueny Doktorov, Stepanov Institute of Physics, Belarus (February to May)
Alexei Efros, University of Utah, USA (October to November)
Sergey Gredeskul, Ben-Gurion University, Israel (August)
Sergei Kun, ANU
Humberto Michinel, University of Vigo, Spain (July to August)
Alexander Reznik, Nizhny Novgorod, Russia (October to November)
Maria Rodas-Verde, University of Vigo, Spain (July to August)
Mark Saffmann, University of Wisconsin, USA (October to December)
Alexander Volyar, Tavrida National University, Crimea (April)
Herbert Winful, University of Michigan, USA (April)
Nina Zharova, Nizhny Novgorod, Russia (September to December)

Research Assistant

Robert Fischer, MSc Darmstadt

Departmental Administrator

Wendy Quinn, BA

Publications

Legend: * *External to the University*
Member of another area of this University other than this School

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Nuclear Physics

The Department had a productive year in terms of both the research carried out by staff and in the development and operation of the Heavy Ion Accelerator Facility which provides a broad range of energetic ion beams for research ranging from applications in materials science to basic studies of nuclear structure and nuclear reactions. It is the main laboratory in Australia for accelerator-based research and training in nuclear physics.

This year approximately 51 papers were published in major peer-reviewed journals by department staff, many in conjunction with international collaborators. About 20 invited papers were delivered at international meetings and there were numerous contributions to international and national conferences and workshops.

In the area of development and applications of accelerator mass spectrometry (AMS), significant advances were made in developing the heavy nuclides Pu-239 and U-236 as tracers for various studies, funded partly through an Australian Research Council (ARC) Discovery grant. First applications include studies of water-borne sediment transportation into the Great Barrier Reef Lagoon to differentiate between natural processes and those caused by human land-use practices. At another extreme, Hf-182 is being developed as an AMS isotope for sensitive measurements of Hf-182/Hf-180 ratios which has potential as a signature of supernova explosions.

The ARC LIEF funded project to develop a new generation ultra-sensitive radio-carbon system for research on climate, natural resources and ecosystems is making good progress with delivery of the system, to be installed in the Research School of Earth Sciences under a collaborative arrangement involving the ANU as well as other universities and institutions, expected in mid-2006.

Dr Nanda Dasgupta and Professor David Hinde of the Fission-fusion Group were again successful with the ARC Discovery program, winning support for a project with international partners, to develop a new experimental approach aimed at the study of superheavy elements. The main focus of the Group this year has been the development of a range of instrumentation including a new detector array for sub-barrier heavy-ion break-up measurements, and a novel rotating catcher-foil system that will be used on both the local facilities and at several radioactive-ion beam facilities overseas. Considerable progress has also been made on the full development and implementation of the superconducting solenoid – SOLITAIRE – for fusion studies, with extensive testing and modeling completed, as well as the first full measurement of a fusion excitation function.

The Spectroscopy Group also hopes to use SOLITAIRE as a transport device for the study of the nuclear structure of neutron-deficient nuclei in a project which has been partially funded by the ARC and also supported through the ANU Major Equipment Committee with equipment funds for 2005 (Lane, Dracoulis and Kibédi). Tests have been carried out by the Fission-fusion Group and members of the Spectroscopy Group, particularly Dr Paivi Nieminen, Dr Greg Lane and Dr Tibor Kibédi, to optimise the arrangement of the device and to identify the parameters needed to produce a compact

image at the focal plane which will determine the physical constraints on the gamma-ray and electron detectors to be installed.

As well as the studies of neutron-deficient nuclei, significant progress continues to be made by the Spectroscopy Group on the discovery and characterisation of isomeric states in deformed nuclei near to, and to the neutron-rich side of stability, drawing on the extensive data sets obtained with Gammasphere at Argonne National Laboratory in 2003 and 2004. A new Gammasphere proposal to extend these studies to the edge of the deformed region was developed and approved. The new experiments will be carried out in 2006.

Other experiments which involve complementary studies on the local facilities and exploit the capabilities of overseas accelerators include a new generation of magnetic moment measurements on exotic radioactive ions, led by Dr Andrew Stuchbery. The first results of these, on the unexpected properties of the neutron-rich isotopes S-38 and S-40, have been published, while on the local scene, the low-temperature stage of the new Hyperfine Spectrometer has been commissioned and used in experiments probing the origins of the transient magnetic fields in various hosts.

In the public arena, Professor George Dracoulis delivered a lecture to the Victorian Branch of the Australian Institute of Physics on the occasion of the presentation of the 2004 Walter Boas medal and Professor Aidan Byrne contributed to the growing nuclear debate on various occasions, including at the 2005 Science Festival. New honours this year include the Vice-Chancellor's Award for Excellence in Innovation and Service Quality presented to the National Heavy Ion Accelerator Facility Team at the awards ceremony in November 2005, and the announcement of the award of the 2006 Pawsey Medal of the Australian Academy of Science to Nanda Dasgupta for her contributions to the understanding of nuclear fusion.

Staff List

Professor and Head of Department

George Dracoulis, BSc PhD Melb, FAIP, FAPS, Hon. FRSNZ, FAA

Professors

Aidan Byrne, MSc Auck, PhD ANU, FAIP (jointly with Department of Physics, The Faculties)

Keith Fifield, MSc Auck, PhD Penn, FAIP

David Hinde, BSc Manc, PhD ANU, FAIP, FInstP

Senior Fellows

Mahananda Dasgupta, BSc MSc Rajasthan, PhD Bombay, FAIP

Tezer Esat, MSc Queens, PhD ANU (jointly with Research School of Earth Sciences)

Andrew Stuchbery, BSc PhD Melb, FAIP

Fellows

Tibor Kibédi, PhD Debrecen

Greg Lane, BSc PhD ANU (ARC Fellowship)

Anna Wilson, BSc Bristol, PhD Liverpool (jointly with Department of Physics, The Faculties)

Research Fellows

Timothy Barrows, BSc, PhD ANU (ARC Fellowship)

Alexis Diaz-Torres BSc MSc Havana, PhD Giessen (from September)

Clyde Morton, BSc Sydney, PhD ANU

Stephen Tims, BSc PhD Melb

Ricardo Yanez, BSc PhD Uppsala (until April)

Postdoctoral Fellows

Bertrand Bouriquet, PhD Caen (until October)

Rakesh Dogra, PhD Chandigarh, (jointly with Electronic Materials and Engineering)

Paivi Nieminen, Msc PhD Jyväskylä

Hiroshi Watanabe, BSc PhD Kyushu

Visiting Fellows

Jorge Fernández Niello, Comisión Nacional De Energía Atómica, Argentina (until January)

Karl-Hugo Maier, Berlin, Germany (until January, from November)

John Newton, FAA, ANU (Emeritus Professor)

Heiko Timmers, ADFA, UNSW (jointly with Electronic Materials and Engineering)

Wolf-Dietrich Zeitz, Hahn-Meitner-Institut Berlin, Germany (until February)

Accelerator Research and Operations Manager

David Weisser, MSc, PhD Minn, FAIP

Engineer

Nikolai Lobanov, BSc Moscow, PhD St Petersburg

Research Officers

Paul Davidson, BSc, MSc Auckland, PhD ANU

Gordon Foote, BSc Lond, PhD ANU

Vladimir Levchenko, MSc PhD St Petersburg (until July)

Technical Officers

John Bockwinkel, AssocDipMechEng

Alan Cooper, AssocDipMechEng

Alan Harding

Justin Heighway, AssocDipAppSci

John Kennedy

Lorenzo Lariosa

Matthew Lenahan (from January)

Alistair Muirhead

Mark Paddick (January to March)

Andrew Rawlinson (until May)

Bob Turkentine
Howard Wallace

Departmental Administrator
Marj O'Neill

Publications

Legend: * *External to the University*
Member of another area of this University other than this School

Books and Book Chapters

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COMMAD 04, Brisbane (2005) 1097-2137

Optical Sciences Group

The Group's main research interests relate to non-linear and linear propagation problems within the general area of guided wave photonics.

On the theoretical side a new comprehensive book on "Dissipative Solitons" with contributions from world leaders in the area was edited by Professor Nail Akhmediev and Dr Adrian Ankiewicz and published by Springer in 2005. Modelling is developing new applications for holey fibres in high-resolution microscopy, for the application of few-mode fibres to optical transmission systems and providing further insight into bend loss mechanisms in fibres.

On the experimental side work has focused on the fabrication of thin silica films in collaboration with Plasma Research Laboratory for application to microelectronic devices and for second harmonic generation in waveguides. Other experiments relate to tapered fibres for high-intensity source application and to bent fibres to complement the theoretical work.

The Group also organises and provides major support through lectures and demonstrating for teaching guided wave photonics in six courses at the undergraduate and masters levels in the Department of Physics and the Department of Engineering in the Faculties and for the ANU Master of Contemporary Science distance education degree.

Staff List

Professors

John Love, MA Camb, MA DPhil DSc Oxf
Nail Akhmediev, MS PhD DSc Moscow, FOSA

Fellow

Adrian Ankiewicz, BSc BE UNSW, PhD ANU

Research Fellow

Douglas Bulla, PhD Sao Paulo

Postdoctoral Fellow

Céline Durniak, PhD Lille

Research Assistant

Wonk Keun Chang, MSc Auckland (from August)

Visiting Fellow

Andrew Stevenson, ANU

Departmental Administrator

Trina Merrell (part time)

Publications

Legend: * *External to the University*

Member of another area of this University other than this School

Books and Book Chapters

Akhmediev, N.N. and Ankiewicz, A.

Dissipative Solitons in the Complex Ginzburg-Landau and Swift Hohenberg Equations
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PLASMA RESEARCH LABORATORY

TOROIDAL PLASMA GROUP

The Toroidal Plasma Group studies basic phenomena in magnetically confined plasma, and a variety of related and complementary areas: advanced imaging and remote measurement systems; fluid dynamics and turbulence; and electromagnetics, in particular, the application to wireless communications (BushLAN). The Group operates the National Plasma Fusion Research Facility centred around the H-1 heliac, an innovative plasma confinement device with flexible geometry that allows exploration of basic plasma physics, and advanced concepts ultimately for improved design of fusion power stations.

In 2005 the contract with the Commonwealth for operation of the National Facility was extended until 2010, marking a transition from parallel efforts of construction, commissioning and operation to a more efficient, largely automated mode of operation in support of research. Concurrently, the staff profile of the Group was restructured to match the increased emphasis on operation and on the research pursuits below. Dr Horst Punzmann joined the Group as Research Engineer and Facility Manager, and Dr Boyd Blackwell became Head of the Group and Director of the Facility, replacing Professor Jeffrey Harris who was invited to take up the position of Distinguished Scientist at the Oak Ridge National Laboratory.

Supported by an Australian Research Council (ARC) Discovery grant to commence in 2006, and in collaboration with researchers at Chalmers University in Sweden, the Advanced Imaging and Inverse Methods Group led by Dr John Howard has this year expanded its activities to commence research into the development of a radar backscatter system and associated inverse techniques for microwave imaging of human tissue. The Group maintains a strong interest in the physics of high temperature plasma in the H-1 heliac with three postgraduate students and a number of honours scholars. A spinoff from this work, the advanced 4-quadrant coherence imager was this year supplied under contract to the Korean Basic Science Institute for fast, high-spectral-resolution imaging on the KSTAR superconducting tokamak. With funding support from Bluescope Steel, our recently patented coherence-pyrometry systems are also scheduled for extensive field testing in early 2006.

The Turbulence and Transport Studies Group led by Dr Michael Shats has made remarkable progress in understanding the role of the turbulence generated flows in plasma confinement. Also a new research direction has emerged in 2005: interdisciplinary studies of quasi-two-dimensional turbulence in plasma and fluids. These studies have led to the discovery of the universality of self-organisation of turbulence in plasma and fluids. The results of this work have been published in 2005 and open new opportunities in this direction. Among other highlights of the Turbulence Group are studies of the spectral transfer in plasma turbulence (Xia) and of the mechanisms of transport barrier formation (Punzmann).

Through an ARC Linkage Project grant with Standard Communications of Sydney, the BushLAN team, led by Dr Gerard Borg, is developing a wireless broadband modem for use in the UHF TV bands in remote areas. Specifications are complete and we are currently developing the system for deployment on Optus' network. The project involves two PhD, one MPhil and two Honours students. Future directions for BushLAN involve the Faculty of Engineering and Information Technology where courses are being delivered in Telecommunication Systems and Radio Engineering.

The Plasma Configurations Group has identified a range of Alfvén instabilities in the H-1 plasma, by use of an innovative data mining technique. The wide range of magnetic configurations and the precise computer control of H-1 make it uniquely suitable for fundamental studies of these instabilities, the understanding of which is crucial to the success of future large experiments, such as the International Thermonuclear Experimental Reactor (ITER). As part of a cross-campus and international collaboration, application of this technique to related phenomena in the Heliotron-J device at Kyoto University has begun. The H-1 magnetic surfaces were mapped in the highest detail so far, leading to an improved magnetic model, in preparation for a study of the effect of magnetic islands on plasma in H-1.

Staff List

Professor and Head of Department

Jeffrey Harris, MS MIT, PhD Wisc, FAPS, FAIP (until July)

Head, Toroidal Group

Boyd Blackwell, BSc PhD Syd (from August)

Senior Fellows

John Howard, BSc PhD Syd

Michael Shats, MSc Kiev Poly Inst, PhD Gen Phys Inst Mosc

Fellow

Gerard Borg, BSc PhD Syd

Research Engineer and H-1NF Facility Manager

Horst Punzmann, BSc Regensburg, PhD ANU (from December)

Adjunct Fellows

Scott Collis, BSc Syd

Benjamin Powell, BSc BLM CQU

Horst Punzmann, BSc Regensburg, PhD ANU (until November)

Hua Xia, Msc Chongqing

Visiting Fellows

Joe Baker, OBE, FTSE, ANU

Marcela Bilek, University of Sydney

Andrew Cheetham, ANU

Roger Gammon, FinstP, Cphys, MIE Aust, CP Eng, FAIE, FAIM, ANU
Sydney Hamberger, FAIP (Emeritus Professor), ANU
Dennis Mather, AINSE
John O'Connor, University of Newcastle
Anthony Sproule, Connell Wagner PPI
Robin G. Storer, Flinder's University
Masayuki Yokoyama, National Institute for Fusion Science, Japan

Head Technical Officer

Clinton Davies (until November)

Senior Technical Officers

Ray Kimlin (until July)
John Wach, BAppSci CAE Ball, GradDipEl CCAE

Technical Officers

Ian McRobert
Costanzo Costa

Departmental Administrator

Helen Hawes, BA

Publications

Legend: * *External to the University*
Member of another area of this University other than this School

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Time Resolved Coherence Imaging Spectrometer on WEGA Stellarator
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Nuclear Fusion **45** (2005) 595-607

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Visible Emission Tomography in the H-1NF Helic

IEEE Transactions on Plasma Science **33** (2005) 472-473

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Physics of Plasmas **12** (2005) 056119-1-11

Shats, M.G., Xia, H. and Punzmann, H.

Spectral Condensation of Turbulence in Plasmas and Fluids and its Role in Low-to-high Phase Transitions in Toroidal Plasma

Physical Review E (Statistical, Nonlinear and Soft Matter Physics) **71** (2005) 046409-1-9

Yamada, Y.* , Harris, J.H., Dinklage, A.* , Ascasibar, E.* , Sano, F.* , Okamura, S.* , Talmadge, J.* , Stroth, U.* , Kus, A.* , Murakami, S.* , Yokoyama, M.* , Beidler, C.D.* , Tribaldos, V.* , Watanabe, K.Y.* and Suzuki, Y.*

Characterization of Energy Confinement in Net-current Free Plasmas Using the Extended International Stellarator Database

Nuclear Fusion **45** (2005) 1684-1693

SP3 GROUP

The SP3 Group is lead by Professor Rod Boswell and Dr Christine Charles and conducts work on both basic and applied plasma physics. The recent discovery of current free double layers has lead to an invitation from the European Space Agency and a DEST contract with the CRC for Satellite Systems and AUSPACE Pty Ltd to construct a space thruster prototype which was tested in the European Space Agency Technology Division (ESTEC) in April 2005. This test campaign was successful and led to the discovery of a new high density mode of operation allowing the possibility of greater thrust. The thruster is now back in our laboratories and two students are presently working on the Helicon Double Layer Thruster (HDLT) in our own small space simulation chamber to optimise performance and measure the thrust.

During the wrap up of the test program in ESTEC, a new gridded ion thruster was discussed, and in June negotiations commenced on the design and fabrication of the dual stage thruster using an rf plasma source, similar to our focussed ion beam source. The contract was awarded and the ion thruster was designed and built from scratch by a small team in the short time of 3 months. The test campaign in ESTEC in November was extraordinarily successful with the thruster being run up to 30kV with an ion current of 10 mA. An extension to this contract has been agreed upon for improved beam optics, with the prototype to be delivered to ESTEC for a test campaign in May 2006.

We have a major program to simulate and model the double layer phenomena observed in the laboratory. Computer simulation using millions of particles shows the dynamics of the plasma and allows us to determine fundamental processes associated with the thruster. Analytical modelling allows more dimensions to be considered and is useful for discovering the basic physics underlying the plasma phenomena. Applied space plasma thruster work includes plasma detachment from spacecraft which allows us to find the best conditions to prevent the plasma ion beam from returning and consequently not generating any thrust.

Nano-fabrication in the laboratory is based on optimisation of our bright plasma source for FEI Company in the USA, and is proceeding well with two post doctoral fellows being employed on the project for the majority of the year. Previous focussed ion beams use metal ions which can change the properties of the nano-structures being machined whereas our source uses inert gas ions. Present measurements show that it is many times brighter than presently available sources and FEI Company have decided to move the source into commercialisation. We are presently investigating different size sources and their stability under high voltage and rf fields.

After a number of years of fruitful collaboration with the University of Orleans, France, we were successful in obtaining funding until 2009 from the Australian Research Council to pursue our own fuel cell development program. There are two post doctoral fellows and two students working on the sputter deposition of platinum onto carbon electrodes, testing of membrane electrode assemblies (MEAs) using Nafion membranes and the development of a completely new plasma deposition system for methyl insensitive membranes which will allow methanol to be used as a fuel instead of hydrogen. The work on the electrodes is progressing along with diagnostics such as Rutherford Backscattering Spectrometry (RBS) for depth analysis and the testing station is complete.

We also have a hot press so we can fabricate MEAs. A new deposition system for growing nanotubes and co-sputtering catalyst is nearing completion. This will allow a greater flow of gas through the gas diffusion layer/electrode while have an adequate supply of catalyst distributed through the film.

We are developing outreach programs with the ACT Government for showcasing hydrogen economy systems to schools and colleges to commence later in 2006. As part of increasing the public profile of fuel cells and non-pollute commute we intend to actively push for permission to run Neighbourhood Electric Vehicles on roads or perhaps cycle tracks as is done in the European Union. We wish to add fuel cells to these cars and bikes (trikes) in a push to really demonstrate that there is an alternative to hydrocarbon fuelled vehicles.

The work on non-linear properties of optical thin films we deposit is continuing and has given birth to a discovery that the deposition system is also very good for the growth of nanotubes and fibres. These have many application and we are actively pursuing this new avenue of research. A new model of deposition and stress growth has been developed for very thin films as they move from 2D to 3D growth. This has lead to the development of an *in situ* method of measuring stress which can be applied to most thin films being grown.

Our expertise in plasma modification of surfaces is being used to functionalise both hard and soft (polymer) surfaces. Primarily this devolves about changing the hydrophobicity (wetting property) of the surface as antibodies and protein attachment to these substrates and be controlled. In protein mobility studies we are developing a very small sample plate for large population sampling in collaboration with the University of Sydney.

In order to be able to modify the properties of surfaces in the most effective way possible for industrial applications, an atmospheric pressure plasma system has been developed and is yielding very good results: filamentary discharges can be eliminated and replaced by uniform glow discharges, which, when pulsed have been successfully used to reduce the hydrophobicity of plastic surfaces for some days.

Application of our results to solar and space physics is very successful with a new mechanism for the genesis and ion heating of the solar wind being proposed.

Staff List

Professor and Head of Group

Roderick Boswell, BSc Adel, PhD Flin, FAPS, FATS

Senior Fellow

Christine Charles, Ingénieur INSA Rennes, PhD Orléans

Post-doctoral Fellows

Ane Aanesland, MSc PhD, Tromso

Douglas Bulla, MSc PhD USP Brazil (jointly with Optical Sciences Group)

Orson Sutherland, BE, PhD ANU

Wei Tang Li, MSc China, PhD Syd

Visiting Fellows

Mike Lieberman, University of California at Berkeley, USA (from December)

Senior Technical Officer

Peter Alexander

Departmental Administrator

Helen Hawes, BA

Publications

Legend: * *External to the University*

Member of another area of this University other than this School

Aanesland, A., Charles, C., Boswell, R.W. and Frederiksen, A.*
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Department of Theoretical Physics

The Department of Theoretical Physics is one of the University's oldest departments. During 2005 the Department was restructured to better reflect its main research activities. The core research areas are plasmas and fluids, condensed matter physics, mathematical physics and biophysics. The Department also undertakes research in atomic and molecular physics through joint appointments with the Atomic and Molecular Physics Laboratories.

Research highlights for 2005 include fundamental new results for: conduction mechanisms in ion channels; quantum point contacts and mesoscopic transport; T-duality, the eight-vertex model; mixed boson-fermion gases; the Bazhanov-Stroganov model; the extended Falicov-Kimball model and the development of a new approach to the 50-year-old problem of the existence of three-dimensional plasma equilibria within the framework of ideal magnetohydrodynamics.

Staff highlights for 2005 include the promotion of Dr Rowena Ball and Dr Sergei Sergeev to Level C. Professor Peter Bouwknegt, along with a number of his students, joined the Department from the University of Adelaide as a joint appointment with the Department of Mathematics (MSI). Peter is a world leader in string theory and related mathematics.

On 29th September the Hon Gary Nairn MP officially launched the ANU Educational Research Initiative in Mathematical Physics. This initiative has received on-going funding from the Vice-Chancellor to enhance the training of students in theoretical and mathematical physics. Members of the Department continued their active involvement in undergraduate teaching in both the Physics and Mathematics Departments in the Faculties. They also continued their significant role in the PhB program through providing research projects and student mentoring.

In December Dr Matthew Hole appeared before the House of Representatives Standing Committee on Industry and Resources as a representative of the Australian International Thermonuclear Experimental Reactor (ITER) Forum, presenting the case for Australian participation in the next step fusion energy project, the world's largest science project.

The Department continued its strong success in competitive funding, with over \$1M held in external grants and fellowships for 2005. New Australian Research Council Discovery grants awarded from 2006 include "The Mathematical Analysis of Ultra-cold Quantum Gases" by Professor Murray Batchelor and Professor Vladimir Bazhanov with colleagues at The University of Queensland.

The Department is host to the Centre for Complex Systems (CCS). The Centre's activities are highlighted elsewhere.

Staff List

Professors and Head of Department

Murray Batchelor, BSc (Hons) UNSW, PhD ANU, FAIP, FAustMS, FInstP, (ARC Fellowship) (jointly with Mathematical Science Institute) (from June)

Vladimir Bazhanov, PhD Serpukhov (until May)

Professors

Vladimir Bazhanov, PhD Serpukhov

Peter Bouwknegt, BSc MSc Utrecht, PhD Amsterdam, FAIP, FAustMs (jointly with Mathematical Science Institute)

Robert Dewar, MSc Melb, PhD Princ, FAIP, FAPS, FAA

Senior Fellows

Shin-Ho Chung, BSc Stanford, PhD Harv

Mukunda Das, MSc Utkal, PhD Roorkee, FAIP, CPhys.FInstP

Miklos Gulacsi, BSc MSc Cluj, PhM PhD Trieste (until December)

Anatoli Kheifets, Msc PhD St Petersburg (jointly with Atomic and Molecular Physics Laboratories)

Fellows

Vladimir Mangazeev, MSc Moscow, PhD Serpukhov

Sergei Sergeev, MSc Moscow, PhD Serpukhov, 2nd PhD St Petersburg

Wen Xu, BSc MSc PhD Antwerp

Research Fellows

Rowena Ball, BSc PhD Macquarie (ARC Fellowship)

Xi-Wen Guan, BSc Qufu, MSc Sichuan, PhD Jilin (jointly with Mathematical Science Institute)

Post-Doctoral Fellows

Alex Flournoy, PhD Boulder (from April)

Matthew Hole, BSc BE PhD Sydney

Matthew Hoyles, BSc PhD ANU

Igor Ivanov, BSc Moscow IPT, PhD RAS

Ryusuke Numata, BSc MSc PhD UTokyo

Megan O'Mara, BAsC UCan, PhD ANU (until September)

ARC Linkage International Fellow

Benedicte Ponsot, MIP Paris6-Ulm, PhD Montpellier 2 (until May)

Visiting Fellows

Fred Barker, (Emeritus Professor), ANU

Michael Bortz, Bergische Universität Wuppertal, Germany (from April)

Kevin Bryant, ANU (until October)

Jorgen Frederiksen, CSIRO Atmospheric Research

Michael Hall, ANU

Nicholas Halmagyi, University of Southern California, USA (May to June)
Brian Kenny, FAIP, ANU
Sang-Hoon Kim, Mokpo National Maritime University, Korea (from July)
Kailash Kumar, FAIP, ANU
Sergei Kun, ANU (jointly with Nonlinear Physics Centre)
Xi Li, Fudan University, China (until February)
David Ridout, La Trobe University (July to August)
Brian Robson, FAIP, ANU
Robert Robson, FRMS, FAPS, FAIP (jointly with Atomic and Molecular Physics Laboratories)
Hisham Sati, ANU
Susan Scott, ANU
Andrew Stewart, FAIP, FInstP, ANU
Irina Talanina, ANU (until May)
Lindsay Tassie, FAIP, ANU
Zengo Tsuboi, University of Tokyo, Japan (November to December)
William Woolcock, FAIP, ANU
Eui-Soon Yim, Semyung University Chechon, Korea (from February)

Departmental Administrator

Mrs Trina Merrell (part time)

Publications

Legend: * *External to the University*
Member of another area of this University other than this School

Books and Book Chapters

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Stability for Kinetic Ballooning Modes in Stellarators

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Stewart, A.M.

Orbital and Spin Components of the Angular Momentum of a General Electromagnetic Field

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