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WELCOME TO THE SCHOOL OF CHEMICAL AND PHYSICAL SCIENCES

Welcome to the School of Chemical and Physical Sciences at Victoria University. Chemistry and physics are the sciences that form the basis of much of our technological society, and they also underpin other branches of science, including geology and biological sciences. This booklet provides you with information on the research interests of the staff, the collaborations and networks that link us to the rest of the scientific world, the facilities available for research, and the research degrees that the University offers through the School. The research interests of the staff, as the following pages reveal, cover a wide spectrum of chemistry and physics, ranging from new materials and nanotechnology and the discovery of bioactive natural products from New Zealand marine organisms through to theoretical physics, astrophysics and geophysics. New areas of research recently established are in the conservation of heritage materials and alternative energy. Particular strengths of the School, which draw on both chemistry and physics, are materials science and nanotechnology.

Our School offers an outstanding graduate programme. We have a multinational group of motivated young scientists engaged in research that ranges across chemistry, physics, and nanotechnology. The School hosts the MacDiarmid Institute for Advanced Materials and Nanotechnology, which is named after VUW chemistry graduate Professor Alan MacDiarmid, co-winner of the Nobel Prize in Chemistry for 2000 for the discovery and development of conducting polymers. The Institute is one of the New Zealand Centres of Research Excellence and the only one covering chemistry, physics and materials science. The School also has excellent links with the School of Biological Sciences, the Centre for Biodiscovery and the Malaghan Institute for Medical Research, with joint research programmes in the discovery and evaluation of new bioactive compounds for the treatment of disease.

The School is housed in the Laby Building on the Kelburn Campus, and also occupies specialized new laboratories in the adjoining Alan MacDiarmid Building. Other new laboratories, including a fully equipped clean room, are located in an annex to the Laby Building and in the Central Services Building (CSB). The new laboratories reflect the expansion of our postgraduate numbers and Victoria University's commitment to developing scientific research. They have been built to the highest specification and are fully equipped with modern facilities and equipment. Special care has been taken to incorporate full office facilities for postgraduate students.

Victoria University is situated close to the centre of Wellington, the political, cultural and intellectual capital of New Zealand. The School enjoys good relationships and numerous collaborations with the Crown Research Institutes and other research organizations that are located in the Greater Wellington region. These relationships can offer research students access to a wide range of instrumentation and expertise, and there are also opportunities for students to conduct much of their research in close collaboration with scientists in external organizations while enrolled and supervised through Victoria University.

The School offers a number of postgraduate qualifications to suit the objectives and backgrounds of prospective students, including BSc Honours, MSc, and PhD. I hope you will find this booklet helpful. Please contact the School if you would like further information.

We look forward to helping you develop your career in science.

John Spencer, Head of School,
Chemical and Physical Sciences



School of Chemical and Physical Sciences Te Wānanga Matū

Location: Laby Building (unless otherwise stated)
 Phone: 04-463 5335
 Fax: 04-463 5237
 Email: scps@vuw.ac.nz
 Website: www.victoria.ac.nz/scps

STAFF CONTACTS

| | | | |
|--|--|-------------|------------------------|
| Head of School: | Prof John Spencer john.spencer@vuw.ac.nz | 406a | 463 5119 |
| Deputy Head of School: | Prof Denis Sullivan denis.sullivan@vuw.ac.nz | 501 | 463 5962 |
| Manager, School Administration: | Kara Eaton kara.eaton@vuw.ac.nz | 406 | 463 5946 0275645946 |
| General Enquiries: | Helen Rowley scps@vuw.ac.nz | 101 | 463 5335 |
| Chemistry Enquiries: | | | |
| BSc (Hons) & MSc Part 1 | Dr Joanne Harvey | AM207 | 463 5956 |
| MSc / PhD | Assoc Prof Richard Tilley | 006 | 463 5016 |
| Physics Enquiries: | | | |
| BSc (Hons) | Prof Pablo Etchegoin | 204 | 463 5233 |
| MSc / PhD | Prof Alan Kaiser | 508 | 463 5955 |
| Laboratory Operations Manager: | Dr Gordon Heeley | 104 | 463 5955 0211301592 |
| ACADEMIC STAFF | RESEARCH AREAS | ROOM | CONTACT |
| CHEMISTRY | | | |
| Professors: | | | |
| James Johnston | Applied chemistry; new materials, nano-structured and nano-hybrid materials, new products and technology development and commercialisation | 303 | 463 5334 |
| Kenneth MacKenzie | Materials chemistry, solid-state NMR spectroscopy of inorganic materials, ecologically-friendly materials | 504 | 463 5885 |
| Kathryn McGrath | Soft matter, biophysical chemistry and materials science | 409 | 463 5963 |
| John Spencer | Organometallic chemistry | 406a | 463 5119 |
| Associate Professors: | | | |
| Martyn Coles | Catalysis, organometallic chemistry, hydrogen-bonded materials | 413 | 463 6357 |

| ACADEMIC STAFF | RESEARCH AREAS | ROOM | CONTACT |
|--|---|-------------|-----------------------|
| Peter Northcote | Natural products, NMR spectroscopy | 412 | 463 5960 |
| Gerald Smith | Photochemistry, protection of materials, heritage science | 522 | 463 5547 |
| Richard Tilley | Nanoparticle research and electron microscopy | 006 | 463 5016 |
| Senior Lecturers: | | | |
| Joanne Harvey | Total synthesis, design and synthesis of natural product analogues, organic reaction methodology | AM207 | 463 5956 |
| Matthias Lein | Computational and Theoretical chemistry | 505 | 463 6926 |
| Mattie Timmer | Immunoglycomics, design and synthesis of glyconjugate probes | 507 | 463 6529 |
| Lecturers: | | | |
| Justin Hodgkiss | Ultrafast laser spectroscopy, conjugated polymers, organic solar cells | AM209 | 463 6983 |
| Robert Keyzers | Natural products, food and wine chemistry, NMR spectroscopy and mass spectrometry | AM208 | 463 5117 |
| Senior Teaching Fellow: | | | |
| Suzanne Boniface | | 514 | 463 6485 |
| Emeritus Professors: | | | |
| Neil Curtis | | 414 | 463 6514 |
| Brian Halton | | 102 | 463 5954 |
| PHYSICS | | | |
| Professors: | | | |
| Sir Paul Callaghan <i>GNZM – Alan MacDiarmid Chair in Physical Sciences</i> | NMR methodologies for molecular dynamics and new NMR technologies | 403 | 463 5945 |
| Pablo Etchegoin | Surface enhanced Raman scattering (SERS) | 204 | 463 5233 ext. 8910 |
| Shaun Hendy | Computational materials science and nanotechnology | 503 | 463 5809 |
| Alan Kaiser | Electronic properties of novel materials, especially nanoscale materials | 508 | 463 5957 |
| John Lekner | Optics, electromagnetism and quantum theory | 513 | 463 5959 |
| Denis Sullivan | Astrophysics: white dwarf stars, extrasolar planets | 501 | 463 5962 |
| Uli Zülicke | Theoretical condensed-matter physics, theory and modelling of functional nanostructures, nano-electronic transport and spin-electronic devices, with applications in quantum information theory | 510 | 463 6851 |

| ACADEMIC STAFF | RESEARCH AREAS | ROOM | CONTACT |
|--------------------------------------|--|-------------|-----------------------|
| Associate Professor: | | | |
| Andy Edgar | Glasses, glass ceramics, radiation imaging and dosimetry | 519 | 463 5949 |
| Senior Lecturers: | | | |
| Michele Governale | Theoretical condensed-matter physics, quantum transport in nanoscale systems | 402 | 463 5951 |
| Malcolm Ingham | Environmental physics, geophysics | 515 | 463 5216 |
| Melanie Johnston-Hollitt | Astrophysics: Radio astronomy, Galaxy clusters and Large-scale structure | 502 | 463 6543 |
| Eric Le Ru | Electromagnetism, fluorescence and Raman spectroscopy | 205 | 463 5233 ext. 7509 |
| Ben Ruck | Experimental condensed matter physics | 506 | 463 5089 |
| Gillian Turner | Geophysics, geomagnetism | 521 | 463 6478 |
| Senior Research Fellow: | | | |
| Petrik Galvosas | | 404 /308 | 463 6062 /5911 |
| Senior Teaching Fellows: | | | |
| John Hannah | | 511 | 463 5223 |
| Howard Lukefahr | | 511 | 463 5223 |
| Professorial Research Fellow: | | | |
| Grant Williams | | AM202 | 463 5544 |
| Emeritus Professor: | | | |
| Joe Trodahl | | 516 | 463 5964 |

IMPORTANT DATES

| | |
|-----------------------|-----------------|
| Trimester 1 commences | 5 Mar |
| Good Friday | 6 Apr |
| Easter Monday | 9 Apr |
| Mid trimester break | 6 Apr – 22 Apr |
| Graduation | 15 – 17 May |
| Queen's Birthday | 4 Jun |
| Examinations | 18 Jun – 4 Jul |
| Mid year break | 5 Jul – 15 Jul |
| Trimester 2 commences | 16 Jul |
| Mid trimester break | 27 Aug – 9 Sep |
| Labour Day | 22 Oct |
| Examinations | 29 Oct – 17 Nov |
| Trimester 3 commences | 19 Nov |
| Graduation | 12 – 13 Dec |

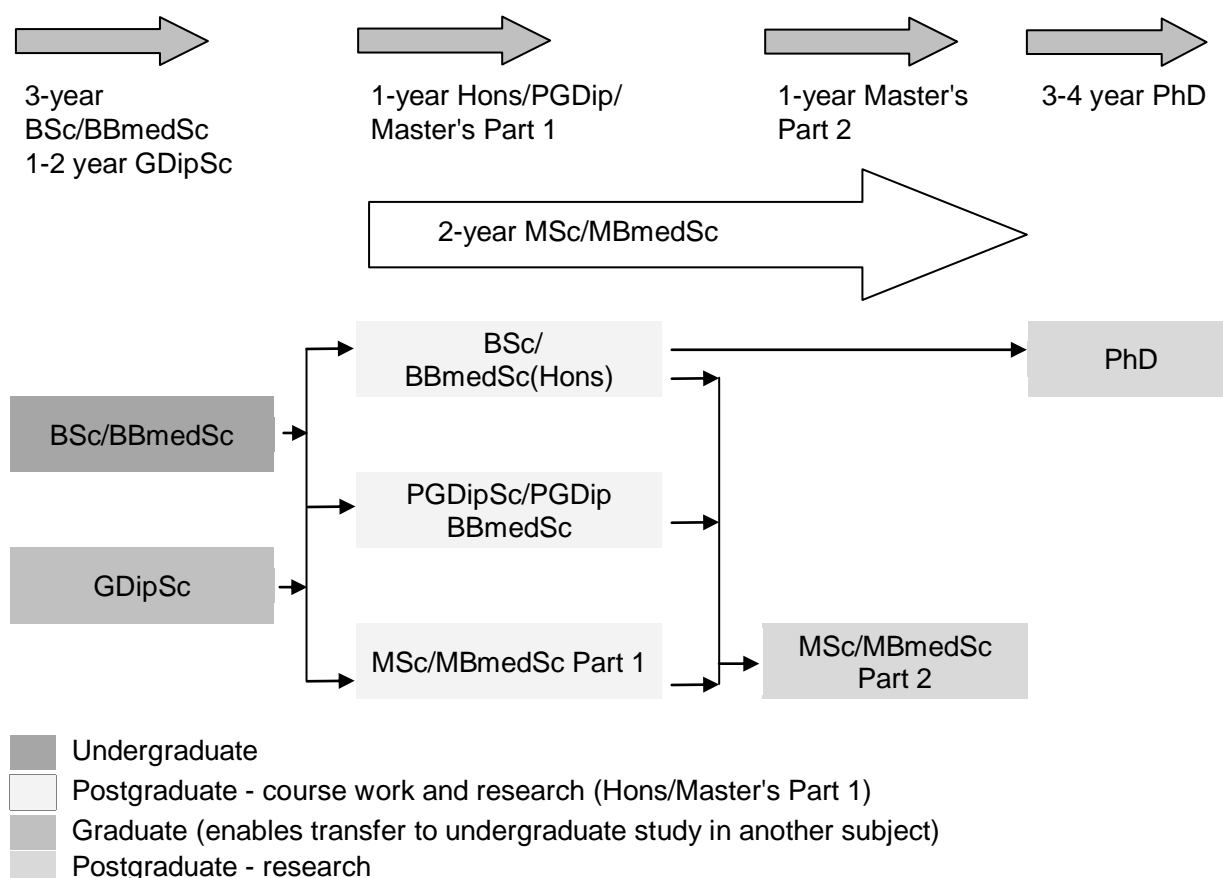
TIMETABLE

The timetable is online at www.victoria.ac.nz/timetables/

QUALIFICATIONS AVAILABLE

Wellington is home to New Zealand's largest science community. Studying at a postgraduate level in SCPS you will get the benefit not only of the international expertise and links of our own teaching staff, but also of our strong interactive with Crown Research Institutes such as Industrial Research, GNS Science and NIWA. Through the MacDiarmid Institute for Advanced Materials and Nanotechnology and other collaborations we also have research associations with the other New Zealand universities and with the Malaghan Institute for Medical Research.

There is a wide range of programmes offered at graduate and postgraduate levels depending on your interests, career focus and academic background. The diagram below represents the structure of postgraduate study in science.



POSTGRADUATE STUDY

Bachelors with Honours degrees: BSc(Hons) in Chemistry or Physics:

- Is 1 year fulltime or up to 2 years part-time with permission
- Has a research project or projects with the balance (67-75%) in taught postgraduate courses
- Usually requires a B+ grade average in related 300-level subjects for admission
- Is awarded with Honours and may allow direct admission to a PhD (Doctorate) degree.

Postgraduate Certificate in Science: PGCertSc in Chemistry, Physics or Heritage Materials:

- Is 1 semester fulltime or up to 2 years part-time
- Usually consists of all course work (60 points) at PG level
- Usually requires a B grade average in related 300-level subjects for admission
- Is endorsed in a subject offered for the MSc degree
- May be converted to a PGDipSc programme with the addition of 60 further approved points

Postgraduate Diploma in Science: PGDipSc in Chemistry, Physics or Heritage Materials:

- Is 1 year fulltime or up to 4 years part-time
- Usually consists of course work and a research project (120 points) at PG (400-level) level
- Usually requires a B grade average in related 300-level subjects for admission
- Is endorsed in a subject offered for the MSc degree
- May permit admission to an MSc by Thesis if achieved at a high academic level

Research Master's Degrees: Master of Science (MSc) in Physics, Chemistry or Heritage Materials:

- Is 2 years fulltime or up to 4 years part-time
- Permits an extension of 6 months with academic support, thus allowing up to 2.5 years fulltime study or 5 years part-time
- Consists of PG course work in the first year and usually includes research preparation
- Allows admission to Part 2 based on academic performance in Part 1 or BSc(Hons)
- Consists of second year involving research and submission of a thesis
- Requires a B+ grade average in related 300-level subjects for admission
- Is awarded with Honours (2 year MSc) or distinction/merit (MSc by Thesis only)

With a Victoria Science postgraduate qualification you will be well equipped with the skills, knowledge and firsthand experience to be successful in science in New Zealand or worldwide.

Check out: www.victoria.ac.nz/science/research

RESEARCH FACILITIES IN THE SCHOOL

To facilitate the School's wide spectrum of chemistry and physics research, we are well equipped with standard and specialised equipment (see pages 59-60).

The School also hosts a glass-blowing facility and electronic & mechanical workshops for customised support of our facilities.

PLANNING A PROGRAMME IN CHEMISTRY

Chemistry is the study of matter in all its many and varied forms. Chemistry is concerned with the synthesis, composition, structure, properties, and reactivity of matter. As such, chemistry intersects with physics and underpins geology and biology.

BSC WITH HONOURS – PROGRAMME & COURSES

The programme leading to an Honours degree in Chemistry is intended to provide candidates with a thorough understanding of the important principles and practices in the subject. The course work is rigorous and the experimental project work (carried out under the supervision and guidance of a member of the academic staff) is demanding. Nevertheless the programme provides a stimulating and enjoyable year.

A total of 120 points are required for Honours, with the standard option being CHEM 421 - 425 together with CHEM 480 (Research Preparation) and CHEM 489 (Research Project). The last is a 30 point two-trimester course, the rest are 15 point courses. Flexibility is provided through CHEM 441 (Directed Individual Study) which is a programme that can be tailored to the requirements of the individual student. All courses have a component of internal assessment, and those lecture courses taught in Trimester 1 are examined mid-year.

COURSE INFORMATION INDEX

| Course code | Course reference number | Title | | Trimester |
|-----------------|-------------------------|---------------------------|------------------|--------------|
| ↓ | ↓ | ↓ | | ↓ |
| CHEM 423 | CRN 13727 | PHYSICAL CHEMISTRY | 15 POINTS | [1/3] |

400-LEVEL COURSES

| | | | | |
|-----------------|------------------|--|------------------|--------------|
| CHEM 421 | CRN 13725 | ORGANIC & BIO-ORGANIC CHEMISTRY | 15 POINTS | [2/3] |
|-----------------|------------------|--|------------------|--------------|

Prerequisite: CHEM 301

An 18 lecture course, with tutorials, covering important aspects of modern organic chemistry and its interface with the bio-sciences.

| | | | | |
|-----------------|------------------|----------------------------|------------------|--------------|
| CHEM 422 | CRN 13726 | INORGANIC CHEMISTRY | 15 POINTS | [1/3] |
|-----------------|------------------|----------------------------|------------------|--------------|

Prerequisite: CHEM 302

An 18 lecture course, with tutorials, covering key areas of modern inorganic and organometallic chemistry.

| | | | | |
|-----------------|------------------|---------------------------|------------------|--------------|
| CHEM 423 | CRN 13727 | PHYSICAL CHEMISTRY | 15 POINTS | [1/3] |
|-----------------|------------------|---------------------------|------------------|--------------|

Prerequisite: CHEM 303

An 18 lecture course, with tutorials, covering advanced aspects of physical and materials chemistry.

| | | | | |
|-----------------|------------------|--|------------------|--------------|
| CHEM 424 | CRN 13728 | ADVANCED ASPECTS OF CHEMISTRY A | 15 POINTS | [1/3] |
|-----------------|------------------|--|------------------|--------------|

Students select from topics offered by research staff covering a range of chemistry.

| | | | | |
|-----------------|------------------|--|------------------|--------------|
| CHEM 425 | CRN 13729 | ADVANCED ASPECTS OF CHEMISTRY B | 15 POINTS | [2/3] |
|-----------------|------------------|--|------------------|--------------|

Students select from further topics offered by staff covering a range of chemistry.

| | | | | |
|-----------------|------------------|----------------------------------|------------------|--------------|
| CHEM 441 | CRN 13732 | DIRECTED INDIVIDUAL STUDY | 15 POINTS | [1/3] |
| | CRN 13733 | | | [2/3] |
| | CRN 13734 | | | [3/3] |

A supervised programme of study approved by the Head of School. This might involve, where appropriate, following a course of study as prescribed for CHEM 301, 302 or 303 but with assessment appropriate for a 400-level course.

| | | | | |
|-----------------|------------------|-----------------------------|------------------|--------------|
| CHEM 480 | CRN 13735 | RESEARCH PREPARATION | 15 POINTS | [1/3] |
| | CRN 13736 | | 15 POINTS | [2/3] |

Corequisite: CHEM 489
Restriction: CHEM 580

This course entails training in advanced skills required to research and to communicate the results, including utilising the chemical literature, record keeping, writing reports and research proposals, and techniques of oral communication.

| | | | | |
|-----------------|------------------|-------------------------|------------------|----------------|
| CHEM 489 | CRN 735 | RESEARCH PROJECT | 30 POINTS | [1+2/3] |
| | CRN 13724 | | | [3+1/3] |

Prerequisites: CHEM 305 or 306

An individual research project that includes training in advanced laboratory skills, supervised by an academic staff member.

MASTERS & PhD – PROGRAMMES

MSc HONOURS

The MSc Honours (in Chemistry) programme involves the same 400-level lecture courses as stated for Honours with the exception of CHEM 480 and CHEM 489 which are replaced by CHEM 580 which is the only compulsory course in the MSc programme. (Please note that CHEM 580 is worth 30 points as compared to a total of 45 points for CHEM 480 and CHEM 489 and as such, MSc students will be required to undertake an additional 15 point paper). The research project (CHEM 591) forms Part 2 of the degree programme with a formal thesis submission and examination of it by an external and internal examiner. The time commitment for Part 2 is normally *12 months* but not more than *18 months* including write-up and submission. Candidates may register for Part 2 immediately after completion and assessment of the written papers, including CHEM 580, on December 1 or at any time thereafter, but normally no later than the commencement of the next academic teaching year.

Other assessments for MSc Honours include two oral presentations, a full research proposal, an introduction to the thesis and draft submissions of the final thesis. Final submission must be no later than 18 months after first registration for Pt 2 as this is the maximum time allowable under the MSc regulations for full-time study.

BSc (Hons) candidates are eligible to change to MSc Part 1 at any time prior to examination for the BSc (Hons) degree, with approval of the School.

| | | | | |
|-----------------|-----------------|-----------------------------|------------------|----------------|
| CHEM 580 | CRN 7773 | RESEARCH PREPARATION | 30 POINTS | [1+2/3] |
|-----------------|-----------------|-----------------------------|------------------|----------------|

Restriction: CHEM 480

Training in advanced skills required to perform the research to be conducted during CHEM 591 and in the communication of scientific results. Specific aspects will include advanced laboratory skills, utilisation of the chemical literature, record keeping, writing reports and proposals, and the techniques of oral communication.

| | | | | |
|-----------------|----------------|---------------|-------------------|----------------|
| CHEM 591 | CRN 744 | THESIS | 120 POINTS | [1+2+3] |
|-----------------|----------------|---------------|-------------------|----------------|

An individual research project that includes training in advanced laboratory skills.

MSc by thesis only (Part 2) – CHEM 591

Students who have reached a satisfactory standard in the BSc(Hons) degree, PGDipSci or their equivalent may obtain an MSc degree by thesis alone by enrolling for the MSc (Part 2). In this case the assessment is by thesis only, Honours are not awarded. However, the MSc may be awarded with merit or with distinction.

PhD – CHEM 690

The PhD is the internationally recognised research degree in the scientific community, and the School of Chemical and Physical Sciences has a long history of successful completions. The School is committed to the provision of intellectual stimulation and first class facilities that allow the student to achieve a research education comparable to that received in the best overseas universities. These degrees open up rich and varied career opportunities. The chemistry academic staff of the School of Chemical and Physical Sciences have many years of experience in teaching both part-time and full-time research students, and offer their internationally recognised expertise in the following key areas of chemical research: organic and bio-organic synthetic chemistry (including total synthesis), marine natural products chemistry, materials chemistry, grape and wine analytical chemistry, ceramics, new product and process development, molecular self-assembly and liquid crystals, environmental analytical chemistry, carbon nanotubes, inorganic synthetic chemistry, nanobiology, biomineralisation, colloid and surface chemistry, soft matter, organometallic chemistry, immunoglycomics, heritage materials, conservation science, ultrafast laser spectroscopy, organic electronics, computational chemistry, nanoparticle/quantum dot synthesis, characterisation and use (for example as biological imaging agents and catalytic particles), and composite materials (nanoparticle fibre systems).

The School offers state-of-the-art instrumental (e.g. NMR, SEM, TEM, AFM, XRD, SAXS, rheology, particle analysis, standard spectroscopy techniques) and computing facilities. It also offers the possibility of considerable interaction and collaboration with biologists, physicists and industry.

Research supervisors organise their own groups and research meetings. They encourage their students to attend relevant lectures and seminars within the University. All students must give three presentations during their studies, and prepare and defend a full research proposal. Students are encouraged to attend, and participate in, national and international conferences. Part-time students may carry out some of their research at their place of work. Distance supervision for full-time and part-time students is also possible, but students are expected to spend some time each year on campus (up to one month). Additionally, students may visit other national or international laboratories to complete part of their studies. All students are enrolled on a provisional basis for a minimum of 12 months before gaining full registration based on successful completion and examination of a full research proposal and oral presentation.

Formal assessment of the Chemistry PhD degree is by means of a thesis and an oral examination, but there are progress reports and seminars required during the course. Students must have a BSc(Hons), MSc, or equivalent, to be admitted to the PhD programme. Various scholarships and other sources of financial support are available and enquiries should be made to the Scholarships website www.victoria.ac.nz/scholarships.

MSc (Hons) and MSc Part 2 candidates may be eligible to change to a PhD at any time prior to examination for the MSc degree, with approval of the School.

AVAILABLE CHEMISTRY RESEARCH PROJECTS

COMPUTATIONAL CHEMISTRY

- Coordination and Organometallic Chemistry: Metal ligand interaction, theoretically guided ligand design and the prediction of spectroscopical properties of transition metal compounds. [Matthias Lein]
- Homogeneous Catalysis: Theoretical investigation of the fundamental steps in a catalytic cycle. Prediction of the influence of structural changes to the catalyst molecule. [Matthias Lein]
- Chemical Bonding: Analysis and characterization of the detailed electronic structure of interesting or unusual chemical bonds. Correlation of empirical bonding models and actual electronic structure. [Matthias Lein]
- Spectroscopic properties: Prediction and confirmation of spectroscopic properties. Influence of structural changes on observed spectra. [Matthias Lein]

ENVIRONMENTAL ANALYTICAL CHEMISTRY

- Identification of air and water pollutants in the Wellington Region. [David Weatherburn]

GRAPE AND WINE CHEMISTRY

- Identification of bound-volatiles: Volatile organic molecules contribute to wine flavour and aroma but may be found conjugated with other molecules in a non-volatile storage form. Identification and exploitation of new bound-volatiles could contribute to improving the flavour characteristics of New Zealand wines. [Rob Keyzers]

HERITAGE MATERIALS (CONSERVATION SCIENCE)

- Use of solid-state NMR and X-ray diffraction to study degradation mechanisms in ancient stone, concrete and brick structures and artefacts and the development of methods for their conservation. [Ken MacKenzie]
- Stabilisation of natural biological fibres (cellulosic and/or proteinaeous). [Gerald Smith]
- Light-induced fading of dyes and pigments. [Gerald Smith]

MARINE NATURAL PRODUCTS

- New Zealand marine sponges are a particular interest, isolating biologically active metabolites from several species including peloruside as a potential anti-cancer agent. Also investigating holothurians (sea cucumbers), nudibranchs (sea slugs) and marine macroalgae. [Peter Northcote]
- Bioassay guided isolation of biologically active natural products: This project utilizes a variety of bioassays to test extracts of marine organisms for potential medically useful properties (anti-TB, anti-inflammatory etc). The active principles are then isolated and chemically identified using modern chemical and spectroscopic techniques. [Rob Keyzers]

MATERIALS CHEMISTRY

Biom mineralisation

- Crystallisation on a soft template: this project explores the synergistic interaction between a soft template (here a self-assembled monolayer) and a nucleating crystal in defining the form of the growing crystal. [Kathryn McGrath]

-
- Biomineral mimics: investigating the process of crystallisation using a variety of reaction environments aimed at mimicking key process in biomineralisation. [Kathryn McGrath]

Ceramics

- Development of new or improved oxynitride engineering ceramics and energy-efficient methods for their production. [Ken MacKenzie]
- Synthesis of new inorganic polymers with novel functions and the use of solid-state NMR spectroscopy to determine their structures. [Ken MacKenzie]
- Development of ecologically-friendly materials for passive cooling of buildings or photodegradation of organic species. [Ken MacKenzie]

Composite Materials

- Reinforcement of inorganic polymers with organic fibres (e.g. protein, cellulose fibres) and a study of their mechanical properties and fibre-matrix bonding mechanisms. [Ken MacKenzie]
- Composites of inorganic polymers with inorganic fibres, carbon nanotubes or particles. [Ken MacKenzie]

Molecular electronics

- Use of conjugated polyelectrolytes in polymer solar cells: Thin films of conjugated polyelectrolytes will be examined to determine whether ionic effects can improve the efficiency of polymer solar cells. [Justin Hodgkiss]
- Exciton diffusion in thin films of conjugated polymers: Optical spectroscopy will be used to investigate means of enhancing exciton diffusion by manipulating polymer chain packing and incorporating fluorescent dyes. [Justin Hodgkiss]
- Biofunctionalization of conjugated oligomers for use as electronic biosensors. Molecular semiconductors will be hybridized with short peptides and oligonucleotides to create new multifunctional materials. [Justin Hodgkiss]
- Nanostructured organic semiconductors: Solution-based methods will be developed for preparing conjugated polymer nanoparticles and multilayered films to use as the building blocks of solar cells. [Justin Hodgkiss]

Nano-structured and Nanocomposite Materials for Consumer and Industry Applications

- The development and application of gold, silver and palladium nanoparticles as stable colourants and active entities in high value fashion apparel, functional textiles and carpets. [Jim Johnston]
- The development of novel hybrid materials involving quantum dots with wool and cellulose fibres and plastics, and their use in functional textiles, security and packaging applications. [Jim Johnston]
- The development and use of nanoparticles, conducting polymers and quantum dots in plastics and surface coatings and to provide new composite materials with novel chemical, optical, electronic, sensing and anti-microbial properties for consumer and industry applications. [Jim Johnston]
- The development of new nano-structured materials for use in coatings on paperboard packaging to scavenge and control the water vapour, carbon dioxide, oxygen and ethylene content of the atmosphere in package for the safe transport of perishable food. [Jim Johnston]

Quantum Dots and nanoparticles

- Synthesis of Magnetic Nanoparticles for Biomedical Imaging: investigating magnetic nanoparticles of transition metal carbides and nitrides as new and more effective MRI contrast agents for the treatment of diseases including cancer. Research will involve a variety of techniques including; colloidal synthetic chemistry, nanoparticle characterization by transmission electron microscope (TEM) and magnetic characterization of the nanoparticles. [Richard Tilley]
- Synthesis of III-V quantum dots: Quantum dots (QDs) or nanocrystals of group III – V semiconductors (gallium nitride (GaN), indium phosphides (InP)) are a class of interesting semiconducting materials that exhibit unique optical and electronic properties not found in their molecular and bulk counterparts. This project aims to establish new routes based on liquid phase synthesis to produce high quality colloidal QDs of group III - V semiconductors through the use of surfactant molecules as size-and-shape controllers and as surface modifiers. Quantum dots would be characterized with optical characterization and using transmission electron microscope (TEM). [Richard Tilley]

SOFT MATTER (COLLOID AND SURFACE CHEMISTRY)

- The use of rheology and nuclear magnetic resonance (NMR) spectroscopy and micro-imaging to investigate the relationship between molecular organisation and complex mechanical properties for liquid crystals, emulsions and colloids. [Kathryn McGrath]
- Exploration of the fundamental properties of soft materials such as coalescence and deformational flow using monodisperse emulsions (prepared using microfluidics). [Kathryn McGrath]
- The stability of emulsions – understanding the relationship between emulsion microstructure and macroscopic stability. [Kathryn McGrath]
- Probing complex non-equilibrium processes and structure of soft materials such as liquid crystals, including metallomesogens. [Kathryn McGrath]

SYNTHETIC CHEMISTRY

Bio-organic

- Synthesis and testing of small-molecule growth inhibitors of Mycobacterium tuberculosis. [Mattie Timmer in collaboration with Bridget Stocker, Malaghan Institute of Medical Research]
- Solid-phase combinatorial synthesis of natural product compound libraries. [Mattie Timmer in collaboration with Bridget Stocker, Malaghan Institute of Medical Research]
- Synthesis of analogues of bioactive natural products, especially including zampanolide, aigialomycin D, peloruside A, pateamine. [Joanne Harvey in collaboration with Paul Teesdale-Spittle, SBS]

Immunoglycomics

- Synthesis of glycoconjugate probes to study the role of carbohydrates in allergy and asthma. [Mattie Timmer in collaboration with Bridget Stocker, Malaghan Institute of Medical Research]
- Synthesis and evaluation of glycolipids for the development of improved anti-cancer vaccines. [Mattie Timmer in collaboration with Bridget Stocker, Malaghan Institute of Medical Research]

Inorganic

- The synthesis of new macrocyclic ligands and their complexes and kinetic studies of the cobalt(III) complexes of these ligands. [David Weatherburn]
- Synthesis and structure of inorganic polymers containing Li or Mg. [Ken Mackenzie]

Organic

- Use of carbohydrate scaffolds in synthetic routes to natural products and analogues. [Joanne Harvey]
- Cyclopropanes as reactive intermediates for synthesis of small-molecule bioactives. [Joanne Harvey]
- Synthesis of fluorescent dyes and fluorescent molecular probes. [Mattie Timmer in collaboration with Bridget Stocker, Malaghan Institute of Medical Research]

Organometallic

- Designing ligands that will create unusual coordination environments for Group 10 elements, Ni, Pd and Pt, to encourage unique patterns of reactivity and the stabilization of novel complexes with the specific objective of achieving controlled activation of alkanes. [John Spencer]
- Use of organometallic reactions in organic synthesis. [Joanne Harvey]

Total synthesis

- Total synthesis of the labillarides E-H, zampanolide, TAN-2483B and other natural products (macrocyclic oxylipin natural products). [Joanne Harvey]
- Total synthesis of quinoline natural products and testing as antiinflammatory and anticancer agents. [Mattie Timmer in collaboration with Bridget Stocker, Malaghan Institute of Medical Research]

ULTRAFAST LASER SPECTROSCOPY

- Development of novel techniques for data acquisition and analysis: This project will advance experimental capabilities for generating and detecting ultrafast laser pulses. These technical advances will allow ultrafast electron dynamics to be observed under a range of conditions. [Justin Hodgkiss]
- Charge separation in organic solar cells: This project will apply ultrafast laser spectroscopy to directly probe the mechanism by which electronic charge pairs are separated in organic solar cells. [Justin Hodgkiss]
- Exciton transport in organic solar cells: This project will apply ultrafast laser spectroscopy to investigate long range resonant energy transfer as a means of enhancing exciton transport in thin films of organic semiconductors. [Justin Hodgkiss]

ACADEMICS—RESEARCH AREAS

Martyn P. Coles, PhD (*Durham*), Associate Professor

Inorganic Chemistry

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My research involves synthetic inorganic and organometallic chemistry of the *s*-, *p*- and *d*-block elements. Specific targets include novel catalysts for organic transformations and polymerization based on main-group elements, and kinetic stabilization of unusual organometallic species employing bulky carbanions. These areas further our understanding of catalytic processes and allow the development of new reagents that will benefit researchers in academic and industrial environments. In addition we have been involved in the use of compounds containing the guanidine functionality as 'super-bases', with application in a number of areas including organocatalysis and anion recognition. This has led us to investigate methods by which hydrogen-bonds may be propagated in the solid-state to generate novel polymeric materials.

Our group uses glovebox and vacuum-line techniques to prepare and manipulate air- and moisture-sensitive compounds and reagents. The products are characterized in solution using spectroscopic (multi-nuclear NMR, IR, uv/vis) techniques, and in the solid-state by X-ray diffraction, where appropriate. We work collaboratively with international synthetic and theoretical groups to gain further insight and understanding of our areas of interest.

Main Group Catalysis

B. M. Day, N. E. Mansfield, M. P. Coles, and P. B. Hitchcock, *Bicyclic guanidinate compounds of magnesium and their activity as pre-catalysts in the Tishchenko reaction*. Chemical Communications, 47: p. 4995-4997, **2011**.

B. M. Day, and M. P. Coles, *Synthesis and reactivity of the phospho-Grignard reagent, Mg(P{SiMe₃})₂Br(THF)*. European Journal of Inorganic Chemistry: p. 5471-5477, **2010**.

Bulky Organometallic Ligands

M. P. Coles, S. E. Sözerli, J. D. Smith, P. B. Hitchcock and I. J. Day, *An ether-free, internally coordinated dialkylcalcium(II) complex*. Organometallics, 28: p. 1579-1581, **2009**.

M. P. Coles, S. M. El-Hamruni, J. D. Smith and P. B. Hitchcock, *An organozinc hydride cluster: An encapsulated tetrahydrozincate?* Angewandte Chemie International Edition, 47: p. 10147-10150, **2008**.

Super-Basic Guanidines

M. P. Coles, P. J. Aragón-Sáez, S. H. Oakley, P. B. Hitchcock, M. G. Davidson, Z. B. Maksić, R. Vianello, I. Leito, I. Kaljurand and D. C. Apperley, *Super-basicity of a bis-guanidino compound with a flexible linker: a theoretical and experimental study*. Journal of the American Chemical Society, 131: p. 16858-16868, **2009**.

Hydrogen-Bonded Materials

M. P. Coles, F. A. Stokes, B. F. K. Kingsbury, B. M. Day, and P. B. Hitchcock, *Planar chirality and helical polymers: Ferrocenyl-substituted amidinium-carboxylate salts*. Crystal Growth and Design, 11: p. 3206-3212, **2011**.

M. S. Khalaf, S. H. Oakley, M. P. Coles and P. B. Hitchcock, *A strategy for the propagation of hydrogen-bonding in bicyclic guanidinium salts*. CrystEngComm, 10: p. 1653-1661, **2008**.

Joanne Harvey, PhD (ANU), Senior Lecturer*Synthetic Organic Chemistry*Email – joanne.harvey@vuw.ac.nz

The design and synthesis of new organic molecules and natural products for the purpose of obtaining material with biological activity and/or structural significance is the main aim of my research group. To this end, we combine a diverse range of known procedures with chemical methods that we develop ourselves, particularly focussing on reactions of complex cyclopropane-containing molecules, organometallic chemistry, and macrocycle synthesis. We have recently completed the total synthesis of the bioactive macrocyclic natural product aigialomycin D and are currently working on syntheses of TAN-2483B and structural analogues of peloruside A and aigialomycin D (in collaboration with Paul Teesdale-Spittle of SBS).

Selected publications:

- “Synthesis of C-furanosides from a D-glucal-derived cyclopropane through a ring-expansion/ring-contraction sequence”, Russell J. Hewitt and Joanne E. Harvey, *Chem. Commun.*, **2010**, DOI: 10.1039/c0cc02244f.
- R.J. Hewitt, J.E. Harvey, “Synthesis of Oxepines and 2-Branched Pyranosides from a D-Glucal-Derived *gem*-Dibromo-1,2-cyclopropanated Sugar”, *J. Org. Chem.*, **2010**, *75*, 955-958.
- L. J. Baird, M. S. M. Timmer, P. H. Teesdale-Spittle, J. E. Harvey, “Total Synthesis of Aigialomycin D Using a Ramberg-Bäcklund/RCM Strategy”, *J. Org. Chem.* **2009**, *74*, 2271-2277.
- E. M. Casey, P. Teesdale-Spittle, J. E. Harvey, “Synthesis of the C12–C24 Fragment of Peloruside A by Silyl-Tethered Diastereomer-Discriminating RCM”, *Tetrahedron Lett.*, **2008**, *49*, 7021-7023.
- J.E. Harvey, S.A. Raw, R.J.K. Taylor, “A Versatile and Stereocontrolled Route to Pyranose and Furanose C-Glycosides”, *Org. Lett.*, **2004**, *6*, 2611-2614.

Justin Hodgkiss, PhD (MIT), Lecturer

Time-resolved optical spectroscopy, conjugated polymers, organic solar cells

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I am interested in the optical and electronic properties of conjugated polymers and other functional molecular materials. This research is motivated by applications for printable plastic electronics such as solar energy conversion and biosensing.

A prominent aspect of my research is using ultrafast laser spectroscopy to probe electronic dynamics in molecular electronic materials. We are developing and applying ultrafast laser spectroscopy tools to investigate mechanisms of photocurrent generation in plastic solar cells. By understanding electronic dynamics over a wide range of timescales (femtoseconds to milliseconds), our work guides the design of more effective materials for low-cost solar cells.

Another focus of my research is devising simple ways to overcome some of the fundamental limitations associated organic semiconductors. Strategies include the controlled incorporation of ions and nanoscale control of material interfaces.

This interdisciplinary research draws on a range of other tools to characterize the structural, optical, and electronic properties materials and functional devices.

My research involves collaborations with several other research groups at VUW, around New Zealand and in Cambridge, U.K.

Hodgkiss, J. M., Campbell, A. R., Marsh, R. A., Rao, A., Albert-Seifried, S., Friend, R. H. "Sub-nanosecond geminate charge recombination in polymer:polymer photovoltaic devices" *Phys. Rev. Lett.* **2010**, *104*, 177701.

Marsh, R. A., Hodgkiss, J. M., Albert-Seifried, S., Friend, R. H. "Effect of Annealing on P3HT:PCBM Charge Transfer and Nanoscale Morphology Probed by Ultrafast Spectroscopy" *Nano Lett.* **2010**, *10*, 923-930.

Marsh, R. A., Hodgkiss, J. M., Friend, R. H. "Direct Measurement of Electric Field-Assisted Charge Separation in Polymer:Fullerene Photovoltaic Diodes" *Adv. Mat.* **2010**, *22*, 3672-3676.

J. M. Hodgkiss G. Tu, S. Albert-Seifried, W. T. S. Huck, R. H. Friend "Ion-induced Formation of Charge-transfer States in Conjugated Polyelectrolytes" *J. Am. Chem. Soc.* **2009**, *131*, 8913-8921.

A. R. Campbell, J. M. Hodgkiss, S. Westenhoff, I. A. Howard, R. A. Marsh, C. R. McNeill, R. H. Friend, N. C. Greenham "Low-Temperature Control of Nanoscale Morphology for High Performance Polymer Photovoltaics" *Nano Lett.*, **2008**, *8*, 3942-3947.

Y.-S. Huang, S. Westenhoff, I. Avilov, P. Sreearunothai, J. M. Hodgkiss, C. Deleener, R. H. Friend, D. Beljonne "Electronic structures of interfacial states formed at polymeric semiconductor heterojunctions" *Nature Mater.* **2008**, *7*, 483-489.

James Johnston, MSc PhD (VUW), FRSNZ, FNZIC, Professor

Applied chemistry: new materials, nano-structured materials and technology development

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My research interests and activities utilise applied chemistry and materials science and nanotechnology in the development of new high value products and new chemical process technologies, as a basis for the development of new knowledge based industries and innovative consumer products. Current activities include the development of:

Functionalised nano-structured industrial calcium silicates for use in high quality filled and coated papers, high quality ink-jet printing, anticorrosive, anti-microbial, heat storage, humidity control, metal and phosphate recovery, and smart packaging applications.

The novel use of gold, silver and palladium nanoparticles as colourants for wool and other fibres for high value fashion apparel, carpet and functional textiles.

Novel quantum dot – fibre hybrid materials for use in high value functional textiles, smart plastics and packaging.

New functional packaging materials for transporting perishable food and other materials, using temperature control by passive heat storage and release materials, and moisture and atmosphere control by new smart materials.

Novel nanoparticle and conducting polymer-hybrid materials involving plastics, paper, wool and paint substrates with smart chemical, electronic and anti-microbial functionality.

Enhanced energy recovery from geothermal resources.

The materials are characterised by instrumental methods, e.g. XRD, electronmicroscopy, NMR, XPS, DSC, TGA. Much of the research is in collaboration with Research Institutes and industrial companies in NZ, UK, USA, and Germany.

J.H. Johnston, J. Moraes and T. Borrmann, "Conducting Polymers on Paper Fibres", *Synthetic Metals*, 153, 65-68, **2005**.

J.H. Johnston, T. Borrmann and A.J. McFarlane) "Nano-structured Silicate, Functionalised Forms Thereof, Preparation and Uses". NZ Patent Specification No. 537747 **2006**; International PCT Specification PCT/NZ2006/000003, **2006**.

Michael J. Richardson and James H. Johnston: "Sorption and Binding of Nanocrystalline Gold by Merino Wool Fibres – An XPS Study". *J. Colloid Interface Science*. Vol 310, Iss 2, 425-430, **2007**.

Fern M. Kelly, James H. Johnston, Thomas Borrmann and Michael J. Richardson, "Functionalised Hybrid materials of Conducting Polymers with Individual Wool Fibres". *J. Nanosci. Nanotech.* Vol 8, 1-8 **2007**.

James H. Johnston, James E. Grindrod, Margaret Dodds and Katrin Schmitischek: "Composite Nano-structured Calcium Silicate Phase Change Materials for Thermal Buffering in Food Packaging". *Current Applied Physics*, 8 508-511 **2008**.

Aaron C. Small and James H. Johnston: "Novel Hybrid Materials of Cellulose and Doped ZnS Nanoparticles". *Current Applied Physics* 8, 512-515 **2008**.

James H. Johnston, Fern M. Kelly, Kerstin A. Burrige and Thomas Borrmann: "Hybrid Materials of Conducting Polymers with Natural Fibres and Silicates", *Int. J. Nanotechnology* 309-325 **2009**.

Rob Keyzers, PhD (VUW), Lecturer

Organic and analytical chemistry

Email – robert.keyzers@vuw.ac.nz



My research interests lie in two areas of organic and analytical chemistry. One area is bio-prospecting to find new pharmaceutical lead compounds for treatments in several medically important areas. To do this we are undertaking bioassay guided isolation of natural products from marine invertebrates collected from around New Zealand and the wider Pacific community. We employ a variety of different bioassays for screening and guiding isolations including anti-mycobacterial (anti-TB) and anti-inflammatory tests.

A second area is developing our understanding of the links between grape metabolism and New Zealand wines. Wine is a complex biotechnological product made mostly using fermentation of grape juice by yeast. The flavours and aromas of a wine are therefore most dependent on both the grape juice and the metabolism of the yeast that carries out the fermentation and that may biochemically modify grape flavour precursors.

My group is involved in several projects relating to identifying compounds in grapes and wine that contribute to the final flavour and aroma of table wines, as well as health related benefits of wine and other food products.

R.A. Keyzers and P.K. Boss, "Changes in volatile production in fermentations made from musts with increasing grape content," *J. Agric. Food Chem.*, **2010**, 58, 1153-1164.

J.D. Dunlevy, K.L. Soole, M.V. Perkins, E.G. Dennis, R.A. Keyzers, C.M. Kalua and P.K. Boss, "Two grape O-methyltransferases involved in the biosynthesis of methoxypyrazines: grape-derived aroma compounds important to wine flavour." *Plant Mol. Biol.*, **2010**, 74, 77-89.

C. Bottcher, R.A. Keyzers, P.K. Boss and C. Davies, "Sequestration of auxin by the indole-3-acetic acid-amido synthetase GH3-1 in grape (*Vitis vinifera*) and the proposed role of auxin conjugation during ripening," *J. Exp. Bot.*, **2010**, 61, 3615-3625.

C. Young, P. Truman, R.A. Keyzers, P. Northcote and T.W. Jordan, "The Algal Metabolite Yessotoxin Affects Heterogenous Nuclear Ribonucleoproteins in HepG2 Cells," *Proteomics*, **2009**, 9, 2529-2542.

R.A. Keyzers, J. Daoust, M.T. Davies-Coleman, R. van Soest, A. Balgi, E. Donohue, M. Roberge and R.J. Andersen, "Autophagy-Modulating Aminosteroids Isolated from the Sponge *Cliona celata*," *Org. Lett.*, **2008**, 10, 2959-2962

DE. Williams, R.A. Keyzers, K. Warabi, K. Desjardine, J.L. Riffell, M. Roberge and R.J. Andersen, "Spirastrellolides C to G: Macrolides Obtained from the Marine Sponge *Spirastrella coccinea*," *J. Org. Chem.*, **2007**, 72, 9842-9845.

C.E. Whibley, K.L. McPhail, R.A. Keyzers, M.F. Maritz, V.C. Leaner, M.J. Birrer, M.T. Davies-Coleman and D.T. Hendricks, "Reactive Oxygen Species Mediated Apoptosis of Esophageal Cancer Cells Induced by Marine triprenyl Toluquinones and Toluhydroquinones", *Mol. Cancer Ther.*, **2007**, 6, 2535-2543.

R.A. Keyzers, P.T. Northcote and M.T. Davies-Coleman, "Spongian Diterpenoids from Marine Sponges", *Nat. Prod. Rep.*, **2006**, 23, 321-334.

R.A. Keyzers, C.A. Gray, M.H. Schleyer, C.E. Whibley, D.T. Hendricks and M.T. Davies-Coleman, "Malonganeones A–C, Novel Tetraprenylated Alkaloids from the Mozambique Gorgonian *Leptogorgia gilchristi*", *Tetrahedron*, **2005**, 62, 2200-2206.

C.E. Whibley, R.A. Keyzers, A.G. Soper, M.T. Davies-Coleman, T. Samaai, and D.T. Hendricks "Antiesophageal Cancer Activity from Southern African Marine Organisms", *Ann. N. Y. Acad. Sci.*, **2005**, 1056, 405-412.

Matthias Lein, PhD (*Marburg*), Senior Lecturer

Computational and Theoretical Chemistry

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My research focuses on fundamental aspects of Chemistry. I investigate the electronic structure and reactivity of compounds through Quantum Chemical calculations with a view to predict spectroscopic properties and reaction mechanisms.

The complexity of the underlying models that are used in these calculations means that this kind of research has to make use of supercomputer facilities here at Vic and both national and international supercomputer centres.

Theoretical Chemistry provides a great opportunity to take a step back from work in the laboratory and concentrate on the underlying processes and how they connect the models we use to plan chemical syntheses with what we observe later in the spectrometer.

One kind of system that I often investigate comes from organometallics, where I am interested in the interaction between the metal and its ligands and how changes in the ligand sphere affect the electronic structure of the metal. Another closely related area is that of homogenous catalysis where a thorough investigation of the reaction mechanism is needed to make adjustments in the metal catalyst in order to improve efficiency or to direct the reaction to a different product altogether.

So, if you are interested in understanding more fundamental aspects of Chemistry and what goes on behind the scenes, come and talk to me to see if Computational Chemistry might be for you.

M. Lein, M. Rudolph, A. S. K. Hashmi and P. Schwerdtfeger "Homogenous Gold Catalysis: Mechanism and Relativistic Effects of the Addition of Water to Propyne" *Organometallics* **2010**, 29, 2206-2210.

R. Tonner, M. Lein, R. Wesendrup, P. Schwerdtfeger "A systematic density functional and wavefunction-based study on dicarboxyl dianions $^-\text{O}_2\text{C-R-CO}_2^-$ with R = C₂, C₂X₂, C₂X₄, and C₆X₄ (X = H, F)" *Theor. Chem. Acc.*, **2009**, 1-10

M. Lein "Characterization of agostic interactions in theory and computation" *Coord. Chem. Rev.*, **2009**, 253, 625-634

P. Schwerdtfeger, M. Lein, R. P. Krawczyk and C. R. Jacob "The adsorption of CO on charged and neutral Au and Au₂. A comparison between wave-function based and density functional theory" *J. Chem. Phys.*, **2008**, 128, 124302

M. Lein, A. Hammerl, H. L. Hermann, P. Schwerdtfeger "Theoretical investigations into trioxo group 7 compounds LRO₃ with perfluorated ligands." *Polyhedron*, **2007**, 26/2, 486-492.

Kathryn McGrath, PhD (ANU), FNZIC, Professor

Soft Matter, Colloid and Surface Chemistry, Biomineralisation and Materials Science

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In my group we are interested in understanding what controls 3D patterning in both soft and hard materials. We aim to determine the why and how such materials respond to processes occurring within and to their environment. More specifically we are interested in determining the role that the inherent intermolecular interactions within the system plays in modifying their response. Our goal is to understand how these types of controls define 3D patterning, be it on the 1-2 nm length scale in liquid crystals or the macroscopic patterning in biominerals (such as sea urchin spines, pāua shells and diatom cell walls).

The work in the group has at its foundation the concepts of molecular self assembly; weak (and maybe not so weak) intermolecular forces; scalability and universality; the interplay of kinetics and thermodynamics and determination of structure/function relationships.

Current projects include:

Investigating the dynamic processes of emulsions, both model systems and those more closely resembling commercial products.

Probing complex non-equilibrium processes and structure of soft materials such as liquid crystals.

Using monodisperse emulsions (prepared using microfluidics) to explore the fundamental properties of soft materials such as coalescence and deformational flow.

Membrane dynamics and structure.

Controlled crystallisation of calcium carbonate on model membranes, films and in bulk solutions.

We use a wide range of techniques including SEM, rheology, light scattering, SAXS, optical microscopy, micro-Raman, Brewster Angle Microscopy, AFM, XRD and diffusion-NMR.

So if investigating liquid crystals, biomineralisation, crystal engineering/tectonic processes, or emulsions sounds like you then we might have a project that would fit.

Bulgarelli, N. and McGrath, K.M., "Dynamics of oil transfer in oil-in-water emulsions, *Soft Matter*, in press **(2009)**

Lendrum, C.D. and McGrath, K.M., "The role of subphase chemistry in controlling monolayer behaviour, *Journal of Colloid and Interface Science*, 331(1):206-213 **(2009)**

Lendrum, C.D. and McGrath, K.M., Calcite nucleation on mixed acid/alcohol monolayers, *Crystal Growth & Design*, **(2009)**

Henderson, G.E., Murray, B.J. and McGrath, K.M., "Controlled variation of calcite morphology using simple carboxylic acids, *Journal of Crystal Growth*, 310(18):4190-4198 **(2008)**

Egger, H and McGrath, K.M., "Aging of oil-in-water emulsions: the role of the oil", *Journal of Colloid and Interface Science*, 299(2): 890-899 **(2006)**

Hubbard, P.L., McGrath, K.M. and Callaghan, P.T., "Orientational anisotropy in the polydomain lamellar phase of a lyotropic liquid crystal", *Langmuir*, 22(9):3999-4003 **(2006)**

Ken MacKenzie, PhD (VUW), DSc, FRSNZ FNZIC, Professor

Materials Chemistry

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My research interests include the development of new inorganic materials for engineering, electronics, bioactive and ecological applications. Typically these materials are new types of inorganic polymers, ceramics, glasses and nanoporous materials. I am particularly interested in developing energy-efficient and ecologically-friendly methods of synthesising these materials and determining their structures and properties by a variety of spectroscopic techniques, especially multinuclear solid-state nuclear magnetic resonance with magic-angle spinning (MAS NMR). I am a Principal Investigator of the MacDiarmid Institute for Advanced Materials and Nanotechnology, and also have strong links with Industrial Research Ltd. I also maintain active research collaborations with the University of Warwick, the Tokyo Institute of Technology and several other Universities in Japan, Thailand and Mongolia.

- K.J.D. MacKenzie and M.E. Smith, "Multinuclear Solid State NMR of Inorganic Materials, Pergamon Materials Series Vol. 6, Pergamon/Elsevier, Oxford, **2002**. 750 pages.
- K. Okada and K.J.D. MacKenzie. „Nanoporous Materials from Mineral and Organic Templates". In *Nano Materials: From Research To Applications*, Ed. H. Hosono, Y. Mishima, H. Takezoe, K.J.D. MacKenzie, Elsevier, Oxford. (**2006**). pp. 349-82.
- J. Temuujin, G. Burmaa, Ts. Jadambaa, B. Munkhtsetseg, K.J.D. Mackenzie and A. van Riessen. "Processing of Synchysite, A Potential Source of Rare Earth Elements". Ch. 13 in *Rare Earths: Processing and Applications*, Ed. K.N. Delfrey, Nova Science Publishers, New York, (**2008**). pp. 391-406.
- K.J.D. MacKenzie, S. Komphanchai and R. Vagana. "Formation of inorganic polymers (geopolymers) from 2:1 layer lattice aluminosilicates". *J. Eur. Ceram. Soc.*, **28** (**2008**) 177-81.
- K.J.D. MacKenzie, M.E. Smith, T.F. Kemp, D. Voll. "Crystalline Aluminium Borates with the Mullite Structure: A ^{11}B and ^{27}Al NMR Study". *Appl. Magn. Reson.*, **32** (**2007**) 647-62.
- K.J.D. MacKenzie, M.E. Smith and A. Wong. "A Multinuclear MAS NMR Study of Calcium-Containing Inorganic Polymers". *J. Mater. Chem.*, **17** (**2007**) 5090-6.
- F.J. Li, T. Wakihara, J. Tatami, K. Komeya, T. Meguro and K.J.D. MacKenzie. "Elucidation of the Formation Mechanism of β -SiAlON from a Zeolite". *J. Amer. Ceram. Soc.*, **90**, (**2007**), 1541-4.
- M. Sopicka-Lizer, M. Tancula, T. Włodek, K. Rodak, M. Hüller, V. Kochnev, E. Fokina and K.J.D. Mackenzie. "The Effect of Mechanical Activation on the Properties of β -Sialon Precursors". *J. Eur. Ceram. Soc.*, **28** (**2008**) 279-88.
- K.J.D. MacKenzie, T. Dougherty and J. Barrel, "The Electronic Properties of Complex Oxides of Bismuth with the Mullite Structure". *J. Eur. Ceram. Soc.*, **28** (**2008**) 499-504.
- S. Eitssayeam, U. Intatha, K. Pengpat, K.J.D. MacKenzie and T. Tunkasiri, "Ferroelectric, Pyroelectric and Dielectric Properties of Complex Perovskite-Structured $\text{Pb}_{0.84}\text{Ba}_{0.16}(\text{Zr}_{0.44}\text{Ti}_{0.40}\text{Fe}_{0.08}\text{Nb}_{0.08})\text{O}_3$ Ceramics". *Current Appl. Phys.*, **8** (**2008**) 266-9.

Peter Northcote, PhD (*Brit Co*), FNZIC, Associate Professor

Natural Products, NMR Spectroscopy

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My main research interest is in marine natural products chemistry; the isolation and structural elucidation of novel compounds of pharmaceutical interest from marine organisms. New Zealand marine sponges are a particular interest, and my research group has isolated biologically active metabolites from several species including peloruside which is currently being investigated by a multi-disciplinary team of scientists in New Zealand and overseas as a potential anti-cancer agent. We are also currently investigating holothurians (sea cucumbers), nudibranchs (sea slugs) and marine macroalgae. I am more generally interested in the use of high field and multi dimensional NMR spectroscopy as a tool to investigate structural problems in chemistry.

J.W. Blunt, B.R. Copp, M.H.G. Munro, P.T. Northcote, M.R. Prinsep, "Marine natural products", *Natural Product Reports*, 23(1), 26-78, **2006**.

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Bordeleau, M.E.; Matthews, J.; Wojnar, J.; Lindquist, L.; Novac, O.; Jankowsky, E.; Sonenberg, N.; Northcote, P.; Teesdale-Spittle, P.; Pelletier, J., "Stimulation of mammalian translation initiation factor eIF4A activity by a small molecule inhibitor of eukaryotic translation", *Proc. Of the Nat. Acad. Of Sciences of the U. S. A.* (**2005**) 102(30) 10460-10465.

G. Moraes, P.T. Northcote, V.I. Kalinin, S.A. Avilov, A.S. Silchenko, P.S. Dmitrenok, V.A. Stonik, V.S. Levin, "Structure of the major triterpene glycoside from the sea cucumber *Stichopus mollis* and evidence to reclassify this species into the new genus *Australostichopus*", *Biochemical Systematics and Ecology*, 32(7), 637-650, **2004**.

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R.A. Keyzers, P.T. Northcote, M.V. Berridge, "Clathriol B, a new 14b marine sterol from the New Zealand sponge *Clathria lissosclera*", *Australian Journal of Chemistry*, 56(4), 279-282, **2003**.

Gerald Smith, PhD (*Canterbury*), Associate Professor

Photochemistry, Protection of Materials, Heritage Science

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My main research theme is the investigation of the fundamental chemical and physical processes responsible for the degradation of organic materials – particularly those of cultural significance such as textiles, wood, paper, pigments and natural dyes. Light is an important initiator of such degradation and the photophysical events and subsequent chemical reactions are studied with a variety of spectroscopic techniques.

I am involved in collaborative research with the Crown Research Institute, Industrial Research, and the Universities of Otago and Auckland on dyes and photonics. Overseas, I work with colleagues at the University of Melbourne, The British Museum, the National Gallery, London and the University of Southampton.

I direct a postgraduate programme in Heritage Materials Science. The content deals with the protection, physical characterization and analysis of materials of cultural significance such as Māori/Polynesian objects, manuscripts and easel painting. However, the underpinning science is germane to modern materials and even to future photonic devices.

“Evaluation of consolidants for black-dyed Maori textiles”, *Dyes Hist. Archaeol.*, 21, **2005**

“Phototendering of wool sensitized by natural polyphenolic dyes”, *J. Photochem. Photobiol. A*, 169,147, **2004**

“Stabilization of cellulosic textiles decorated with iron-containing dyes”, *Dyes Hist. Archaeol.*, 20, 87, **2004**

“The green fluorescence from the hair of Lindow Man”, *Antiquity*, 67,117, **1993**

“Jason’s Golden Fleece Explained? *Nature* 327, 561, **1987**

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“The fluorescence and photostabilities of naturally occurring isoflavones”, *Photochem. Photobiol. Sci.* 2, 611, **2003**

“The effect of UV absorbing sunscreens on the UV reflectance and consequent protection of skin”, *Photochem. Photobiol.*, 75, 122, **2002**

“Energy and electron transfer in coronene-doped polymethylmethacrylate”, *J. Photochem. Photobiol. A*, 154, 267, **2002**

John Spencer, PhD (Otago), FNZIC, Professor / Head of School

Organometallic Chemistry

Email – john.spencer@vuw.ac.nz



Organometallic transition metal compounds have a diverse and interesting chemistry that includes applications in homogeneous catalysis. I am interested in designing ligands that will create unusual coordination environments for Group 10 elements, Ni, Pd and Pt, to encourage unique patterns of reactivity and the stabilization of novel complexes. A major objective of the work is the development of new catalysts for application in organic synthesis.

Other areas of research include the activation of alkanes by transition metals, and the interaction of transition metal with highly energetic organic molecules

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- K. Allan and J. L. Spencer, "The synthesis and characterisation of novel o-substituted benzyldi-t-butylphosphine–boranes", *Tetrahedron. Lett.*, 2009, 50, 834 – 835.
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- A. H. Clemens, T. Dougherty and J. L. Spencer, "Coal as a Reductant in the Carbothermal Production of silicon Nitride Nanostructures", *Proceedings of the 24th Pittsburgh Coal Conference, Johannesburg, RSA, 2007.*
- X. Liu, J. L. Spencer, A. B. Kaiser, W. M. Arnold, "Selective Purification of Multiwalled Carbon Nanotubes by Dielectrophoresis within a Large Array", *Curr. App. Phys.*, 2006, 6, 427 - 431.
- K Edgar and J. L. Spencer "The Synthesis of Carbon Nanotubes from Müller Clusters", *Curr. App. Phys.*, 2006, 6, 419 - 421.

Richard Tilley, PhD (Cambridge), Associate Professor*Nanoparticle research and electron microscopy*Email – richard.tilley@vuw.ac.nz

My research revolves around the synthesis, characterisation and applications of nanoparticles, quantum dots and nanomaterials. Nanoparticles hold a great fascination because they have different fundamental physical properties compared to bulk solids due to the very small size. Unique properties of nanoparticles include particle size dependent luminescence from semiconductor materials, superparamagnetism in magnetic materials and new and unusual crystal structures. Current projects include preparation and investigation of magnetic nanoparticles and quantum dots for medical applications. Nanoparticles are characterisation using transmission and scanning electron microscopy (TEM and SEM) and powder X-ray diffraction. I have strong research links with Oxford University, Tokyo University and several companies

www.vuw.ac.nz/staff/richard_tilley/

- A. Shiohara, S. Hanada, S. Prabakar, T. H. Lim, K. Fujioka, K. Yamamoto, P. T. Northcote and R. D. Tilley 'Chemical reactions on surface molecules attached to silicon quantum dots' *Journal of the American Chemical Society*, 132, 248–253 (2010).
- J. Watt, N. Young, S. Haigh, A. I. Kirkland and R. D. Tilley 'Synthesis and Structural Characterization of Branched Palladium Nanostructures' featured as issue cover article, *Advanced Materials*, 21, 2288-2293 (2009).
- X. Ying, C. W. Bumby, N. Al-Salim and R. D. Tilley 'Synthesis of SnS Quantum Dots' *Journal of the American Chemical Society*, 131, 15990–15991 (2009).
- S. Cheong, J. Watt, B. Ingham, M. F. Toney and R. D. Tilley 'In Situ and Ex Situ Studies of Platinum Nanocrystals: Growth and Evolution in Solution' *Journal of the American Chemical Society*, 131, 14590–14595 (2009).

Mattie Timmer, PhD (Leiden), Senior Lecturer

Immunoglycomics – Design and synthesis of glycoconjugate probes

Email – mattie.timmer@vuw.ac.nz



In recent years it has been recognised that carbohydrates control a vast array of cellular processes. Carbohydrates, in the form of glycoconjugates, are found at the surface of living cells and play a critical role in cellular events such as cell signalling, bacterial and viral infection, and in the recognition and metastasis of tumour cells. Yet despite this knowledge, little is known about the precise function and mode of action of most glycoconjugates.

My research interests lie in unravelling the role glycoconjugates play in the human immune response through the synthesis and immunological evaluation of novel glycoconjugates and glycoconjugate probes. To this end I have collaborated with a number of leading immunologists at the Malaghan Institute of Medical Research, and in conjunction with Dr B. Stocker (MIMR), formulated a unique Immunoglycomics Platform which functions at the interface of synthetic organic chemistry and immunology. Projects developed within this platform include investigating the role of glycolipids in cancer immunotherapy, the use of glycoconjugate probes to unravel the causes of asthma, and the properties of mycobacterial glycolipids and how they correlate to the immune evasive nature of *M. tuberculosis*.

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Win-Mason, A. L.; Dangerfield, E. M.; Tyler, P. C. Stocker, B. L.; Timmer, M. S. M., Stereoselective Strecker and Carbamate Annulation Methodology for the Synthesis of 1-Amino-1,2,5-trideoxy-2,5-imino-L-idoitol. *European Journal of Organic Chemistry* **2011**, 4008-4014.

Cheng, J. M. H.; Chee, S. H.; Knight, D. A.; Acha-Orbea, H.; Hermans, I.; Timmer, M. S. M.; Stocker, B. L., An improved synthesis of dansylated alpha-galactosylceramide and its use as a fluorescent probe for the monitoring of glycolipid uptake by cells. *Carbohydrate Research* **2011**, *346*, 914-926.

Stocker, B. L.; Dangerfield, E. M.; Win-Mason, A. L.; Haslett, G. W.; Timmer, M. S. M., Recent Developments in the Synthesis of Pyrrolidine-Containing Iminosugars. *European Journal of Organic Chemistry* **2010**, 1615-1637.

Mulchin, B. J.; Newton, C. G.; Baty, J. W.; Grasso, C. H.; Martin, W. J.; Walton, M. C.; Dangerfield, E. M.; Plunkett, C. H.; Berridge, M. V.; Harper, J. L.; Timmer, M. S. M.; Stocker, B. L., The anti-cancer, anti-inflammatory and tuberculostatic activities of a series of 6,7-substituted-5,8-quinolinequinones. *Bioorganic & Medicinal Chemistry* **2010**, *18*, 3238-3251.

Dangerfield, E. M.; Plunkett, C. H.; Win-Mason, A. L.; Stocker, B. L.; Timmer, M. S. M., Protecting-Group-Free Synthesis of Amines: Synthesis of Primary Amines from Aldehydes via Reductive Amination. *The Journal of Organic Chemistry* **2010**, *75*, 5470-5477.

Dangerfield, E. M.; Gulab, S. A.; Plunkett, C. H.; Timmer, M. S. M.; Stocker, B. L., A fast, efficient and stereoselective synthesis of hydroxy-pyrrolidines. *Carbohydrate Research* **2010**, *345*, 1360-1365.

Timmer, M. S. M.; Stocker, B. L.; Northcote, P. T.; Burkett, B. A., Az-a colourful azulene-derived protecting group. *Tetrahedron Letters* **2009**, *50*, 7199-7204.

Dangerfield, E. M.; Timmer, M. S. M.; Stocker, B. L., Total Synthesis Without Protecting Groups: Pyrrolidines and Cyclic Carbamates. *Organic Letters* **2009**, *11*, 535-538.

PLANNING A PROGRAMME IN HERITAGE MATERIALS SCIENCE

Heritage Materials: Conservation, Preservation and Identification –

The School of Chemical and Physical Sciences of Victoria University offers a programme in Heritage Materials Science featuring the conservation, preservation and identification of culturally significant materials. The University's departments of Biological Sciences, Museum and Heritage Studies, Art History and Maori Studies Te Kawa a Maui, along with practitioners from museums and art galleries, collaborate and are involved in guiding the course.

The programme highlights how advanced materials science can serve in the conservation, display and interpretation of heritage objects. This science is germane to the protection of all materials, ancient and modern. As such, the programme is directed to both heritage professionals and producing science graduates for the manufacturing sector - dyes, paints, textiles and construction materials.

The unique strength and competitive advantage of the programme lies in the combination of the advanced instrumentation and scientific expertise of the School of Chemical and Physical Sciences enhanced by its association with the MacDiarmid Institute. This will produce graduates familiar with state-of-the-art scientific techniques that can be used in aiding the preservation and identification of materials. In addition, we offer part-time postgraduate certificate and diploma courses in modern techniques for heritage materials specifically designed for conservators.

MELBOURNE UNIVERSITY: CONSERVATION PRACTICE MASTERS

Students seeking a Masters qualification in conservation practice from Melbourne University's Centre for Cultural Materials Conservation will be credited with 50 points towards the 200 point Melbourne MA course by gaining a B+ pass in the Victoria University of Wellington's Post Graduate Certificate in Science (Heritage Materials Science).

ENTRY REQUIREMENTS

Graduates without tertiary level science should discuss their admission to the programme with the programme director, Associate Professor Gerald Smith prior to the commencement of the third trimester (November 16, 2009).

PROGRAMME STRUCTURE

MSc – 2 years full time study:

- The first year is coursework of 120 points that includes core courses and the opportunity to include approved electives.

Core

- HMSC 501 – The principles of Heritage Materials Science
- HMSC 502 – Heritage Materials Science: Technology and Analysis
- HMSC 580 – Research preparation

Electives

- HMSC 561 – Practicum (this is not available for students with relevant practical experience).
- HMSC 562/563* – Individual Study course/s
- Any 400-level Chemistry course excluding the project
- Any 400-level art history course excluding the research essay
- Any 500-level Māori course excluding the research essay
- Any 500-level Museum and Heritage Studies course
- MBIO 434 – Microbiology

* Note HMSC 562 and 563 can be used in many ways to suit particular student needs such as to enhance relevant aspects of required scientific background;

- The second year is a 120 point research thesis

Post Graduate Certificate in Science endorsed in Heritage Materials Science PGCertSc (HMSC)

- A semester programme of 60 points full time study or up to two years part time
- HMSC 501 and HMSC 502 or HMSC 562 plus HMSC 563

Post Graduate Diploma in Science endorsed in Heritage Materials Science PGDipSc (HMSC)

- A one year programme of 120 points of full time study or up to four years part time.
- HMSC 501 and HMSC 502 and 60 additional approved points as listed above under the MSc.

COURSE INFORMATION INDEX

| Course code | Course reference number | Title | | Trimester |
|-----------------|-------------------------|-----------------------------------|------------------|--------------|
| ↓ | ↓ | ↓ | | ↓ |
| HMSC 502 | CRN 15191 | HERITAGE MATERIALS SCIENCE | 30 POINTS | [2/3] |

HMSC COURSES

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|-----------------|------------------|---|------------------|--------------|
| HMSC 501 | CRN 15190 | HERITAGE MATERIALS SCIENCE: PRINCIPLES | 30 POINTS | [1/3] |
|-----------------|------------------|---|------------------|--------------|

Topics include: Materials science of heritage objects, their composition and properties. Outline of analytical methods – principles of UV-Vis, IR, Raman, fluorescence, reflectance spectroscopies, HPLC, EM, GCMS. Forensics and authentication of documents, art, museum objects. Materials degradation and stabilization. Light – Photochemistry and photodegradation mechanisms and prevention. Other damaging agents - atmospheric pollutants, environmental control. Protection and conservation. Protective coatings and cleaning - varnishes, paints, resins. Maori and Pacific - Traditional textiles, colourants, wood conservation. Conservation ethics. Philosophy and conservation/restoration dilemmas, respect for the sensitivities of the cultures from which objects originate.

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| HMSC 502 | CRN 15191 | HERITAGE MATERIALS SCIENCE: TECHNOLOGY AND ANALYSIS | 30 POINTS | [2/3] |
|-----------------|------------------|--|------------------|--------------|

The techniques studied include fluorescence and reflectance spectroscopies, colour measurement, FTIR, chromatography, electron microscopy and X-ray fluorescence.

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| HMSC 561 | CRN 15193 | INTERNSHIP / PRACTICUM | 30 POINTS | [TBC] |
|-----------------|------------------|-------------------------------|------------------|--------------|

The Practicum provides students with work experience in a heritage institution such as a museum or art gallery and is offered during the third trimester. Previous students have undertaken practicums at Te Papa, Alexander Turnbull Library (National Library) and the NZ Historic Places Trust.

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|-----------------|------------------|------------------------------------|------------------|--------------|
| HMSC 562 | CRN 15195 | DIRECTED INDIVIDUAL STUDY 1 | 15 POINTS | [1/3] |
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A supervised programme of study approved by the Head of School.

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| HMSC 563 | CRN 15196 | DIRECTED INDIVIDUAL STUDY 2 | 15 POINTS | [2/3] |
|-----------------|------------------|------------------------------------|------------------|--------------|

A supervised programme of study approved by the Head of School.

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|-----------------|------------------|-------------------------|------------------|--------------|
| HMSC 580 | CRN 15198 | RESEARCH METHODS | 15 POINTS | [1/3] |
|-----------------|------------------|-------------------------|------------------|--------------|

Preparation for thesis research in Heritage Materials Science.

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| HMSC 591 | CRN 15189 | THESIS | 120 POINTS | [FULL YEAR/3] |
|-----------------|------------------|---------------|-------------------|--------------------------|

MSc Thesis in Heritage Materials Science.

AVAILABLE HERITAGE MATERIALS SCIENCE RESEARCH PROJECTS

- Stabilisation of Maori weaving and other textiles.
- Fading of dyes and pigments.
- Light/UV induced degradation of materials.

For additional information contact:

Associate Professor Gerald Smith,

Programme Coordinator

gerald.smith@vuw.ac.nz

ACADEMICS - RESEARCH AREAS

Gerald Smith, PhD (*Canterbury*), Associate Professor

Photochemistry, Protection of Materials, Heritage Science

Email – gerald.smith@vuw.ac.nz



My main research theme is the investigation of the fundamental chemical and physical processes responsible for the degradation of organic materials – particularly those of cultural significance such as textiles, wood, paper, pigments and natural dyes. Light is an important initiator of such degradation and the photophysical events and subsequent chemical reactions are studied with a variety of spectroscopic techniques.

I am involved in collaborative research with the Crown Research Institute, Industrial Research, and the Universities of Otago and Auckland on dyes and photonics. Overseas, I work with colleagues at the University of Melbourne, The British Museum, the National Gallery, London and the University of Southampton.

I direct a postgraduate programme in Heritage Materials Science. The content deals with the protection, physical characterization and analysis of materials of cultural significance such as Māori/Polynesian objects, manuscripts and easel painting. However, the underpinning science is germane to modern materials and even to future photonic devices.

Heritage Science Publications

“Evaluation of consolidants for black-dyed Maori textiles”, *Dyes Hist. Archeol.*, 21, **2005**

“Phototendering of wool sensitized by natural polyphenolic dyes”, *J. Photochem. Photobiol. A*, 169, 147, **2004**

“Stabilization of cellulosic textiles decorated with iron-containing dyes”, *Dyes Hist. Archeol.*, 20, 87, **2004**

“The green fluorescence from the hair of Lindow Man”, *Antiquity*, 67, 117, **1993**

“Jason’s Golden Fleece Explained? *Nature* 327, 561, **1987**

“The effects of molecular aggregation and isomerization on the fluorescence of hyperpolarizable chromophores”, *J. Photochem. Photobiol. A*, 157, **2005**

“Effect of molecular environment on the photoisomerization of urocanic acid”, *Photochem. Photobiol.*, 80, 257, **2004**

“The fluorescence and photostabilities of naturally occurring isoflavones”, *Photochem. Photobiol. Sci.* 2, 611, **2003**

“The effect of UV absorbing sunscreens on the UV reflectance and consequent protection of skin”, *Photochem. Photobiol.*, 75, 122, **2002**

“Energy and electron transfer in coronene-doped polymethylmethacrylate”, *J. Photochem. Photobiol. A*, 154, 267, **2002**

PLANNING A PROGRAMME IN PHYSICS

Physics is the most fundamental of the sciences, providing the basis for understanding a wide range of science and technology, ranging from the behaviour of stars to the operation of semiconductors in electronic devices.

BSc WITH HONOURS – PROGRAMME & COURSES

Honours courses are usually taken in the 4th year of study after completing a 3-year BSc degree course. They teach the principles and practice in different areas of physics to give students the background to pursue a research degree (MSc or PhD), or to pursue careers requiring a solid foundation in physical science.

Honours courses are labelled by 400-level numbers. 120 points are needed for a full-time course, i.e. eight of the 15-point courses listed below (four courses in trimester 1 and another four in trimester 2). Two of the courses must be the Research Project courses PHYS 490 and PHYS 491 (these courses are assessed internally). Other courses are assessed primarily by end-of-course examinations (80%), with a contribution from work performed during the year (20%).

With the approval of the Head of School appropriate papers from other disciplines, e.g. Chemistry, Electronic and Computer Systems Engineering, Geophysics or Mathematics, may be substituted in place of up to four Physics courses.

Part-time study over two years is possible.

COURSE INFORMATION INDEX

| Course code | Course reference number | Title | Points | Trimester |
|-----------------|-------------------------|----------------------------|------------------|--------------|
| ↓ | ↓ | ↓ | | ↓ |
| PHYS 412 | CRN 9070 | THEORETICAL PHYSICS | 15 POINTS | [2/3] |

400-LEVEL COURSES

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|-----------------|-----------------|--------------------------|------------------|--------------|
| PHYS 411 | CRN 9069 | QUANTUM MECHANICS | 15 POINTS | [1/3] |
|-----------------|-----------------|--------------------------|------------------|--------------|

Lecturers: Eric Le Ru, Ben Ruck
 Restriction: PHYS 322, 403
 Lectures: Mon, Thur, TBA
 Non-relativistic quantum mechanics applied to atoms, molecules and nuclei.

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| PHYS 412 | CRN 9070 | THEORETICAL PHYSICS | 15 POINTS | [2/3] |
|-----------------|-----------------|----------------------------|------------------|--------------|

Lecturers: Shaun Hendy, Michele Governale
 Restriction: PHYS 403
 Lectures: Mon, Thur, TBA

The theory of phase transitions, critical phenomena and methods in many-particle physics.

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|-----------------|-----------------|-----------------------------------|------------------|--------------|
| PHYS 413 | CRN 9071 | CONDENSED MATTER PHYSICS A | 15 POINTS | [1/3] |
|-----------------|-----------------|-----------------------------------|------------------|--------------|

Lecturers: Pablo Etchegoin, Alan Kaiser
 Restriction: PHYS 404
 Lectures: Mon, Thur, TBA

Vibrational and electron states in crystalline insulators, metals, semiconductors and novel conducting materials. Charge and heat transport.

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|-----------------|-----------------|-----------------------------------|------------------|--------------|
| PHYS 414 | CRN 9072 | CONDENSED MATTER PHYSICS B | 15 POINTS | [2/3] |
|-----------------|-----------------|-----------------------------------|------------------|--------------|

Lecturers: Petrik Galvosas, Andy Edgar, Joe Trodahl
 Restriction: PHYS 404
 Lectures: Mon, Thur, TBA

Soft Matter: polymer physics, fundamentals of semiconductors, optical properties of structured materials and topics in current research.

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|-----------------|-----------------|-------------------------|------------------|--------------|
| PHYS 415 | CRN 9073 | ELECTROMAGNETISM | 15 POINTS | [1/3] |
|-----------------|-----------------|-------------------------|------------------|--------------|

Lecturers: Andy Edgar, Uli Zuelicke
 Restriction: PHYS 410
 Lectures: Mon, Thur, TBA

Static and dynamic solutions to Maxwell's equations including electromagnetic waves in materials and in confined geometries, scattering and diffraction.

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|-----------------|-----------------|---------------------------------------|------------------|--------------|
| PHYS 416 | CRN 9074 | RELATIVITY AND ELECTRODYNAMICS | 15 POINTS | [2/3] |
|-----------------|-----------------|---------------------------------------|------------------|--------------|

Lecturers: John Lekner, Uli Zuelicke
 Restriction: PHYS 410
 Lectures: Mon, Thur, TBA

Einstein's theory of special relativity, the dynamics of relativistic particles and electromagnetic fields and radiation by moving charges.

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|-----------------|-----------------|---------------------|------------------|--------------|
| PHYS 417 | CRN 9075 | ASTROPHYSICS | 15 POINTS | [2/3] |
|-----------------|-----------------|---------------------|------------------|--------------|

Lecturers: Denis Sullivan, Melanie Johnston-Hollitt
 Lectures: Mon, Thur, TBA

A selection of topics in modern astrophysics such as stellar structure and evolution, nuclear astrophysics, the physics of white dwarfs and observational general relativity. Formation of large-scale structure in relation to currently favoured cosmological models, evolution and properties of galaxy clusters, radiative processes in astrophysics with particular emphasis on synchrotron emission as observed by radio telescopes.

PHYS 440 CRN 15212 DIRECTED INDIVIDUAL STUDY 15 POINTS [1/3]

A supervised programme of study approved by the Head of School. This might include, where appropriate, following a course of study prescribed for a 300-level course not previously taken, but with assessment appropriate for a 400-level course.

**PHYS 441 CRN 9083 ORIGIN AND EVOLUTION OF THE SOLID 15 POINTS [2/3]
EARTH**

Lecturers: Euan Smith (SGEES), Malcolm Ingham,
Gillian Turner
Restriction: PHYS 406, GPHS 405
Lectures: Mon, Thur, TBA

Methods of radiometric dating, the age of the Earth, and the thermal and gravitational structures of the Earth. Also taught as GPHS 441.

PHYS 447 CRN 9607 INTRODUCTION TO GEOMAGNETISM 15 POINTS [1/3]

Lecturers: Malcolm Ingham, Gillian Turner
Restriction: PHYS 442, GPHS 408, 442
Lectures: Mon, Thur, TBA

An introduction to the geomagnetic field including physical and mathematical models, study of the past behaviour of the field, and magnetohydrodynamic theory of the geodynamo. Also taught as GPHS 447.

PHYS 460 CRN 15213 DIRECTED INDIVIDUAL STUDY 15 POINTS [2/3]

A supervised programme of study approved by the Head of School. This might include, where appropriate, following a course of study prescribed for a 300-level course not previously taken, but with assessment appropriate for a 400-level course.

PHYS 490 CRN 9085 RESEARCH PROJECT A 15 POINTS [1/3]

Restriction: PHYS 489

A research project on a topic approved by the Head of the School of Chemical and Physical Sciences.

PHYS 491 CRN 9086 RESEARCH PROJECT B 15 POINTS [2/3]

Restriction: PHYS 489

A research project on a topic approved by the Head of the School of Chemical and Physical Sciences.

MASTERS & PhD – PROGRAMMES

MSc Parts 1 and 2

The MSc (in Physics) programme in its first year (Part 1) involves the same 400-level lecture courses as listed for the BSc Honours programme. The MSc also includes a second year (Part 2) in which students complete a research project and submit a formal thesis that is examined by internal and external examiners.

The time for submission of the thesis for Part 2 is normally approximately 12 months but not more than 18 months after first registration for Part 2, as 18 months is the maximum time allowable under the MSc Part 2 regulations for full-time study. With permission of the Head of school, candidates may register for Part 2 immediately after completion and assessment of the written papers on 1 December or any time thereafter, but normally no later than the commencement of the next academic teaching year.

BSc(Hons) candidates may elect to change to MSc Part 1 at any time prior to examination for the BSc(Hons) degree.

MSc by thesis only (Part 2)

Students who have reached a satisfactory standard in the BSc(Hons) degree or its equivalent may obtain an MSc degree by thesis alone by enrolling for the MSc (Part 2). In this case where the assessment is by thesis only, Honours are not awarded. However, the MSc may be awarded with merit or with distinction.

PhD

Victoria University offers an outstanding PhD programme. Victoria's Physics group was one of only two New Zealand university physics research groups given a research quality grade above 5 in the government's 2006 Performance-Based Research Fund evaluation. The research environment in the School is also greatly enhanced by the fact that it hosts the MacDiarmid Institute for Advanced Materials and Nanotechnology, the first Centre of Research Excellence in the physical sciences to be set up by the government. Twelve of its staff are Principal Investigators of the Institute, and others are Associate Investigators. The School has numerous international research collaborations with leading Universities and laboratories in the USA, Europe and Asia, many involving exchange visits of staff and students.

The general areas of research in physics available for PhD students are listed below, together with the names of staff supervisors (please consult the research summaries of individual staff members for more detailed information).

AVAILABLE PHYSICS RESEARCH PROJECTS

MATERIALS SCIENCE

Electronic Properties of Materials

- High temperature superconducting cuprates: the preparation of a series of samples and then transport, magnetic, optical, vibrational and high pressure measurements. The aim is to understand the electronic properties and spin dynamics. [Grant Williams, Ben Ruck in collaboration with Industrial Research Ltd, Leipzig University and other institutions]
- Iron pnictide superconductors and other iron based compounds: the preparation of samples as well as transport, magnetic, optical, vibrational and high pressure measurements. Iron based compounds are interesting because they can display a range of phenomena that include superconductivity, spin polarized transport, magnetism, ferroelectricity and they can even be multiferroic (displaying magnetic order and ferroelectricity). [Grant Williams, Ben Ruck in collaboration with GNS Science, Industrial Research Ltd, Leipzig University, and other institutions]
- Ion implanted near surface nanoparticles. This involves low energy ion implantation followed by furnace or electron beam annealing and magnetotransport and magnetic measurements. These resultant properties are interesting and they include a very large magnetoresistance. [Grant Williams with John Kennedy from GNS Science]
- Rare-earth and transition metal nitrides: preparation of thin films and studies of their structural, electronic and magnetic properties. [Joe Trodahl, and Ben Ruck, Grant Williams, Industrial Research Ltd and overseas laboratories collaboration]
- Novel conducting materials: graphene and carbon nanotubes - modelling of conduction and other properties. [Alan Kaiser, in collaboration with Chris Bumby and overseas laboratories]
- Novel conducting materials: semiconducting nanowire films - measurement of the electronic and other properties. [Chris Bumby, Natalie Plank and Alan Kaiser]
- Novel conducting materials: measurement and modelling of electronic properties. [Ben Ruck, Joe Trodahl, in collaboration with Industrial Research Ltd and overseas laboratories]

Interaction of Light with Condensed Matter Systems

- Theory of reflection of electromagnetic, acoustic and particle waves from interfaces. Quantum and electromagnetic scattering and diffraction. Theory of electromagnetic beams and pulses. [John Lekner]
- Theory of electromagnetic properties of nanometer sized metallic and dielectric objects, oriented to the study of nonlinear laser spectroscopy of molecules and biomolecules. Surface Enhanced Raman Scattering (SERS). [Pablo Etchegoin]

Physics of Soft Materials

- The use of nuclear magnetic resonance (NMR) spectroscopy and micro-imaging to investigate the relationship between molecular organisation and complex mechanical properties for polymers, liquid crystals, emulsions, colloids and other soft materials in deforming flows. [Paul Callaghan]
- NMR studies of novel ordering and relaxation effects for elastomers under shear and extensional deformation. [Paul Callaghan]
- Protein and macromolecular physics. Statistical mechanics, optical, and physical properties of biomolecules in solution and solid substrates. Physics oriented to biotechnology: proteomics and genomics. [Pablo Etchegoin]

Flow, Diffusion and Dispersion in Porous Media

- The development of new NMR methods used pulsed and amplitude-modulated field gradients in order to study restricted fluid motion in porous materials and interconnected structures. [Paul Callaghan]
- Measurement of velocity correlations for dispersive flow in porous media using a two dimensional pulsed gradient NMR method. [Paul Callaghan]
- Low field NMR and Portable NMR. [Paul Callaghan]
- The development of new magnet, data processing and probe technologies for use in novel NMR applications. [Paul Callaghan]

Solid State Spectroscopy and Radiation Imaging

- Glass ceramics, glasses, organic and composite materials for x-ray and gamma ray scintillators. Composite phosphors and storage phosphors for high-resolution and energy-sensitive X-ray imaging. [Andy Edgar]
- Optically stimulated luminescence with applications to dosimetry. [Andy Edgar, Grant Williams]
- Glass ceramics and novel compounds for optical switching and storage. This includes materials preparation and optical measurements that include optically modulated Bragg grating. [Grant Williams, Andy Edgar]
- Glasses and glass ceramics for wavelength shifting in optical communications. [Andy Edgar]
- Electrically-detected electron paramagnetic resonance in OLEDs and photovoltaics. [Andy Edgar]

Sensors and Instrumentation

- The development of various sensors and instrumentation systems for materials characterisation or environmental monitoring. A number of projects are available, ranging from the development of passive remote sensors for monitoring various environmental parameters, to the development of instrumentation for geophysical measurements. In collaboration with Industrial Research Limited, projects on the development of ultrasonic sensors and the application of these sensors to structured materials. [Gideon Gouws]

Theory of quantum effects in nanostructures

- Hybrid normal-superconducting systems (Cooper-pair transport through nanoscale conductors, proximity effect in quantum-dot systems, non-local Andreev transport). [Michele Governale]
- Time-dependent transport in nanostructures (charge and spin pumping, response times of interacting nanoscale systems). [Michele Governale]
- Charge and spin transport through quantum-dot/low-dimensional and nano-scale systems. [Michele Governale and Uli Zuelicke]
- Spin-dependent phenomena in semiconductor hetero- and nano-structures. [Uli Zuelicke]
- Emergent quasi-relativistic behaviour in condensed-matter systems. [Uli Zuelicke]

Computational materials science and nanotechnology

- Nanofluidics: modelling flows in micro and nanofluidic devices across a range of length scales using molecular dynamics, lattice Boltzmann and continuum methods. [Shaun Hendy]
- Multiscale Modelling of Crystal Growth: modelling the growth of nanoparticles using kinetic Monte Carlo and first principles quantum mechanical methods to investigate the structure and properties of magnetic nanoparticles for medical applications. [Shaun Hendy]
- Growth of oxide films: applying multiscale simulation techniques such as kinetic Monte Carlo to understand the growth of oxide films on metals (e.g. stainless steels). [Shaun Hendy]
- Multiscale Modelling of Catalysis: using first principles and multiscale methods to describe the performance of nanostructured catalysts for energy applications. [Shaun Hendy]
- Theoretical fluid mechanics [John Lekner]

ENVIRONMENTAL PHYSICS

- The measurement and interpretation of the electrical, thermal and microstructural properties of sea ice and permafrost. [Joe Trodahl, Malcolm Ingham]
- Nuclear Magnetic resonance studies of sea ice micro-structure and sea ice brine diffusivity. [Paul Callaghan]
- The use of dc resistivity techniques, particularly surface-borehole measurements, in the detection and monitoring of saline intrusion in coastal aquifers. [Malcolm Ingham]

ASTROPHYSICS*Radio Astronomy*

- Understanding the role of environment in the evolution of radio sources in galaxy clusters. [Melanie Johnston-Hollitt, European collaborators]
- Development of new algorithms to detect extended sources with the next generation of radio telescopes. [Melanie Johnston-Hollitt, NZ, Australian & European collaborators]
- Dynamical analysis of the Horologium-Reticulum Supercluster. [Melanie Johnston-Hollitt, US collaborators]
- Survey science for galaxy clusters using the next generation radio telescopes. [Melanie Johnston-Hollitt, Australian collaborators]

Optical Astronomy

- The study of compact stars (e.g. white dwarfs) using the techniques of asteroseismology, whereby detected stellar pulsation modes are used as diagnostic tools. [Denis Sullivan, the Whole Earth Telescope collaboration]
- The study of stellar variability by regularly monitoring large numbers of stars. The use of high magnification stellar microlensing events in a search for extrasolar planets. [Denis Sullivan, the NZ-Japan MOA collaboration]
- Software development for astronomical image acquisition and analysis. [Denis Sullivan, overseas collaborators]

GEOMAGNETISM AND PALAEOMAGNETISM

- The study of the evolution and development of Earth's magnetic field over time from historical records and from palaeomagnetic records preserved in rocks and sediments. Detailed analyses of historical secular variation and the source field. [Gillian Turner]
- Modelling of the behaviour of the geomagnetic field through polarity reversals. [Malcolm Ingham. Gillian Turner]
- The use of naturally occurring variations in the geomagnetic field as a tool for determining Earth structure, in particular associated with geothermal and volcanic areas and in the study of fault systems. [Malcolm Ingham]

ULTRAFAST LASER SPECTROSCOPY

- Development of novel techniques for data acquisition and analysis: This project will advance experimental capabilities for generating and detecting ultrafast laser pulses. These technical advances will allow ultrafast electron dynamics to be observed under a range of conditions. [Justin Hodgkiss]
- Charge separation in organic solar cells: This project will apply ultrafast laser spectroscopy to directly probe the mechanism by which electronic charge pairs are separated in organic solar cells. [Justin Hodgkiss]
- Exciton transport in organic solar cells: This project will apply ultrafast laser spectroscopy to investigate long range resonant energy transfer as a means of enhancing exciton transport in thin films of organic semiconductors. [Justin Hodgkiss]

ACADEMICS—RESEARCH AREAS

Sir Paul Callaghan, GNZM, FRS, FRSNZ, FInstP, FNZIP, DPhil, DSc (Oxford), Professor

NMR Methodologies for Molecular Dynamics and new NMR technologies

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My interests are (i) developing Nuclear Magnetic Resonance (NMR) methodologies for the study of molecular dynamics and molecular organization in complex fluids, soft matter and porous materials. Basically I try to find out how molecules move about and organise at the nanoscale when the fluids containing them are subjected to flow, or are dispersed within a porous material. The fluids we look at have intriguing elastic and viscous properties, just like many real fluids in biology, and advanced materials processing. With NMR we can use radio waves to track the molecules. (ii) Developing new NMR technologies for applications inside and outside the laboratory, through partnership with a New Zealand spin-out company, 'magritek' Ltd.

S.A. Rogers, D. Vlassopoulos and P.T. Callaghan "Aging, yielding and shear-banding in soft colloidal glasses", *Physical Review Letters*, **100**, 128304 (2008)

M.W. Hunter and P.T. Callaghan, "NMR measurement of non-local dispersion in complex flows", *Physical Review Letters*, **99**, 210602 (2007)

K.E. Washburn and P.T. Callaghan, "Tracking Pore to Pore Exchange using Relaxation Exchange Spectroscopy", *Physical Review Letters*, **97**, 175502 (2006)

P. Galvosas and P.T. Callaghan, "Fast magnetic resonance imaging and velocimetry for liquids under high flow rates", *J. Magn. Reson.*, **181**, 119-225 (2006)

H. Wassenius and P.T. Callaghan, "NMR velocimetry and the steady shear rheology of a concentrated hard sphere system", *Eur. Phys. Journal*, **18**, 69-84 (2005)

For more information please visit www.macdiarmid.ac.nz/nmr

Andrew Edgar, PhD (Canterbury), Associate Professor

Glasses, Glass Ceramics, and Radiation Imaging and Dosimetry

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My research activity is centred on the optical properties of glasses and glass ceramics, particularly as they apply to radiation imaging and detection. We have funding under the NERF scheme to develop new materials for radiation imaging and sensing, particularly for X-rays, gamma rays and neutrons, with applications to medical imaging and to non-destructive testing. Our group investigates physical effects such as the radiation induced storage-phosphor effect, scintillation, and radiation-induced luminescence, theoretically and experimentally. We use the knowledge to guide the development of new glassy and crystalline optical materials for ionising radiation sensing and imaging. We work collaboratively with the CRI's Industrial Research Limited and Geological and Nuclear Sciences, and with several overseas laboratories.

A new area of interest is spin-dependent processes in organic light emitting diodes. We have customised an ESR spectrometer for measurements of electrically-detected and optically detected ESR in OLEDs.

- A. Edgar, J. Zimmerman, H. von Seggern, and C. Varoy, *Lanthanum stabilized europium-doped cubic barium chloride – an efficient X-ray phosphor*. *Journal of Applied Physics*, 107: p. 083576, **2010**
- Dixie, L., A. Edgar, and M. Bartle, *Excitonic and X-ray phosphor properties of samarium and lanthanum-doped cubic barium chloride*. *Phys Stat solidi (c)*, C8: p. 132– 135, **2011**.
- N. Winch, and A. Edgar, *Light scattering in glass ceramic x-ray storage phosphors*, *Journal of Applied Physics*, 105: p. 023506-1/8, **2009**
- A. Edgar, C.R. Varoy, C. Koughia, D. Tonchev, G. Belev, G. Okada, S.O. Kasap, H. von Seggern, and M. Ryan, *Optical properties of divalent samarium-doped fluorochlorozirconate glasses and glass ceramics*. *Journal of Optical Materials*, 31 p. 1459-1466 **2009**
- G.V.M. William, A. Edgar, C. Dotzler, and S.R. Raymond, *Optically Rewriteable gratings in Mn²⁺ doped RbCdF₃*. *Journal of Materials Science: Materials in Electronics*, 20 p. 268-271, **2009**
- A. Edgar, M. Bartle, S.G. Raymond, G.V.M. Williams, and C. Varoy, *Structural and Scintillation Properties of Cerium-Doped Ba_{1-x}La_xCl_{2+x} Ceramics*. *IEEE Transactions on Nuclear Science*, 55: p. 1160-1163, **2008**
- Edgar, A., M. Bartle, C. Varoy, G.V.M. Williams, and S.G. Raymond, *Structure and Scintillation Properties of Cerium-Doped Barium Chloride Ceramics: Effects of Cation and Anion Substitution*. *IEEE Transactions on Nuclear Science*, 57: p. 1218-1222, **2010**..

For more information please visit www.victoria.ac.nz/xray

Pablo Etchegoin, PhD (Stuttgart), Professor

Surface Enhanced Raman Scattering

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My research interests include the study of optical method for the detection of small quantities of molecules and the study of single molecules by laser spectroscopy. My particular interest is in the use of Surface Enhanced Raman Scattering (SERS) in its various implementations with a view towards applications in a biological context. In addition we have several theoretical projects running in parallel around SERS, like the study of surface plasmon resonances in metallic nanostructures where huge laser field amplifications are observed. I have strong research links with Imperial College in London with both the Physics Department (Blackett Laboratory) and the Department of Electrical and Electronic Engineering, as well as with the University of Tokyo in Japan.

Bi-analyte single molecule SERS technique with simultaneous spatial resolution, P.

G. Etchegoin, E. C. Le Ru, and A. Fainstein, *Phys. Chem. Chem. Phys.* 13, 4500 (2011).

Combining Surface Plasmon Resonance (SPR) Spectroscopy with Surface-Enhanced Raman Scattering (SERS), S. A. Meyer, E. C. Le Ru, and P. G. Etchegoin, *Anal. Chem.* 83, 2337 (2011).

Basic electromagnetic theory of SERS, Pablo G. Etchegoin and Eric C. Le Ru, in *Surface Enhanced Raman Spectroscopy: Analytical, Biophysical and Life Science Applications* (ed S. Schlucker), Wiley-VCH, Weinheim, Germany , (2011).

Monitoring the Electrochemistry of Single Molecules by Surface-Enhanced Raman Spectroscopy, Emiliano Cortes, Pablo G. Etchegoin, Eric C. Le Ru, Alejandro Fainstein, Maria E. Vela, and Roberto C. Salvarezza, *J. Am. Chem. Soc.* 132, 18034 (2010).

Electrochemical Modulation for Signal Discrimination in Surface Enhanced Raman Scattering (SERS), Emiliano Cortes, Pablo G. Etchegoin, Eric C. Le Ru, Alejandro Fainstein, Maria E. Vela, and Roberto C. Salvarezza, *Anal. Chem.* 82, 6919 (2010).

Estimating the Raman Cross Sections of Single Carbon Nanotubes, J. E. Bohn, P. G. Etchegoin, E. C. Le Ru, R. Xiang, S. Chiashi, and S. Maruyama, *ACS Nano* 4, 3466 (2010).

For more information, please visit www.vuw.ac.nz/raman

Petrik Galvosas, PhD (*Leipzig*), Senior Research Fellow

NMR in Porous Media and Soft Matter

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My research revolves around Nuclear Magnetic Resonance (NMR) and its application in the field of soft matter and porous media. For soft matter it explores the behavior of complex non-Newtonian fluids such as polymer solutions or surfactant systems under mechanical shear. Current research includes spatio-temporal fluctuations due to flow instabilities or shear induced structural transformations. For transport processes in porous media, advanced NMR methods may contribute to the understanding of molecular exchange processes as seen in microporous materials such as zeolites. It may also improve our understanding of transport and diffusion in natural porous media such as soil, rocks or aquifers. Ultimately, current research is continuously pushing the boundaries and versatility of the NMR-toolbox.

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- N. Spindler, P. Galvosas, A. Pohlmeier and H. Vereecken, *NMR velocimetry with 13-interval stimulated echo multi-slice imaging in natural porous media under low flow rates*. *Journal of Magnetic Resonance*, 212: p. 216-223, **2011**
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- Y. Qiao, P. Galvosas and P.T. Callaghan, *Diffusion Correlation NMR Spectroscopic Study of Anisotropic Diffusion of Water in Plant Tissues*. *Biophysical Journal*, 89, p. 2899-2905, **2005**
- P. Galvosas, F. Stallmach and J Kärger, *Background gradient suppression in stimulated echo NMR diffusion studies using magic pulsed field gradient ratios*. *Journal of Magnetic Resonance*, 166, p. 164-173, **2004**
- P. Galvosas, F. Stallmach, G. Seiffert, J. Kärger, U. Kaess and G. Majer, *Generation and Application of Ultra-High-Intensity Magnetic Field Gradient Pulses for NMR Spectroscopy*. *Journal of Magnetic Resonance*, 151, p. 260-268, **2001**

Gideon Gouws, PhD (*Port Eliz*), Senior Lecturer

Sensor Systems and Applications

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(Dr Gouws is based in the School of Engineering and Computer Science)



My research interest is focussed on the development of sensors or sensor system for a variety of applications. Over the past few years my students and I have studied various aspects of ultrasonic sensors, particularly shear mode (TSM) quartz resonators, for application as materials sensors. The use of different measurement configurations, together with signal processing techniques have shown that these sensors can successfully be used as sensors of material characteristics in the vapour, liquid or solid phase. Work is currently also being done in conjunction with Industrial Research Limited on ultrasonic sensors for non destructive testing of materials. Work is also in progress on the development of passive (non-powered) sensors using magnetoelastic materials.

- A. Dawson, P. Harris, G.Gouws, "High Frequency Ultrasonic Wave Propagation in Porous Aluminium Samples", In "*Smart Sensors and Sensing Technology*", pp. 221 – 232, eds. S.C. Mukhopadhyay and G.S. Gupta, Springer Verlag, July **2008**
- G. Gouws, G. Smith and N. Hasegawa, "Magnetoelastic materials: From anti-theft tags to environmental sensors", *Proceedings of the 14th Electronics New Zealand Conference, Wellington NZ, 12 – 13 November 2007*
- A. Dawson, P. Harris and G. Gouws, "High frequency ultrasonic wave propagation in anisotropic materials", *Proceedings of 2nd International Conference on Sensing Technology, Palmerston North, New Zealand, November 26 – 28 2007*, pp. 552 – 556.
- R.C. Holt, G.J Gouws, J.Z. Zhen, "Measurement of Polymer Shear Modulus Using Thickness Shear Acoustic Waves", *Current Applied Physics*, 6, pp. 334 – 339, **2006**
- G.J. Gouws, A.Ristic, D. Ward, D. Cordery, "Control Electronics for a Miniature Four Rotor Helicopter.", *Proceedings of the 13th Electronics New Zealand Conference, 13 – 14 November 2006*, Christchurch NZ, pp. 30 – 34.
- T.J. Stewart, G.J. Gouws, P.T. Callaghan, A. Coy, "High Temperature Superconductor Magnet Assist for a One-Sided NMR Instrument.", *Proceedings of the 13th Electronics New Zealand Conference, 13 – 14 November 2006*, Christchurch NZ, pp. 13 – 17.
- G.J. Gouws, J.Z. Zhen, R.C. Holt, "Sensor Applications of Quartz Thickness Shear Mode Resonators.", *Proceedings of the 13th Electronics New Zealand Conference, 13 – 14 November 2006*, Christchurch NZ, pp. 234 - 239.
- A. Dawson, P. Harris, G.J. Gouws, "Design and Evaluation of Ultrasonic Transducer Circuits for Material Characterisation.", *Proceedings of the 13th Electronics New Zealand Conference, 13 – 14 November 2006*, Christchurch NZ, pp. 261 - 265.

Michele Governale, PhD (*Pisa*), Senior Lecturer

Quantum transport in nanostructures

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I am a condensed-matter theorist and my research activity pertains to the theory of quantum transport in nanostructures. Nanostructures are very intriguing from a solid-state physicist's perspective due to quantum effects, reduced dimensionality, electron-electron interactions, and the possibility of tuning their properties. From an applied point of view, the study of the basic electronic properties of nanostructured systems is a prerequisite for nanoelectronics – a current area of intense research where the key aim is to design new devices with dimensions in the nanometre range.

My ongoing research topics include:

- Time-dependent transport phenomena (charge pumping);
- Hybrid superconducting-normal structures comprising quantum dots;
- Spin-dependent transport (spin-orbit coupling effects, spin pumping);
- Noise and full-counting statistics.

I have strong research links with researchers in France, Germany, Italy and Switzerland.

- T. Kernreiter, M. Governale, A. R. Hamilton, and U. Zülicke, "Charge transport by modulating spin-orbit gauge fields for quasi-1D holes", *Appl. Phys. Lett.* **98**, 152101 (2011).
- J. Eldridge, M. Pala, M. Governale, and J. König, "Superconducting proximity effect in interacting double-dot systems", *Phys. Rev. B* **82**, 184507 (2010).
- J. Splettstoesser, M. Governale, J. König, and M. Büttiker, "Charge and spin dynamics in interacting quantum dots", *Phys. Rev. B* **81**, 165318 (2010).
- F. Cavaliere, M. Governale, and J. König, "Non-adiabatic pumping through interacting quantum dots", *Phys. Rev. Lett.* **103**, 136801 (2009).
- D. Futterer, M. Governale, M. G. Pala, and J. König, "Non-local Andreev transport through an interacting quantum dot", *Phys. Rev. B* **79**, 054505 (2009).
- J. Splettstoesser, M. Governale, and J. König, "Adiabatic charge and spin pumping through quantum dots with ferromagnetic leads", *Phys. Rev. B* **77**, 195320 (2008).
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- M. G. Pala, M. Governale, and J. König, "Non-Equilibrium Josephson and Andreev Current through Interacting Quantum Dots", *New J. Phys.* **9**, 278 (2007).
- F. Giazotto, F. Taddei, M. Governale, C. Castellana, R. Fazio, and F. Beltram, "Cooling electrons by magnetic-field tuning of Andreev reflection", *Phys. Rev. Lett.* **97**, 197001 (2006).
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- M. Governale, F. Taddei, Rosario Fazio, and F. W. J. Hekking, "Adiabatic pumping in a Superconductor-Normal-Superconductor weak link", *Phys. Rev. Lett.* **95**, 256801 (2005).
- J. Splettstoesser, M. Governale, J. König, and R. Fazio, "Adiabatic pumping through interacting quantum dots", *Phys. Rev. Lett.* **95**, 246803 (2005).

Shaun Hendy, PhD (Alberta), Professor*Computational Materials Science and Nanotechnology*Email – shaun.hendy@vuw.ac.nz

My group is interested in theoretical and computational materials science and nanotechnology. In general nanostructures can behave quite differently to their macroscale counterparts due to surface, quantum and finite-size effects. We study the interplay between these effects in nanoparticles, nanowires, ultrathin films, nanostructured glasses and nanofluidic flows with a particular focus on applications of these systems to nanotechnology. We have access to New Zealand's leading supercomputing facilities, and have ongoing collaborations with Industrial Research Ltd, the University of Canterbury, the London Centre for Nanotechnology, the University of Lyon, the University of Sydney and the University of Tennessee.

- D. Schebarchov and S. C. Hendy, "Epitaxial strain effects in the melting of supported metal nanoparticles", *Phys. Rev. B* 84, 085407 2011.
- G. R. Willmott, C. Neto and S. C. Hendy, "An experimental study of microfluidic interactions between droplets and a nonwetting capillary", *Faraday Discussions* 146, 233-245 (2010).
- A. I. Ayesh, S. A. Brown, A. Awasthi, S. C. Hendy, P. Y. Convers and K. Nichol "The Coefficient of Restitution for Bouncing Nanoparticles", *Physical Review B* 81, 195422 (2010).
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- D. Schebarchov and S. C. Hendy, "The dynamics of capillary absorption of metal droplets by carbon nanotubes", *Phys. Rev. E* 78 046309 2008.
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- P. Zoontjens, T. P. Schulze and S. C. Hendy, "A hybrid kinetic Monte Carlo-Molecular Dynamics method for modeling epitaxial growth", *Phys. Rev. B* 76 245418, 2007.
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Malcolm Ingham, PhD (*Edinburgh*), Senior Lecturer

Environmental physics, Geophysics

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My research interests centre on the application of electrical and electromagnetic geophysical techniques to environmental physics. I also maintain an interest in modelling of the geomagnetic field and its past behaviour.

DC electrical techniques in particular have considerable application in both hydrological studies and in studying the internal microstructure of structure of sea-ice. Em techniques such as magnetotelluric sounding and EMAP are applicable to geothermal and volcanological studies.

Potential PhD/MSc projects include:

- * the development of in-situ techniques for the measurement of the physical properties (e.g. the relative permittivity) of sea ice
- * the use of dc resistivity techniques, particularly surface-borehole measurements, in the detection and monitoring of saline intrusion in coastal aquifers
- * modelling of the behaviour of the geomagnetic field through polarity reversals

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Melanie Johnston-Hollitt, PhD (*Adelaide*), Senior Lecturer

Astrophysics: Radio Astronomy, Galaxy Clusters and Large-Scale Structure

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I am interested in understanding both how the Universe behaves on the largest scales and what new tools will be required to answer outstanding questions. Thus, I research galaxy clusters, which are the largest gravitationally bound objects in the Universe, and also design aspects of the next generation of radio telescopes.

One of the most exciting developments in the field of radio astronomy will be the Square Kilometer Array (SKA) – a new radio telescope with 100 times the sensitivity of current instruments. The SKA is being designed by 19 countries and NZ is part of the Australasian bid to host this ground breaking instrument with an excellent chance we will succeed. Thus, a fantastic opportunity exists right now to undertake radio astronomy research.

While I have a particular focus on radio astronomy, recently my group has adopted a multiwavelength approach to understanding clusters and superclusters. We are using several of the world's best radio telescopes in Australia, the US & India (ATCA, VLA & GMRT) along with optical data and X-ray images from the ESA XMM-Newton satellite to understand how cluster mergers, the most energetic events since the Big Bang, shape the galaxies within them.

Current projects include:

understanding the role environment plays on the generation and evolution of radio galaxies;

multiwavelength investigations of cluster dynamics (radio, X-ray & optical); and

science & technical requirements for next generation radio arrays.

We have strong collaborations with groups in Germany, the US and Australia and students working with us have the opportunity work with the international teams.

Norris, R.P., + 58 others including Johnston-Hollitt, M., EMU: Evolutionary Map of the Universe, Publications of the Astronomical Society of Australia, 2011, (in press).

Feain, I.J., Cornwell, T.J., Ekers, R.D., Ott, J., Calabretta, M.R., Norris, R.P., Johnston-Hollitt, M., Murphy, T., Middelberg, E. and Voronkov, M.A., The Radio Continuum Structure of Centaurus A at 20cm, *The Astrophysical Journal*, (in press).

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Electronic properties of novel materials, especially nanoscale materials

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My current research interests focus mainly on finding out what the electronic conduction mechanisms are in different types of novel material, particularly those with nanoscale dimensions. The research is carried out in collaboration with researchers at overseas laboratories. The materials we investigate include:

Graphene: we are investigating the conductance and related properties of graphene (sheets of carbon with thickness of only one atom) in collaboration with experimentalists in Germany.

Carbon nanotubes: we are investigating how carbon nanotubes can improve thermoelectric materials (with a U.S.A. group), and the modification of the conduction and other properties of carbon nanotube networks (at Victoria University and other groups).

Conducting polymers and nano-wires: our modelling can help explain conduction many materials with nanoscale structure.

- A.B. Kaiser and V. Skákalová, Electronic conduction in polymers, carbon nanotubes and graphene, *Chemical Society Reviews*, 40, 3786 - 3801, 2011.
- C.A.Hewitt, A.B. Kaiser et al., Varying the concentration of single walled carbon nanotubes in thin film polymer composites, and its effect on thermoelectric power, *Applied Physics Letters*, 98, Article number 183110, 2011.
- S. Ravi, A.B. Kaiser and C.W. Bumby, Improved conduction in transparent single walled carbon nanotube networks drop-cast from volatile amine dispersions, *Chemical Physics Letters*, Vol.496, pp 80-85, 2010.
- A.B. Kaiser, C. Gomez-Navarro et al., "Electrical conduction mechanism in chemically derived graphene monolayers", *Nano Letters*, 7,1787-1792, 2009.
- V. Skákalová, A.B. Kaiser et al., "Correlation between resistance fluctuations and temperature dependence of conductivity in graphene", *Physical Review B*, 80, Article number 153404, 2009.
- V. Skákalová, A.B. Kaiser et al., Ion irradiation effects on conduction in single-wall carbon nanotube networks, *Applied Physics A Rapid Communication* 90, 597-602, 2008.
- P.J.S. Foot and A.B. Kaiser, "Conducting Polymers", *Concise Encyclopedia of Chemical Technology*, 5th Edition (ISBN 0470047488), John Wiley & Sons, New York, 239 - 243, 2007.
- V. Skákalová, A.B. Kaiser, Y.-S. Woo and S. Roth, "Electronic transport in carbon nanotubes: from individual nanotubes to thin and thick networks", *Physical Review B* 74, 085403, pp1-10, 2006.
- V. Skákalová, A.B. Kaiser, U.Dettlaff-Weglikowska, K. Hrněariková, S. Roth, "Effect of chemical treatment on electrical conductivity, infrared absorption, and Raman spectra of single-walled carbon nanotubes", *Journal of Physical Chemistry B* 109, 7174-7181, 2005.

John Lekner, PhD (Chicago), FRSNZ, Professor*Optics, Electromagnetism and quantum theory*Email – john.lekner@vuw.ac.nz

Propagation, polarization and reflection of focused laser beams. Invariant properties of light beams. Diffraction, scattering. Energy, momentum and angular momentum of electromagnetic and acoustic pulses. Quantum many-body theory. Fluid mechanics.

Analytical expression for the electric field enhancement between two closely-spaced conducting spheres. *J Electrostatics* 68, 299-304 (2010)

Axially symmetric charge distributions and the arithmetic-geometric mean. *J Electrostatics* 67, 880-885 (2009)

Quantum bouncer on a spring. *Eur. J. Phys.* 30, L67-L73 (2009) [with H. Nguyen]

Flow with slip between coaxial cylinders and in an equilateral triangular pipe. *The Open Appl. Phys. J.* 2, 27-31 (2009)

Airy wavepacket solutions of the Schrödinger equation. *Eur. J. Phys.* 30, L43-L46 (2009)

Electrostatics of a family of conducting toroids. *Eur. J. Phys.* 30, 477-486 (2009)

Rotating wavepackets. *Eur. J. Phys.* 29, 1121-1125 (2008)

Reflection and non-reflection of particle wavepackets. *Eur. J. Phys.* 29, 671-679 (2008) [with T. Cox]

Eric Le Ru, PhD (*Paris*), Senior Lecturer

Nano-plasmonics: theory and applications

Email – eric.leru@vuw.ac.nz



My research interests focus mainly on the study, both theoretical and experimental, of electromagnetism at the nano-scale and in particular nano-plasmonics, i.e. the study and applications of the optical properties of sub-wavelength metallic objects.

This includes theoretical studies of the underlying electromagnetism concepts, numerical modelling of the optical properties, and experimental investigations of potential applications in molecular detection, namely: optics-based sensors and surface-enhanced spectroscopies (Raman and fluorescence). These applications have a strong component of physical chemistry.

Part of this work is carried out in collaboration with a group at Université Paris 7 in France.

Principles of surface-enhanced Raman spectroscopy and related plasmonic effects
Eric C. Le Ru and Pablo G. Etchegoin, 663 pp (Elsevier, Amsterdam, 2009).

Ultrafast nonradiative decay rates on metallic surfaces by comparing surface-enhanced Raman and fluorescence signals of single molecules
C. M. Galloway, P. G. Etchegoin, and E. C. Le Ru, Phys. Rev. Lett. 103, 063003 (2009).

Investigation of particle shape and size effects in SERS using T-matrix calculations
R. Boyack and E. C. Le Ru, Phys. Chem. Chem. Phys. 11, 7398 (2009).

Phenomenological local field enhancement factor distributions around electromagnetic hot spots
E. C. Le Ru and P. G. Etchegoin, J. Chem. Phys. (Comm.) 130, 181101 (2009).

Evidence of natural isotopic distribution from single-molecule SERS
P. G. Etchegoin, E. C. Le Ru, and M. Meyer, J. Am. Chem. Soc. 131, 2713 (2009).

Guiding molecules with electrostatic forces in Surface Enhanced Raman Spectroscopy (SERS)
P. D. Lacharaise, E. C. Le Ru, and P. G. Etchegoin, ACS Nano 3, 66 (2009).

The influence of photo-stability on single-molecule SERS enhancement factors
P. G. Etchegoin, P. D. Lacharaise, and E. C. Le Ru, Anal. Chem. 81, 682 (2009).

Surface-enhanced Raman scattering at a planar dielectric interface beyond critical angle
D. Pristiniski, E. C. Le Ru, S. Tan, S. Sukhishvili, and H. Du., Optics Express 16, 20117 (2008).

A perspective on single molecule SERS: Current status and future challenges
P. G. Etchegoin and E. C. Le Ru, Phys. Chem. Chem. Phys. (feature article) 10, 6079 (2008).

Experimental verification of the SERS electromagnetic model beyond the $|E|^4$ -approximation: polarization effects
E. C. Le Ru, J. Grand, N. Félidj, J. Aubard, G. Lévi, A. Hohenau, J. R. Krenn, E. Blackie, and P. G. Etchegoin, J. Phys. Chem. C (Letter) 112, 8117 (2008).

For a full publication list, see: <http://www.victoria.ac.nz/raman/publis/Eric/eric.aspx>

Kathryn McGrath, PhD (ANU), FNZIC, Professor*Soft Matter*Email – kate.mcgrath@vuw.ac.nz

Soft Matter encompasses materials such as polymers, plastics, liquid crystals, membranes, colloids, complex fluids, foams and gels. What makes these materials interesting is that they comprise a variety of physical states that are easily deformed by thermal stresses or thermal fluctuations. The variety of physical behaviour exhibited by these materials occurs at an energy that is comparable with room temperature thermal energy and as such quantum aspects are generally unimportant.

In particular we are interested in exploring the role of molecular self assembly in controlling and defining these materials and so we focus predominantly on liquid crystals and colloidal systems. We are trying to answer questions pertaining to what role some of the following things play in enabling, manipulating and stabilising the systems: Self assembly; Weak (and maybe not so weak) intermolecular forces; Length scale; Kinetics/Thermodynamics; Solution/environmental vagaries; Structure/function relationships.

Current projects include:

Investigating the dynamic processes of emulsions, both model systems and those more closely resembling commercial products; Probing complex non-equilibrium processes and structure of soft materials such as liquid crystals.

Using monodisperse emulsions (prepared using microfluidics) to explore the fundamental physics of soft materials such as coalescence and deformational flow.

Membrane dynamics and structure.

We use a wide range of techniques including cryo-SEM, diffusion-NMR, rheology, light scattering, confocal microscopy, SAXS, optical microscopy and Brewster Angle Microscopy.

So if you are interested in understanding why systems respond the way they do to the processes occurring in their environment and the intermolecular interactions inherent in all systems then we might have a project that would fit.

Malassagne-Bulgarelli, N. and McGrath, K.M., "Dynamics of oil transfer in oil-in-water emulsions, *Soft Matter*, in press (2009)

Lendrum, C.D. and McGrath, K.M., "The role of subphase chemistry in controlling monolayer behaviour, *Journal of Colloid and Interface Science*, 331(1):206-213 (2009)

Lendrum, C.D. and McGrath, K.M., Calcite nucleation on mixed acid/alcohol monolayers, *Crystal Growth & Design*, (2009)

Henderson, G.E., Murray, B.J. and McGrath, K.M., "Controlled variation of calcite morphology using simple carboxylic acids, *Journal of Crystal Growth*, 310(18):4190-4198 (2008)

Egger, H and McGrath, K.M., "Aging of oil-in-water emulsions: the role of the oil", *Journal of Colloid and Interface Science*, 299(2): 890-899 (2006)

Ben Ruck, PhD (VUW), Senior Lecturer

Experimental condensed matter physics

Email – ben.ruck@vuw.ac.nz



My area of research interest is experimental condensed matter physics, with a particular focus on growing thin films of novel materials and determining their structural and electronic properties. This work involves collaboration with numerous students, postdocs, and academics at VUW and the MacDiarmid Institute, and at other institutions in New Zealand and around the world. My current research projects include growing and characterising thin films of rare-earth nitrides and transition metal nitrides.

B.M. Ludbrook, I. L. Farrell, M. Kuebel, B.J. Ruck, A.R.H. Preston, H.J. Trodahl, L. Ranno, R.J. Reeves, and S.M. Durbin, *Growth and properties of epitaxial GdN*, J. Appl. Phys., accepted for publication (2009).

B.J. Ruck, *Spintronics potential of rare-earth nitrides*, chapter in book "Nanomagnetism and Spintronics: Fabrication, Materials, Characterization and Applications", editors Farzad Nasirpouri and Alain Nogaret, World Scientific Publishing Co. Pte. Ltd., (2009) (ISBN: 978-981-4273-05-3).

S. Granville, C. Meyer, A.R.H. Preston, B. Ludbrook, B.J. Ruck, H.J. Trodahl, T.R. Paudel, and W.R.L. Lambrecht, *Vibrational properties of rare-earth nitrides: Raman spectra and theory*, Phys. Rev. B **79**, 054301 (2009).

S. Granville, B.J. Ruck, A.R.H. Preston, T. Stewart, F. Budde, A. Bittar, H.J. Trodahl, J.E. Downes, M. Ridgway, *Electronic properties of (Ga,Mn)N thin films with high Mn content*, J. Appl. Phys. **104**, 103710 (2008).

C. Meyer, B.J. Ruck, J. Zhong, S. Granville, A.R.H. Preston, G.V.M. Williams, and H.J. Trodahl, *Near-zero-moment ferromagnetism in the semiconductor SmN*, Phys. Rev. B **78**, 174406 (2008).

A.R.H. Preston, B.J. Ruck, L.F.J. Piper, A. DeMasi, K.E. Smith, A. Schleife, F. Fuchs, F. Bechstedt, J. Chai, R. Mendelsberg, and S.M. Durbin, *Band structure of ZnO from resonant x-ray emission spectroscopy*, Phys. Rev. B **78**, 155114 (2008).

A.R.H. Preston, S. Granville, D.H. Housden, B. Ludbrook, B.J. Ruck, H.J. Trodahl, A. Bittar, G.V.M. Williams, J.E. Downes, Y. Zhang, A. DeMasi, K.E. Smith and W.R.L. Lambrecht, *Comparison between experiment and calculated band structures for DyN and SmN*, Phys. Rev. B **76**, 245120 (2007).

H.J. Trodahl, A.R.H. Preston, J. Zhong, B.J. Ruck, N.M. Strickland, C. Mitra, and W.R.L. Lambrecht, *Ferromagnetic red shift of the optical gap in GdN*, Phys. Rev. B **76**, 085211 (2007).

S. Granville, B.J. Ruck, F. Budde, A. Koo, D. Pringle, F. Kuchler, A.R.H. Preston, D.H. Housden, N. Lund, A. Bittar, G.V.M. Williams, and H.J. Trodahl, *Semiconducting ground state of GdN thin films*, Phys. Rev. B **73**, 235335 (2006).

B.J. Ruck, A. Koo, U.D. Lanke, F. Budde, S. Granville, H.J. Trodahl, A. Bittar, J.B. Metson, V.J. Kennedy, and A. Markwitz, *Quantitative study of molecular N₂ trapped in disordered GaN:O films*, Phys. Rev. B **70**(23), 235202 (2004).

A. Ballestad, B.J. Ruck, M. Adamcyk, T. Pinnington, and T. Tiedje, *Evidence from the surface morphology for nonlinear growth of epitaxial GaAs films*, Phys. Rev. Lett. **86**, 2377 (2001).

Denis Sullivan, PhD (ANU), Professor

Astrophysics

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My research interests are in a number of areas of stellar astrophysics and astronomy. One activity involves the study of compact stars (primarily white dwarfs) using the techniques of asteroseismology, in which the photometrically detected pulsation modes of these stars are used to probe their interior structures and physical processes. Some of this work is undertaken in collaboration with international colleagues, including the Whole Earth Telescope (WET) group and University of Texas (Austin) astronomers. The work involves instrumentation development, with the current focus on use of a frame-transfer CCD photometer for undertaking the time-series photometry. Another major research activity is undertaken as part of the NZ/Japan MOA (Microlensing Observations in Astrophysics) collaboration, and it employs transient gravitational microlensing events as astrophysical probes. These events are detected via a photometric survey programme using the Japanese-funded 1.8 metre telescope installed at the University of Canterbury's Mt John facility at Lake Tekapo. A key theme of this particular research is a search for extrasolar planets.

- D.J. Sullivan, T.S. Metcalfe, D. O'Donoghue et al. (the WET Collaboration, 24 authors), "Whole Earth Telescope observations of the hot helium atmosphere pulsating white dwarf EC20058-5234", *Monthly Notices of the Royal Astronomical Society*, 387, 137-152 (2008).
- D.J. Sullivan, A. Korpela and P. Chote, "The Wellington microlensing modelling programme", in *Proceedings of the Manchester Microlensing Conference: The 12th International Conference and ANGLES Microlensing Workshop*, eds. E. Kerins, S. Mao, N. Rattenbury and L. Wyrzykowski, PoS(GMC8)002 (2008), (<http://pos.sissa.it/cgi-bin/reader/conf.cgi?confid=54>)
- B.S. Gaudi, D.P. Bennett, A. Udalski, ... D.J. Sullivan et al. (69 authors), "Discovery of a Jupiter/Saturn analogue with gravitational microlensing", *Science* 319, 927-930 (2008).
- J.-P. Beaulieu, D.P. Bennett, P. Fouque, ... D.J. Sullivan et al. (73 authors), "Discovery of a cool planet of 5.5 Earth masses through gravitational microlensing", *Nature*, 439, pp437-440, (2006).
- D.J. Sullivan, "EC20058-5234: a DBV white dwarf and a possible plasmon neutrino detector", *14th European Workshop on white dwarfs, ASP Conference Series 334*, pp495-500 (2005).
- D.E. Winget, D.J. Sullivan, T.S. Metcalfe, S.D. Kawaler and M.H. Montgomery, "A strong test of electroweak theory using pulsating DB white dwarf stars as plasmon neutrino detectors", *The Astrophysical Journal* 602, L109-L112 (2004).
- A.S. Mukadam, F. Mullally, R.E. Nather, ... D.J. Sullivan et al. (18 authors), "Thirty five new pulsating DA white dwarf stars", *The Astrophysical Journal* 607, pp982-998 (2004).
- S. Jha, D. Charbonneau, P.M. Garnavich, D.J. Sullivan, T. Sullivan, T.M. Brown, and J.L. Tonry. "Multicolor observations of a planetary transit of HD209458", *Astrophysical Journal Letters*, 540 L45-L48 (2000).

Gillian Turner, PhD (*Edinburgh*), Senior Lecturer

Palaeomagnetism, Geomagnetism

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My research interests centre on Earth's magnetic field, particularly its polarity reversals and secular variation, and what they mean for the geodynamo in Earth's core. My recent work has centred on series of polarity reversals recorded in Miocene – Pliocene sedimentary sequences throughout New Zealand, particularly Wanganui Basin and Northwest Nelson. We are working closely with Waikato University to develop an integrated chronology of sedimentation in the Wanganui Basin, which will combine magnetostratigraphy with sequence stratigraphy and biostratigraphy. In NW Nelson our studies involve the development and interpretation of high-resolution records of the magnetic field changes as the polarity actually reverses. Our research group maintains collaborations with the National Oceanography Centre, Southampton, UK and the Australian National University, Canberra, as well as Waikato and Otago Universities within New Zealand.

I am also passionate about effective physics teaching and the promotion of science amongst school students and their teachers. We organise workshops for school physics teachers, and have introduced the SCPS schools programme, which brings groups of school children into the university to experience hands-on physics and chemistry for themselves. SCPS hosts the Annual Wellington Science and Technology Fair, for Year 7 – 13 students from throughout the Greater Wellington Region.

Bernd Striewski, Christoph Mayr, John Flenley, Rudolf Naumann, Gillian Turner, and Andreas Lucke. Multi-proxy evidence of late Holocene human-induced environmental changes at Lake Pupuke, Auckland (New Zealand). *Quaternary International*, 202, 69-93, **2009**.

Hidefumi Tanaka, Naoyuki Komuro and Gillian M. Turner. Palaeosecular variation for 0.1--21 Ka from the Okataina Volcanic Centre, New Zealand. *Earth Planets Space*, 60, 1-16, **2008**.

Ingham, M. & Turner, G., **2008**. A model of the Matuyama-Brunhes transition using Gauss coefficients. *Physics of the Earth and Planetary Interiors*, doi:10.1016/j.pepi.2008.06.008. (contribution approx. 40%)

G.M.Turner, J.L.Rasson and C.V.Reeves. Article title; Observation and Measurement Techniques, Schubert, G. (ed) *Treatise on Geophysics. Volume 5 (Geomagnetism)*, pp93-146. Oxford: Elsevier Ltd (**2007**).

Gillian M.Turner, Daniel M. Michalk, Hugh E.G. Morgans, Jan O. Walbrecker. Early Miocene magnetostratigraphy and a new palaeomagnetic pole position from New Zealand. *Earth Planets Space*, 59, 841-851, **2007**.

Gillian M. Turner, Peter J. J. Kamp, Avon P. McIntyre, Shaun Hayton, Donald M. McGuire, and Gary S. Wilson. A coherent middle Pliocene magnetostratigraphy, Wanganui Basin, New Zealand. *Journal of the Royal Society of New Zealand*, 35, 197-227, **2005**

Turner, Gillian M., **2001**. Toward an understanding of the multicomponent magnetization of uplifted Neogene marine sediments in New Zealand. *Journal of Geophysical Research*, 106, 6385-6397.

Grant Williams, PhD (*Victoria*), Professorial Research Fellow

Superconductors, magnetic nanoparticles, spin transport electronics, radiation detection and imaging, and nonlinear optics.

Email – grant.williams@vuw.ac.nz



My research activity is in the general area of experimental solid state physics. I am involved in a number of different programmes that range from fundamental to applied research. The current topics include radiation imaging and dosimetry, iron and copper based superconductors, spin transport electronics, magnetic nanoparticles, and nonlinear optics. The applied research includes the development of prototypes (e.g. a fibre optic dosimeter, 2D dosimeters, etc) and working with New Zealand end users and companies. There is extensive collaboration with researchers in New Zealand (e.g. VUW, GNS Science, IRL, UoC) and overseas (e.g. Leipzig University). The research is funded by the MacDiarmid Institute for Advanced Materials and Nanotechnology, the New Zealand Marsden Fund and the New Zealand Ministry of Science and Innovation.

Selected recent publications:

- 1) G. V. M. Williams, Y. Kutuvantavidia, S. Janssens, My T. T. Do, S. G. Raymond, M. Dhuiyan, N. Denton, and A. J. Kay "The effects of excited state lifetime, optical intensity and oxygen quenchers on the photostability of zwitterionic chromophores", *J. Appl. Phys.* (in press).
- 2) G. V. M. Williams, M. Jurkutat, D. Rybicki, and J. Haase, "Cu nuclear magnetic resonance study of Pr_{1.85}Ce_{0.15}Cu_{1-x}Ni_xO₄", *J. Phys.: Condens. Matter* (in press).
- 3) G. V. M. Williams and S. Raymond, "Fiber-optic-coupled RbMgF₃:Eu²⁺ for remote radiation dosimetry", *Radiation Measurements* (in press).
- 4) U. Skrzypczak, G. V. M. Williams, M. Miclea, M. Delower. H. Bhuiyan, S. Janseens, and S. Schweizer, "z-Scan Characterization of Zwitterionic Chromophores for Optoelectronic Switching" *Applied Physics A* (in press).
- 5) J. Beal, S. Prabakar, N. Gaston, G. The, P. Etchegoin, G. Williams, and R. Tilley, "Synthesis and Comparison of the Magnetic Properties of Iron Sulfide Spinel and Iron Oxide Spinel Nanocrystals", *Chemistry of Materials* 23, 2514 (2011).
- 6) J. Leveneur, J. Kennedy, G. V. M. Williams, J. Metson, and A. Markwitz "Large room temperature magnetoresistance in ion beam synthesised surface Fe nanoclusters on SiO₂", *Appl. Phys. Lett.* 98, 053111 (2011).
- 7) T. Meissner, S. W. Goh, J. Haase, G. V. M. Williams, and P. Littlewood, "High pressure changes in the 17O NMR spin shift pseudo-gap in YBa₂Cu₄O₈", *Phys. Rev. B* 83, 220517(R) 2011.
- 8) S. Janssens, G. V. M. Williams, and D. Clarke, "Systematic Study of LaF₃:Eu³⁺ Nanoparticles", *J. Appl. Phys.* 109, 023506 (2011).

For more information please visit

<http://www.macdiarmid.ac.nz/researchers/williams.php> ,

<http://www.vuw.ac.nz/xray/> and

<http://www.victoria.ac.nz/scps/research/research-groups/spintronics/default.aspx>

Ulrich Zülicke, PhD (*Indiana*), FNZIP, Professor

Theoretical condensed matter physics

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My current research is focused on the theory of functional nanostructures. Using methods of theoretical condensed-matter physics, I am working on descriptions of quantum transport in mesoscopic (i.e., small and/or low-dimensional) conductors. Examples of such structures comprise, e.g., two-dimensional semiconductor heterostructures and quantum wires. Most recently, the subfield of spin electronics has captured my strongest interest. Its objective is to explore ways to control electronic (charge) current by manipulating the electron's intrinsic angular-momentum (i.e., spin) state. In addition to working on purely theoretical problems, I enjoy collaborating with experimentalist colleagues on projects of mutual interest.

- T. Kernreiter, M. Governale, A.R. Hamilton, and U. Zülicke, “*Charge transport by modulating spin-orbit gauge fields for quasi-one-dimensional holes*,” *Applied Physics Letters* 98,152101:1-3, **2011**.
- R. Winkler and U. Zülicke, “*Invariant expansion for the trigonal band structure of graphene*,” *Physical Review B* 82, 245313:1-9, **2010**.
- M. Jääskeläinen and U. Zülicke, “*Anomalous spin-related quantum phase in mesoscopic hole rings*,” *Physical Review B* 81, 155326:1-6, **2010**.
- P. Ingenhoven, J.Z. Bernád, U. Zülicke, and R. Egger, “*Features due to spin-orbit coupling in the optical conductivity of single-layer graphene*,” *Physical Review B* 81, 035421:1-6, **2010**.
- J. Brand, T.J. Haigh, and U. Zülicke, “*Rotational fluxons of Bose-Einstein condensates in coplanar double-ring traps*,” *Physical Review A* 80, 011602(R):1-4, **2009**.
- D. Csontos, P. Brusheim, U. Zülicke, and H. Q. Xu, “*Spin-3/2 physics of semiconductor hole nanowires: Valence-band mixing and tunable interplay between bulk-material and orbital bound-state spin splitting*,” *Physical Review B* 79, 155323:1-16, **2009**.
- D. Csontos and U. Zülicke, “*Tailoring hole spin splitting and polarization in nanowires*,” *Applied Physics Letters* 92, 023108:1-3, **2008**.
- R. Winkler, U. Zülicke, and J. Bolte, “*Oscillatory multiband dynamics of free particles: The ubiquity of zitterbewegung effects*,” *Physical Review B* 75, 205314:1-10, **2007**.
- T. Schäpers, V.A. Guzenko, M.G. Pala, U. Zülicke, M. Governale, J. Knobbe, and H. Hardtdegen, “*Suppression of weak antilocalization in GaInAs/InP narrow quantum wires*,” *Physical Review B* 74, 081301(R):1-4, **2006**.
- R. Danneau, O. Klochan, W.R. Clarke, L.H. Ho, A.P. Micolich, M.Y. Simmons, A.R. Hamilton, M. Pepper, D.A. Ritchie, and U. Zülicke, “*Zeeman splitting in ballistic hole quantum wires*,” *Physical Review Letters* 97, 026403:1-4, **2006**.
- A.I. Signal and U. Zülicke, “*Tunable entanglement generation for mobile-electron spin qubits*,” *Applied Physics Letters* 87, 102102:1-3, **2005**.
- J. Eroms, D. Weiss, J De Boeck, G. Borghs, and U. Zülicke, “*Andreev reflection at high magnetic fields: Evidence for electron and hole transport in edge states*,” *Physical Review Letters* 95, 107001:1-4, **2005**.

RESEARCH FACILITIES IN THE SCHOOL

To facilitate the School's wide spectrum of chemistry and physics research, we are well equipped with standard and specialised equipment, including those instruments listed below.

The School also hosts a glass-blowing facility and electronic & mechanical workshops for customised support of our facilities.

| | |
|---|--|
| Nuclear magnetic resonance 2 instruments devoted to soft matter research 3 instruments devoted to chemical structure identification: 600, 500, 300 MHz | Rheology Controlled stress and controlled strain rheometers |
| Microscopy Transmission electron microscope 2 Scanning electron microscopes (including high resolution cryo SEM) 2 Atomic force microscopes (multimode and bioscope) A range of optical microscopes | Particle size Laser based particle size analyser (both SLS and DLS, and zeta potential) Furnace Radio frequency induction furnace Other electrically heated furnaces |
| Spectroscopy 2 Raman Micro Raman 2 Fluorescence 2 Infrared Visible / Ultraviolet Atomic absorption Ultrafast laser spectroscopy High resolution mass spectrometer | Thermal analysis Differential scanning calorimeter (DSC) Thermal gravimetric analysis (TGA) Palaeomagnetic laboratory Including spinner and cryogenic rock magnetometers, thermal and alternating field demagnetizing equipment, pulse magnetizer and magnetic susceptibility meters. Rock drills and lake sediment corers for the collection of palaeomagnetic samples. |
| X-ray diffraction Powder XRD Laue XRD Small-Angle X-ray scattering | Ellipsometry Ellipsometer Astronomy Frame-Transfer CCD photometer |
| Irradiation Frequency-doubled (Ar/BBO) visible/UV laser 2 X-ray generators Amplified Ti:Sapphire femtosecond laser | Photovoltaic characterization Spectrally resolved photocurrent Source measurement unit |
| Surface area BET surface area | 2 gloveboxes |
| Clean Room Facility Karl Suss Mask Aligner Sputter coater Evaporator Reactive Ion Etching Dektak Spin coaters | |

Nuclear magnetic resonance spectroscopy is used in the study of molecular dynamics and organisation in soft matter and porous materials. This is supported by **rheology**, **ellipsometry** and **light scattering** to investigate the mechanics of materials. **Nuclear**

magnetic resonance spectroscopy is also used to probe the structure of molecules along with techniques such as **infra-red, visible, ultraviolet and Raman spectroscopy**.

The structure of nanomaterials is elucidated using **scanning electron microscopy, transmission electron microscopy, and atomic force microscopy**.

The bulk properties of materials are investigated using **particle size analysis** and **surface area measurements** along with techniques such as **powder X-ray diffraction** and **Laue X-ray diffraction**.

Specialised glasses are produced using a **radio frequency induction furnace**. The application of this type of work requires a **15 W Argon ion laser** and **fluorescence spectroscopy**.

Raman spectroscopy is used to examine the properties of superconductors and develop methods for detecting single molecules of substances.

Ultrafast laser spectroscopy is used to measure the excited state dynamics of molecules and materials, including those used for solar cells. The opto-electronic response of solar cells is measured using a **spectrally-resolved photocurrent** instrument.

Liquid chromatography is used in the isolation, detection and measurement of bioactive compounds while **gas chromatography-mass spectrometry** allows analysis of volatile compounds in a variety of applications.

The way materials behave when heated is examined using **differential scanning calorimetry** and **thermal gravimetric analysis**.

GENERAL INFORMATION

Students are encouraged to view the websites for current information.

POSTGRADUATE RESEARCH SUPERVISION

Academic Board requires all supervisors to provide six-monthly written reports on students enrolled in Master's by thesis and PhD courses. These reports are expected to identify what has been achieved, outline agreed timetables for future work and identify any problems with a student's performance that require to be rectified. Copies of the formal written reports are provided to the student and the School's Postgraduate Coordinator, and put on file in the Faculty Student Administration Office.

Theses are prepared and written in close consultation with a staff member who acts as supervisor. Research students are expected to participate in and contribute to research-in-progress seminars organised from time to time by the School.

FUNDING

The Research Funding Guide is published by the University's Research Policy Office and is available on the University website at www.victoria.ac.nz/home/publications/research_funding_guide.pdf

The Postgraduate Students' Association has information on StudyLink funding. www.victoria.ac.nz/pgsa

POSTGRADUATE SCHOLARSHIPS, PRIZES AND GRANTS

Students should check out the University's Prizes and Scholarships database, accessible at: www.victoria.ac.nz/scholarships

Faculty Research Grants and Summer Scholarships may also be available. margot.neas@vuw.ac.nz: Contact Margot Neas for more information
www.victoria.ac.nz/science/study/summer-scholarships.aspx: Summer scholarships

POSTGRADUATE STUDENTS' ASSOCIATION

www.victoria.ac.nz/pgsa: Provides representation and other services for all Victoria's postgraduate students.
pgsa-members-subscribe@vuw.ac.nz: Subscribe to the PGSA email list

VICTORIA OVERSEAS EXCHANGE (VIC OE)

Students studying course-taught postgraduate studies are able to participate in an exchange, however not all of our partner universities are open to postgraduate students – please talk to the Student Exchange Office about which universities will be open to you. www.victoria.ac.nz/exchange/

STUDENT SUPPORT SERVICES

Student Services provides a range of services to all students to help you make the most of your time at university. If you have an issue, need guidance to get through your studies, help is available.

www.victoria.ac.nz/home/viclife/studentsservice/default.aspx

STUDENT AND ACADEMIC SERVICES - FACULTY OF SCIENCE

Te Wāhanga Pūtaiao

Address: Level 1, Cotton Building

Phone: 04-463 5101

Email: science-faculty@vuw.ac.nz

Web: www.victoria.ac.nz/science

Hours: 8.30 am – 5 pm Monday, Wednesday, Thursday, Friday
9.30 am – 5pm Tuesday

At the Faculty of Science Student Administration Office **student advisers** can help with admission requirements, degree planning, changing courses, transfer of credit from other tertiary institutions, and anything else that may crop up during your time at Vic. They also deal with other aspects of student administration such as enrolment, exams organisation and the maintenance of student records.

The advisers support students throughout their study. To ensure you get good continuity of personal service, advisers manage a particular group of students, identified by the first letter of your surname:

| Area | Student Advisor | Email | Contact |
|-------------|------------------------|--|----------------|
| A-H | Patricia Stein | patricia.stein@vuw.ac.nz | 04-463 5982 |
| I-Q | Rachel Zhang | rachel.zhang@vuw.ac.nz | 04-463 5983 |
| R-Z | Janelle Parry | janelle.parry@vuw.ac.nz | 04-463 5981 |

| | | |
|----------------------|--|------------------|
| Johan Barnard | Manager, Student and Academic Services | Tel: 04-463 5980 |
| Shona de Sain | Associate Dean (Students) | Tel: 04-463 5092 |

TE RŌPŪ ĀWHINA

Address: Cotton Building, Kelburn Parade, Room 148,
Phone: 04-463 5987
Email: teropuawhina@gmail.com
Web: www.victoria.ac.nz/science/awhina

Te Rōpū Āwhina whānau in the Faculties of Science, Engineering and Architecture and Design at Victoria University of Wellington was established in 1999. Āwhina is about people and collective success. The kaupapa of Āwhina is to produce Māori and Pacific science, engineering, architecture and design professionals to contribute to Māori and Pacific community and leadership development. Anyone who assists the building of Āwhina is part of the whānau.

STUDENT AND ACADEMIC SERVICES - FACULTY OF HUMANITIES AND SOCIAL SCIENCES

Te Wāhanga Aronui

Address: Level 4, Murphy Building
Phone: 04-463 5745
Email: fhss-student-admin@vuw.ac.nz
Web: www.victoria.ac.nz/fhss
Hours: 10:30 am – 4 pm Monday, Wednesday, Thursday, Friday
12:00 – 5 pm Tuesday

Dr Kristina McGuinness-King Manager, Student and Academic Services
Tel: 04-463 5192

Dr Kathryn Sutherland Associate Dean (Students)
Tel: 04-463 5795