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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. Physics and chemistry 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 or the discovery of bioactive natural products from New Zealand marine organisms through to theoretical physics, astrophysics and geophysics. 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 in 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.

Prof Ulrich Zuelicke, Head of School
School of Chemical and Physical Sciences

## IMPORTANT DATES 2014

| | |
|---|---|
| Trimester 1 | 3 Mar |
| Good Friday | 18 Apr |
| Easter Monday | 21 Apr |
| Anzac Day | 25 Apr |
| Mid trimester break | 21 Apr – 03 May |
| Graduation | 13 – 15 May |
| Queen’s Birthday | 2 Jun |
| Examinations | 13 Jun – 02 Jul |
| Mid year break | 3 Jul – 12 Jul |
| Trimester 2 | 14 Jul |
| Mid trimester break | 25 Aug – 6 Sep |
| Examinations | 24 Oct – 15 Nov |
| Labour Day | 27 Oct |
| Trimester 3 | 17 Nov |
| Graduation | 10 – 11 Dec |

## TIMETABLE

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

## SCHOOL OF CHEMICAL AND PHYSICAL SCIENCES
## TE WANANGA MATU

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 Ulrich Zuelicke | 406a | 463 6851 |
| **Deputy Head of School:** | A/Prof Richard Tilley | 006 | 4635016 |
| **Manager, School Administration:** | Kara Eaton<br>kara.eaton@vuw.ac.nz | 406 | 463 5946<br>0275645946 |
| **General Enquiries:** | Maryke Barnard<br>scps@vuw.ac.nz | 101 | 463 5335 |
| **Chemistry Enquiries:** | | | |
| BSc (Hons) & MSc Part 1 | Assoc Prof Martyn Coles | 413 | 463 6357 |
| MSc / PhD | Dr Matthias Lein | 505 | 463 6926 |
| **Physics Enquiries:** | | | |
| BSc (Hons) | Dr Ben Ruck | 506 | 463 5089 |
| MSc / PhD | Dr Petrik Galvosas | 404 | 463 6062 |
| **Laboratory Operations Manager:** | Dr Gordon Heeley | 104 | 463 5955<br>0211301592 |
| **MATE Programme Director** | Dr Paul Smith | 414 | 463 5479 |

## Chemistry

| Academic Staff | Research Areas | Room | Contact |
|---|---|---|---|
| A/Prof Martyn Coles | *Catalysis, organometallic chemistry, hydrogen-bonded materials* | 413 | 463 6357 |
| Dr Robin Fulton | *Inorganic synthesis and mechanisms, environmental chemistry* | 524 | 463 9799 |
| Dr Nicola Gaston | *Theoretical quantum chemistry, electronic structure in nanomaterials, clusters* | 514 | 463 6519 |
| Dr Jonathan Halpert | *Nanostructured materials for optoelectronic device applications* | 204 | TBA |
| Dr Joanne Harvey | *Total synthesis, design and synthesis of natural product analogues, organic reaction methodology* | AM207 | 463 5956 |
| Dr Justin Hodgkiss | *Ultrafast laser spectroscopy, conjugated polymers, organic solar cells* | AM209 | 463 6983 |
| Prof James Johnston | *Applied chemistry; new materials, nano-structured and nano-hybrid materials, new products and technology development and commercialisation* | 303 | 463 5334 |
| Dr Rob Keyzers | *Natural products, food and wine chemistry, NMR spectroscopy and mass spectrometry* | AM208 | 463 5117 |
| Dr Matthias Lein | *Computational and Theoretical chemistry* | 505 | 463 6926 |
| Prof Kathryn McGrath | *Soft matter, biophysical chemistry and materials science* | 409 | 463 5963 |
| A/Prof Peter Northcote | *Natural products, NMR spectroscopy* | 412 | 463 5960 |
| Dr Rhian Salmon | *Science in Context: Scientist-centres communication, polar science, communication of climate change, interdisciplinary research* | AM | 463 5507 |
| Prof John Spencer | *Organometallic chemistry* | TBA | 463 5119 |
| Dr Bridget Stocker | *Immunoglycomics, bio-organic, green chemistry* | 508 | 463 6481 |
| A/Prof Richard Tilley | *Nanoparticle research and electron microscopy* | 006 | 463 5016 |
| Dr Mattie Timmer | *Immunoglycomics, design and synthesis of glyconjugate probes* | 507 | 463 6529 |

**Senior Teaching Fellow**

| | | | |
|---|---|---|---|
| Suzanne Boniface | *Chemistry education* | 101a | 463 6485 |

**Professorial Research Fellows:**

| | | | |
|---|---|---|---|
| Dr Kenneth MacKenzie | *Materials chemistry, solid-state NMR spectroscopy of inorganic materials, ecologically-friendly materials* | 511 | 463 5885 |
| Dr Gerald Smith | *Photochemistry, protection of materials, heritage science* | 522 | 463 5547 |

**Emeritus Professors:**

| | | | |
|---|---|---|---|
| Prof Neil Curtis | | 102 | 463 6514 |
| Prof Brian Halton | | 102 | 463 5954 |

## Physics

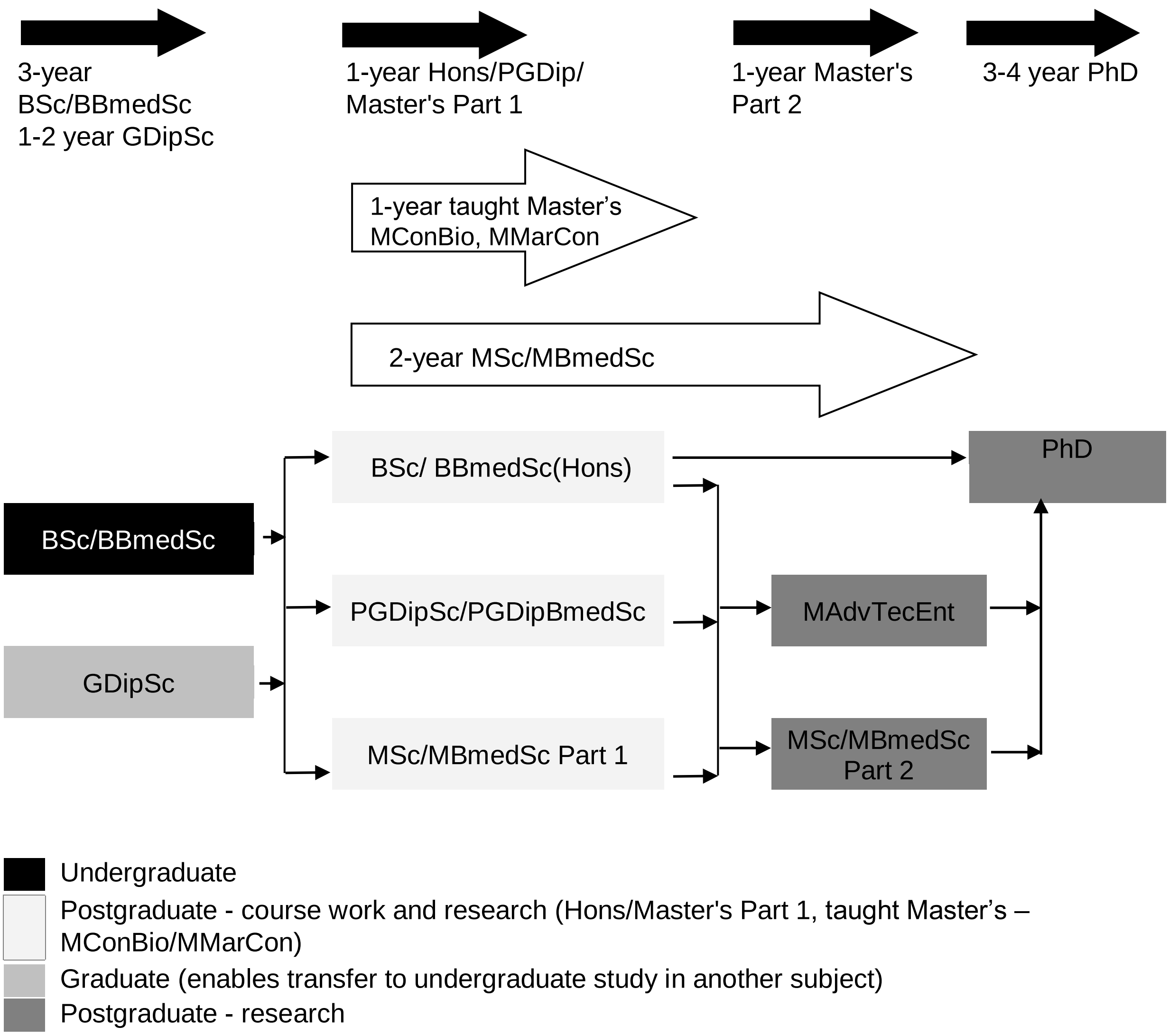
| Academic Staff | Research Areas | Room | Contact |
|---|---|---|---|
| A/Prof Andy Edgar | *Glasses, glass ceramics, radiation imaging and dosimetry, spin-dependent effects in organic conductors, OLEDs* | 519 | 463 5949 |
| A/Prof Michele Governale | *Theoretical condensed-matter physics, quantum transport in nanoscale systems* | 402 | 463 5951 |
| Prof Shaun Hendy | *Computational materials science and nanotechnology* | 510 | 463 5809 |
| Dr Malcolm Ingham | *Environmental physics, geophysics* | 515 | 463 5216 |
| Dr Melanie Johnston-Hollitt | *Astrophysics: Radio astronomy, Galaxy clusters and Large-scale structure* | 502 | 463 6543 |
| Dr Franck Natali | *Novel materials for electronic and optoelectronic applications* | 516 | 463 5964 |
| A/Prof Eric Le Ru | *Electromagnetism, fluorescence and Raman spectroscopy* | 205 | 463 5233 ext. 7509 |
| Dr Natalie Plank | *Electronic device properties of nanomaterials* | 503 | 463 5031 |
| Dr Rebecca Priestley | *Science in Context: history of science, science communication, creative science writing* | AM205 | 463 5233 ext 7194 |
| Dr Ben Ruck | *Experimental condensed matter physics* | 506 | 463 5089 |
| Prof Denis Sullivan | *Astrophysics: white dwarf stars, extrasolar planets* | 501 | 463 5962 |
| A/Prof Gillian Turner | *Geophysics, geomagnetism* | 521 | 463 6478 |
| Prof Ulrich Zuelicke | *Theoretical condensed-matter physics, nano-electronic transport and spin-electronic devices, cold-atoms systems* | 406 | 463 6851 |
| **Senior Research Fellow:** | | | |
| Dr Petrik Galvosas | *NMR methodologies for molecular dynamics in soft matter and porous material, NMR instrumentation* | 404 /308 | 463 6062 /5911 |
| **Senior Teaching Fellows:** | | | |
| John Hannah | | 511 | 463 5223 |
| Dr Howard Lukefahr | | AM217 | 463 5355 |
| **Professorial Research Fellows:** | | | |
| Dr John Lekner | *Optics, electromagnetism and quantum theory* | 513 | 463 5959 |
| Dr Grant Williams | *Superconductors, magnetic nanoparticles, spin transport electronics, radiation detection and imaging, and nonlinear optics* | 523 | 463 5544 |
| **Emeritus Professors:** | | | |
| Prof Alan Kaiser | *Electronic properties of novel materials, especially nanoscale materials* | 508 | 463 5957 |
| Prof Joe Trodahl | *Ferromagnetic semiconductors for spintronics, ferroelectric oxides, heat flow in sea ice* | 516 | 463 5964 |

# 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.

The diagram below represents the structure of postgraduate study in science.



## POSTGRADUATE STUDY

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

- A one year programme
- Has a research project with the balance (62-75%) in taught postgraduate courses
- 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:

- One semester fulltime or up to two 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:

- One year fulltime or up to four years part-time
- Usually consists of course work and a research project (120 points total) 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:

- Two years fulltime or up to four years part-time
- Permits an extension of six months with academic support, thus allowing up to 2.5 years fulltime study or five years part-time
- Consists of PG course work in the first year and usually includes research preparation
- Admission to Part 2 based on academic performance in Part 1 or BSc(Hons)
- The second year involves 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)

## 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 69).

The School also hosts a glass-blowing facility and electronic & mechanical workshops for technical support for our research activities.

# MASTER OF ADVANCED TECHNOLOGY ENTERPRISE

The Master of Advanced Technology Enterprise (MATE) is an interdisciplinary one year research programme, the first of its kind in New Zealand. The programme explores the relationship between scientific research and commercial product development by establishing teams developing high-value enterprises from research projects with real commercial potential.

Through its unique practical approach, the programme explores the many challenges of creating successful technology enterprises, such as coping with an extended development time-frame and technology risks, balancing the often conflicting relationship between research and commercial product development, and applying best practice business activities focussed around advanced technology.

The MATE programme is open to graduates of science, engineering, design, commerce and law, and graduates from other disciplines with appropriate backgrounds. MATE creates an entrepreneurial team environment to allow students to gain knowledge, skills and experience in taking an advanced technology to market.

Within the enterprise, each student assumes individual responsibilities that, when combined, form a dynamic team capable of developing a viable product concept. Students from any discipline are invited to apply to the MATE programme. In each case the individual will inject specific discipline expertise into the team. Their role will draw on expertise gained from previous study and work experiences, and will be shaped by the needs of the particular project and enterprise.

## MATE FOR SCIENTISTS

Scientists are the link between scientific research and the advanced technology enterprise. Goals of research and commerce are quite different, so the scientist must manage the relationship with the research team and ensure that research and commercial development activities are mutually compatible. The scientist understands the scientific method and, while they may not possess expertise in the particular research science, they become the technology expert within the enterprise.

Supervision, mentoring and governance for the teams and individuals within the MATE programme is provided by staff from throughout Victoria University of Wellington, and by external commercial partners. Students learn from experienced technology entrepreneurs, academics and business experts, and build their own professional support network.

At the end of the year, teams present their enterprise to an audience of VUW staff, external programme supporters and potential investors. They aim to prove value added and development of the research towards a viable product—to secure further investment for the enterprise.

Individual research builds on the student’s prior knowledge. Research investigates the role of a discipline expert within a multi-disciplinary team, the team function, and entrepreneurship within an advanced technology enterprise. Students create a Master’s research thesis focused on their role, and aligned with the team outcomes.

Graduates leave having developed their discipline-specific skills within an advanced technology enterprise, added a deep understanding of advanced technology business practice, and developed into confident professionals capable of leading the next wave of new technology businesses.

## ENTRY REQUIREMENTS

1. A four-year degree, honours degree or relevant postgraduate diploma with a B+ average at 400-level from a university in New Zealand or, at the discretion of the Associate Dean (Students) of the Faculty of Science, another university
2. Approved by the Programme Director and the MAdvTecEnt Board of Studies as capable of proceeding with the proposed programme of study.
3. Requirement 1 may be waived by the Associate Dean (Students) of the Faculty of Science, for a candidate who has had extensive practical, professional or scholarly experience of an appropriate kind.

## GENERAL REQUIREMENTS

1. The course of study for the MAdvTecEnt shall consist of courses worth at least 135 points, comprising:
   - Part 1: ATEN 501 - a 15-point course run intensively over 4 weeks
   - Part 2: ATEN 591 - a 120-point thesis & development of business plan
2. Entry to Part 2 requires the successful completion of Part 1 with at least a B+ grade and acceptance by the Programme Director and Board of Studies.
3. Candidates must:
   - enrol full-time for Part 1 and Part 2; and
   - complete Part 1 and enrol in Part 2 in consecutive trimesters.

## ENROLMENT

1. Apply online at **http://www.victoria.ac.nz/home/admisenrol**
2. Programme start date is 21 January 2014

## APPLICATION / ENQUIRY CONTACT DETAILS

Paul Smith: paul.smith@vuw.ac.nz 04 4635479
Shona de Sain: shona.desain@vuw.ac.nz 04 4635092

| **ATEN 501** | CRN 25038 | **ADVANCED TECHNOLOGY ENTERPRISE DEVELOPMENT** | **15 PTS** | **3/3** |
|---|---|---|---|---|

Practical and theoretical frameworks used in development and initiation of an advanced technology enterprise start-up company are introduced, along with collective brainstorming, team development, collaboration and communication. Emphasis on pragmatic, practical learning in entrepreneurial behaviour development, while developing an advanced technology business idea, team formation and an independent research focus.

| **ATEN 591** | CRN 25039 | **ADVANCED TECHNOLOGY ENTERPRISE THESIS** | **120 PTS** | **1/2/3** |
|---|---|---|---|---|

An individual supervised piece of research undertaken within an integrated team environment working on the progression of an advanced technology enterprise. Students will actively participate in a structured seminar and peer-review programme. Their business plan will be presented to an expert panel including investors, as attracting funding is an integral part of the qualification.

## Paul Smith, PhD (*Nottingham*), MATE Programme Director

Email – **paul.smith@vuw.ac.nz**

After graduating from Nottingham University with an Honours degree in Mechanical Engineering and a PhD in the design of fibre-reinforced composite structures, I worked for five years in the automotive industry, firstly as a consultant, then for Land Rover. My area of expertise was craftsmanship – creating physical quality in mass-produced vehicles. This led to a position as leader of the Dimensional Variation Analysis group, establishing processes and collaboration in design, engineering and manufacturing to control quality in new vehicles. I left Land Rover to help establish a craftsmanship research group at Warwick University, before moving to New Zealand in 2004. I was a lecturer in Product Development at Massey University until 2011, where I created and led the 'Product Design Engineering' BE degree – co-taught by the Schools of Design and Engineering. Immediately before joining VUW, I worked for Formway Design in Lower Hutt. My Programme Director role is part-time, and in the remaining time, I encourage people to rediscover a childhood sense of adventure through Inspiring Riding Ltd, a start-up business promoting accessible bicycle adventures through print and digital media.

As the Programme Director I will be responsible for managing the Advanced Technology Enterprise academic programme, including the administration, academic quality and resources, and promotion of the programme within VUW and to external stakeholders, to achieve its wider goals of academic achievement and cross-disciplinary collaboration. I will also be responsible for student recruitment and experience, and manage the ongoing peer review and seminar programmes – attracting speakers from within VUW and from external companies and partners.

Supervision, mentoring and governance for the teams and individuals within the programme are provided by staff from throughout Victoria University of Wellington, and by external commercial partners. Individual supervisors are responsible for the academic progress of the students. Team mentors are used to guide the teams through the development of their enterprise.

For information about the programme contact either **shona.desain@vuw.ac.nz**, **paul.smith@vuw.ac.nz** or the Faculty of Science at **science-faculty@vuw.ac.nz**

# PLANNING A PROGRAMME IN CHEMISTRY

Chemistry is the study of matter is 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 | **Points** | Trimester |
|---|---|---|---|---|
| ↓ | ↓ | ↓ | ↓ | ↓ |
| **CHEM 423** | CRN 13727 | **PHYSICAL CHEMISTRY** | **15 PTS** | **1/3** |

## 400-LEVEL COURSES

| | | | | |
|---|---|---|---|---|
| **CHEM 421** | CRN 13725 | **ORGANIC & BIO-ORGANIC CHEMISTRY** | **15 PTS** | **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 PTS** | **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 PTS** | **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 PTS** | **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 PTS** | **2/3** |

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

| | | | | |
|---|---|---|---|---|
| **CHEM 441** | **CRN 13732** | **DIRECTED INDIVIDUAL STUDY** | **15 PTS** | **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 PTS** | **1/3** |
| | **CRN 13736** | | **15 PTS** | **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 PTS** | **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 course). 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 courses, 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 PTS** | **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 PTS** | **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.

# 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]
- Metal nanoclusters in catalysis. Investigation of the electron structure through quantum chemistry, with consideration of the influence of size, shape and composition on the catalytic activity and selectivity. [Nicola Gaston]
- Superatom complexes. Prediction of super atomic species (clusters of atoms that mimic the chemical reactivity of a halogen, for example) through electronic structure analysis of metal clusters and their complexes. [Nicola Gaston]

### *ENVIRONMENTAL ANALYTICAL CHEMISTRY*

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

### *ENVIRONMENTAL CHEMISTRY*

- Developing silica-supported Fe nanoparticles for use in the reductive degradation of organic pollutants [Robin Fulton]
- The development of 'protecting-group-free' methodologies for the synthesis of biologically active products [Mattie Timmer, Bridget Stocker]

### *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 artifacts and the development of methods for their conservation. [Ken MacKenzie]
- Stabilisation of natural biological fibres (cellulosic and/or proteinaeceous). [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*

*Biomineralisation (formation of hard tissue such as bones)*

- Crystallisation on and in a soft template: this project explores the synergistic interaction between a 2D and 3D soft template made from proteins and/or carbohydrates 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]
- 3D printing is explored as a way of generating synthetic biominerals. [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]

*Functional Materials*

- First-principles design of gas sensors for air quality with improved sensitivity and selectivity [Nicola Gaston]
- First-principles design of heterogeneous catalysts and understanding of solvent and substrate effects on activity [Nicola Gaston]

*Hydrogen-Bonded Molecules*

- The use of charge-assisted hydrogen bonds in the construction of 1-, 2- and 3-dimensional crystalline materials. [Martyn Coles]

*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*

- Modelling of nanoparticle geometric and electronic structure. Nanoparticles have properties that are defined by the exposed facets, which we model with the use of Density Functional Theory to provide understanding of stability and insight into a range of applications. We are also interested in the development of methods enabling the application of wavefunction-based theories to these large systems. [Nicola Gaston]
- 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, small angle X-ray scattering and scanning electron microscopy to investigate the relationship between molecular organisation and complex mechanical properties for liquid crystals, emulsions, colloids and gels. [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]
- Exploring the fundamental basis of emergent behaviour as generated by self assembly of soft matter. [Kathryn McGrath]

## *SYNTHETIC CHEMISTRY*

*Bio-organic*

- Synthesis and testing of small-molecule growth inhibitors of Mycobacterium tuberculosis. [Mattie Timmer, Bridget Stocker]
- Solid-phase combinatorial synthesis of natural product compound libraries. [Mattie Timmer, Bridget Stocker]
- Synthesis of aza-sugars as glycosidase inhibitors [Bridget Stocker, Mattie Timmer]
- Synthesis of analogues of bioactive natural products, with a focus on macrolactones, 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, Bridget Stocker,]
- Synthesis and evaluation of glycolipids for the development of improved anti-cancer vaccines. [Mattie Timmer, Bridget Stocker]
- Converting 'bad' immune cells to 'good': the role of glycolipids from bacteria in switching the immune response [Bridget Stocker, Mattie Timmer]

*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]
- Fundamental coordination chemistry of the metallic pnictogens, antimony and bismuth. [Martyn Coles]
- Cationic phosphorus compounds. [Martyn Coles]
- Heterometallic compounds as single-source precursors to nanostructured materials. [Martyn Coles]
- Group 14/16 compounds as precursors to crystalline semi-conducting materials. [Robin Fulton]
- Understanding the factors controlling the activation of $CO_2$ by metal alkoxide complexes, with ultimate goal of developing new methods for $CO_2$ sequestering. [Robin Fulton]
- Synthesis of low-coordinate main group and battery-group (Zn, Cd, Hg) complexes; trends in M-M bonding. [Robin Fulton]

*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, Bridget Stocker]

- Magnesium-based catalysts for catalytic organic transformations. [Martyn Coles]
- Polyguanidine compounds as ‘super-bases’ for organic chemistry. [Martyn Coles]

*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]
- Application of organometallic reaction cascades to organic synthesis. [Joanne Harvey]
- Bulky guanidine-substituted organosilicon ligands for the stabilization of unusual coordination geometries and oxidation-states in transition- and main group-metal chemistry. [Martyn Coles]
- The chemistry of group 13 alkyls complexes – a group 3 analog? [Robin Fulton]

*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 biologically active natural products using ‘green’ chemistry methodologies [Mattie Timmer, Bridget Stocker]
- Total synthesis of glycolipids with immunomoulatory properties [Bridget Stocker, Mattie Timmer]

## ***THEORY***

- Simulation of the melting behavior of nanoparticles. At what size do materials stop behaving like their bulk counterparts? How should we interpret a phase transition in a finite system, and how does this affect our understanding of thermodynamics?[Nicola Gaston]

## ***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*

Email – **martyn.coles@vuw.ac.nz**

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 phospha-Grignard reagent, Mg(P{SiMe$_3$}$_2$)Br(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**.

## J. Robin Fulton, PhD *(Berkeley)*, Senior Lecturer

*Carbon Dioxide Activation, Materials Precursors, and Environmental Degradation*

Email **– j.robin.fulton@vuw.ac.nz**

My research focuses on understanding how and why reactions occur, and utilizing this knowledge to create more active systems.
*Carbon dioxide activation*: Understanding the factors controlling the activation of $CO_2$ by metal alkoxide complexes, with ultimate goal of developing new methods for $CO_2$ sequestering.
*Materials precursors*: Developing single source precursors for the low-temperature synthesis of mixed group 12/16 and 14/16 thermoelectric materials. Along the way we are generating new molecules with novel bonding modes (ie M-M bonds).
*Environmental degradation*: Developing silica-supported Fe nanoparticles for use in the reductive degradation of organic pollutants.


Tam, E. C. Y.; Maynard, N. A.; Apperley, N. C.; Smith, J. D.; Coles, M. P.*; Fulton, J. R.*, "Group 14 Metal Terminal Phosphides: Correlating Structure with $|J_{MP}|$, *Inorg. Chem.*, **2012**, *51*, 9403 – 9415.

Ferro, L.; Hitchcock, P. B.; Coles, M. P.; Fulton, J. R.* "Reactivity of Divalent Germanium Alkoxide Complexs Is in Sharp Contrast to the Tin and Lead Analogues", *Inorg. Chem.*, **2012**, *51*, 1544 – 1551

Taylor, M. J.; Saunders, A. J.; Coles, M. P.; Fulton, J. R.*, "Low-Coordinate Lead and Tin Cations", *Organometallics,* **2011**, *30*, 1334 – 1339.

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Ferro, L.; Coles, M. P.; Day, I. J.; Fulton, J. R.*, "Taking Advantage of Hg-C Bonds: Synthesis of the First Homoleptic bis-β-Diketiminate Complex Bound through the γ-Carbons", *Organometallics*, **2010**, *29*, 2911-2915.

Johnstone, N. C.; Aazam, E. S.; Hitchcock, P. B.; Fulton, J. R.*, "Synthesis of aluminium complexes bearing a piperazine-based ligand system", *J. Organomet. Chem.*, **2010**, *695*, 170-176.

Tam, E. C. Y.; Johnstone, N. C.; Ferro, F.; Hitchcock, P. B. and Fulton, J. R.* "Carbon Dioxide Activation by "Non-nucleophilic" Lead Alkoxides", *Inorg. Chem.*, **2009**, 48, 8971-8976.

Fulton, J. R.*; Hitchcock, P. B.; Johnstone, N. C.; Tam, E. C. Y. "The Synthesis of Monomeric Terminal Lead Aryloxides: Dependence on Reagents and Conditions." *Dalton Trans.*, **2007**, 3360-3362.

Chen, M; Fulton, J. R;* Hitchcock, P. B; Johnstone, N. C.; Lappert, M. F. Protchenko, A. V. "Synthesis and Theoretical Studies on Rare Three-Coordinate Lead Complexes." *Dalton Trans.*, **2007**, 2770-2778.

## Nicola Gaston, PhD (*Massey*), Senior Lecturer

### *Electronic structure of nanomaterials*

Email – **nicola.gaston@vuw.ac.nz**

We study the electronic structure of nanomaterials using methods of quantum chemistry and solid-state physics, to understand how properties such as melting temperatures or chemical reactivities change with size and structure. We are particularly interested in understanding the complex changes in electronic structure that occur when you go from a simple pair of atoms, to larger clusters of atoms, and then to a bulk metal. There is a lot more variety than you would expect if you were just packing spheres in the same way that you stack oranges. For example, the structures of the elemental metals such as gold, iron, and tin, depend sensitively on the way the electrons interact within the lattice of atoms. Understanding the way that the electronic structure of a simple atom transforms into the distinct electronic properties of diverse materials is a real challenge for both theoretical development (how do you best solve Schrödinger's equation for large systems of thousands of atoms?) and for our computational resources. There are many different problems in nanotechnology where the electronic structure is key to understanding the nanoscale behaviour. This applies to the inherent stability of the nanomaterial (does it exist?) and to all the possible applications it may have (optical, electronic, magnetic, and catalytic behaviour). We are also interested in fundamental questions about the limits of the periodic table: at what point does the periodicity break down? And how well do we understand the boundary between metallic and non-metallic elements?

K. G. Steenbergen, N Gaston "First-principles melting of gallium clusters down to nine atoms: structural and electronic contributions to melting" *Phys. Chem. Chem. Phys.*(in press) **2013**.

D Mollenhauer, N Gaston, E Voloshina, B Paulus "Interaction of Pyridine Derivatives with a Gold (111) Surface as a Model for Adsorption to Large Nanoparticles" *The Journal of Physical Chemistry C* 117 (9), 4470-4479 (**2013**).

K. G. Steenbergen, D. Schebarchov, N. Gaston: "Electronic effects on the melting of small gallium clusters" *The Journal of Chemical Physics* 137, 144307 (**2012**).

D. Schebarchov, N. Gaston: "Throwing jellium at gallium—a systematic superatom analysis of metalloid gallium clusters" *Phys. Chem. Chem. Phys.* 13, 21109 (**2011**).

N. Gaston, D. Andrae, B. Paulus, U. Wedig, M. Jansen:"Understanding the hcp anisotropy in Cd and Zn: the role of electron correlation in determining the potential energy surface" *Phys. Chem. Chem. Phys.* 12, 681-687 (**2009**).

N. Gaston, S. Hendy:"Hydrogen adsorption on model tungsten carbide surfaces" *Catalysis Today* 146, 223-229 (**2009**).

## Jonathan E. Halpert, PhD *(MIT)*, Lecturer

*Nanostructured materials for optoelectronic device applications*

Email – **jonathan.halpert@vuw.ac.nz**

My interest is in the synthesis and characterization of nanostructured materials, such as semiconductor nanocrystals, organic perovskite crystals and polymer-inorganic hybrid materials for optoelectronic applications. These materials can be deposited via solution based processes like spin-casting, inkjet printing and roll-to-roll printing to make solar cells, light emitting devices (LEDs), photodetectors, sensors and other devices that make use of the unique optical and electronic properties of nanoscale materials. Thin film devices produced by these methods are just now beginning to replace older technologies in fields like displays, solar power generation and printable transistors.

At this time, we are focused on novel semiconductor nanocrystals and their use for energy generation as solar cells and thermoelectric devices. We are also currently working on organic perovskites based solar cells to improve device efficiency and determine how these devices work. After synthesizing and purifying our materials, our group makes and tests our own devices. In this way, our physics and applications studies are very much driven by ability to design and synthesize new materials. In collaboration with other groups at VUW, we can also use various ultrafast transient absorption and photoluminescence spectroscopic techniques to characterize the optical and electronic properties of these materials. And we can use these and more generic transient and steady-state electronic measurements to understand how these materials perform in devices. Group members can expect to cover all aspects of the process, from synthesis to characterization to device construction and testing, though with particular focus in one or more areas of interest. In this way our work is interdisciplinary while also generating specific areas of useful expertise.

We expect to collaborate with other groups at VUW and also at the University of Cambridge.

Halpert J.E., Morgenstern F., Vaynzof Y., Ehrler B., Greenham N.C. “Exciton and Charge Dynamics in Solution Processed Nanocrystalline $CuInS_2$ Solar Cells”, 2013, *in preparation*.

X. Lai, J.E. Halpert, D. Wang Recent Advances in Micro-/Nano-structured Hollow Spheres for Energy Applications: From Simple to Complex Systems Energy & Environmental Science 2012, 5 (2): 5604-5618

Halpert J.E., Tischler J.R., Nair G., Walker B.J., Liu W., Bulovic V., Bawendi M.G. Electrostatic Formation of Quantum Dot/J-aggregate FRET Pairs in Solution. Journal of Physical Chemistry C, 2009, 113: 9986–9992.

Anikeeva P.O.*, Halpert J.E.*, Bawendi M.G., Bulovic V. Quantum Dot Light-Emitting Devices with Electroluminescence Tunable over the Entire Visible Spectrum. Nano Letters 2009, 9: 2532-2536.

Wood V.*, Halpert J.E.*, Panzer M.J., Bawendi M.G., Bulovic V. Alternating Current Driven Electroluminescence from ZnSe/ZnS:Mn/ZnS Nanocrystals. Nano Letters 2009, 9: 2367-2371.

Caruge J.M.*, Halpert J.E.*, Wood V.*, Bulovic V, Bawendi MG. Colloidal quantum-dot light-emitting diodes with metal-oxide charge transport layers. Nature Photonics 2008, 2: 247-250.

## Joanne Harvey, PhD (*ANU*), Senior Lecturer

*Synthetic Organic Chemistry*

Email – **joanne.harvey@vuw.ac.nz**

My research in organic synthesis is target driven, with a focus on the synthesis of bioactive natural products and their analogues. This target-led research leads to the development of new chemical methodology.

One particular strength of my group is in the synthesis of macrolactone natural products and analogues. We have achieved the total synthesis of aigialomycin D and are working on novel analogues of zampanolide, pateamine, labillarides E-H and aigialomycin D.

Another arm of research is in utilising the reactivity of halogenated cyclopropanes fused to carbohydrates for preparing new structures. We are currently pursuing the synthesis of TAN-2483B and analogues with this methodology.

The discovery of new organometallic reactions is another interest. We have recently developed a palladium-catalysed allylic substitution cascade of non-symmetric bis-electrophiles. We are currently exploring its scope and utility in synthesis.


M. J. Bartlett, C. A. Turner, J. E. Harvey "Pd-Catalyzed Allylic Alkylation Cascade with Dihydropyrans: Regioselective Synthesis of Furo[3,2-*c*]pyrans", *Org. Lett.* **2013**, *15*, 2430–2433.

E.M. Casey, F. Tho, J.E. Harvey, P.H. Teesdale-Spittle, "Towards a Simplified Peloruside A: Synthesis of C1-C11 of a Dihydropyran Analogue", *Tetrahedron* **2011**, 67, 9376-9381

R. J. Hewitt, J. E. Harvey, "Synthesis of the (–)-TAN-2483B ring system via a D-mannose-derived cyclopropane", *Org. Biomol. Chem*., **2011**, 9, 998-1000. DOI: 10.1039/C0OB00851F.

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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.

## Justin Hodgkiss, PhD *(MIT)*, Senior Lecturer

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

Email – **justin.hodgkiss@vuw.ac.nz**

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.

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

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

Email – **jim.johnston@vuw.ac.nz**

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.

James H. Johnston, Kerstin A. Burridge and Fern M. Kelly: The Formation and Binding of Gold Nanoparticles onto Wool Fibres. *Advanced Materials and Nanotechnology.* Volume 1151,189-192 (2009).

James Johnston Chapter title: Nano-structured Calcium Silicate Phase Change Materials and their Applications in Packaging Temperature Sensitive Products. Book title: Composite Materials / Book 3 (ISBN 978-953-307-1099-2) (2011)

James H Johnston and Aaron C Small: Photoactivity of Nano-structured Calcium Silicate-Titanium Dioxide Composite Materials. J. Mater. Chem. DOI:10.1039/C0JM02685A. Vol 21, 1240-1245 (2011)

Kerstin A Burridge, James H. Johnston and Thomas Borrmann: Silver nanoparticle – Clay Composites. J. Mater. Chem., 21, 734-742 (2011).

Fern M Kelly and James H Johnston: Colored and Functional Silver Nanoparticle Wool Fiber Composites. *ACS Appl. Mater. Interfaces*, 3 (4), 1083–1092, (2011)

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James H Johnston and Thomas Nilsson: Nanogold and Nanosilver Composites with Lignin-containing Cellulose Fibres. *J. Mater. Science*. Vol. 47, Iss. 3, 1103-1112 (2012)

## Rob Keyzers, PhD (*VUW*), Senior Lecturer

*Organic and analytical chemistry*

Email – **rob.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.

E. G. Dennis, R. A. Keyzers, C. M. Kalua, S. M. Maffei, E. L. Nicholson and P. K. Boss "Grape contribution to wine aroma: Production of hexyl acetate, octyl acetate and benzyl acetate during yeast fermentation is dependent upon precursors in the must*", J. Agric. Food Chem*., **2012**, 60, 2638-2646..

P. G. K. Clark, M. Lein and R. A. Keyzers "Studies of the H-D exchange mechanism of malonganenone B." *Org. Biomol. Chem*., **2012**, 10, 1725-1729.

V. Venturi, C. Davies, A. J. Singh, J. H. Matthews, D. S. Bellows, P. T. Northcote, R. A. Keyzers, and P. H. Teesdale-Spittle "The protein synthesis inhibitors mycalamides A and E have limited susceptibility toward the drug efflux network." *J. Biochem. Mol. Toxicol*., **2012**, 26, 94-100.

I.L. Cockburn, E.-R. Pesce, J.M. Pryzborski, M.T. Davies-Coleman, P.G.K. Clark, R.A. Keyzers, L.L. Stephens and G.L. Blatch "Screening for small molecule modulators of Hsp70 chaperone activity using protein aggregation suppression assays: Inhibition of the plasmodial chaperone PfHsp70-1." *Biol. Chem*., **2011**, 392, 431-438.

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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

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

*Computational and Theoretical Chemistry*

Email – **matthias.lein@vuw.ac.nz**

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, J. A. Harrison, A. J. Nielson "Identification of non-classical C–HM interactions in early and late transition metal complexes containing the CH(ArO)3 ligand" *Dalton Trans.* **2013**, 42, 10939-10951

M. Lein, J. A. Harrison "Highly Fluxional [Y(C(SiH(CH3)2)3)3]: A DFT Characterization of Structure and NMR Spectra" *J. Chem. Theory Comput*. **2011** , 7, 385-389

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 $^-O_2C$-R-$CO_2^-$ with R = $C_2$, $C_2X_2$, $C_2X_4$, and $C_6X_4$ (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 $Au_2$. 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 $LRO_3$ 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*

Email – **kate.mcgrath@vuw.ac.nz**

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 and emergent behaviour, 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, including 3D printing of hydrogels for use as scaffolds in the synthesis of synthetic bone.

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

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

Munro, N.H. and McGrath, K.M. Biomimetic approach to forming chitin/aragonite composites, *Chemical Communications*, 2012,48, 4716- 4718, DOI:10.1039/C2CC00135G

Fournier, A and McGrath, K.M. Porous protein/silica composite formation: manipulation of silicate porosity and protein conformation, *Soft Matter*, 7(10) 4918-4297 (2011). DOI: 10.1039/c1sm05299c

Lendrum, C.D and McGrath, K.M. Towards controlled nucleation: balancing monolayer chemistry with monolayer fluidity, *Crystal Growth & Design*, 10:4463-4470 (2010)

Tan, H.L. and McGrath, K.M. The Microstructural and Rheological Properties of Na-caseinate Dispersions, *Journal of Colloid and Interface Science*, 342: 399-406 (2010)

Bulgarelli, N. and McGrath, K.M. Dynamics of oil transfer in oil-in-water emulsions,*Soft Matter*, 5:4804–4813 (2009)

# Ken MacKenzie, PhD (*VUW*), DSc, FRSNZ FNZIC, Professorial Research Fellow

*Materials Chemistry*

Email – **kenneth.mackenzie@vuw.ac.nz**

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, 727 pp, Pergamon/Elsevier, Oxford, 2002.

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 and K.J.D. MacKenzie, Elsevier, Oxford. (2006), pp. 349-82.

M. Alzeer, K.J.D. MacKenzie, Synthesis and mechanical properties of new fibre-reinforced composites of inorganic polymers with natural wool fibres. *Journal of Materials Science* 47 (2012) 6958-65. DOI:10.1007/s10853-012-6644-3

Y.D. Noh, S. Komarneni, K.J.D. MacKenzie, Titanosilicates: Giant exchange capacity and selectivity for Sr and Ba. *Separation and Purification Technology* 95 (2012) 222-6. DOI: 10.1016/seppur.2012.05.013

K.J.D. MacKenzie. Inorganic polymers for environmental protection applications. *Materials Science and Engineering, Institute of Physics Conference Series* 18 (2011) DOI:10.1088/1757-899X/18/17/172001

K. Okada, T. Isobe, K. Katsumata, Y. Kameshima, A. Nakajima and K.J.D. MacKenzie. Porous ceramics mimicking nature- preparation and properties of microstructures with unidirectionally-oriented pores. *Science and Technology of Advanced Materials*, 12, (2011) DOI:10.1088/468-6996/12/6/064701.

K. Okada, A. Yoshizawa, Y. Kameshima, T. Isobe, A. Nakajima, K.J.D. MacKenzie. Adsorption and photocatalytic properties of $TiO_2$/mesoporous silica composites from two silica sources (acid-leached kaolinite and Si-alkoxide). *Journal of Porous Materials*, 18, (2011) 345-54. DOI:10.1007/s10934-010-9384-2

KJ.D. MacKenzie, N. Rahner, M.E. Smith and A. Wong. Calcium-containing inorganic polymers as potential bioactive materials. *Journal of Materials Science*, 45, (2010) 999-

S.J. O'Connor, K.J.D. MacKenzie, M.E. Smith and J.V. Hanna. Ion exchange in the charge-balancing sites of aluminosilicate inorganic polymers. *Journal of Materials Chemistry*, 20, (2010) 10234-40.

K.J.D. MacKenzie, M.E. Smith and A. Wong. A Multinuclear MAS NMR Study of Calcium-Containing Inorganic Polymers. *Journal of Materials Chemistry*, 17 (2007) 5090-6.

## Peter Northcote, PhD (*Brit. Col.*), FNZIC, Associate Professor

*Natural Products, NMR Spectroscopy*

Email – **peter.northcote@vuw.ac.nz**

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**.

Hamel, E.; Day, B.; Miller, J; Jung, D.; Northcote, P.; Ghosh, A.; Curran, D.; Cushman, M; Nicolaou, K.; Paterson, I.; Sorensen, E., "Synergistic effects of peloruside A and laulimalide with taxoid site drugs, but not with each other, on tubulin assembly", *Molecular Biology* (**2006**) published online Aug. 3

Jimenez-Barbero, J.; Canales, A.; Northcote, P.; Buey, R. Andreu, J.; Diaz, F., "NMR determination of the Bioactive Conformation of Peloruside Bound to Microtubules", *J.of the American Chemical Soc.* (**2006**) *128*(*27*) 8757-8765.

Page, M.; Northcote, P.; Webb, V.; Mackey, S.; Handley, S., "Aquaculture trials for the production of biologically active metabolites in the New Zealand sponge *Mycale hentscheli* (Demospongiae: Pooecilosclerida)", *Aquaculture* (**2005**) *250*(*1-2*) 256-269.

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 intiation 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**.

T.N. Gaitanos, R.M. Buey, J.F. Diaz, P.T. Northcote, P. Teesdale-Spittle, J.M. Andreu, J.H. Miller, "Peloruside A Does Not Bind to the Taxoid Site on β-Tubulin and Retains Its Activity in Multidrug-Resistant Cell Lines", *Cancer Research*, *64(15)*, 5063-5067, **2004**.

R.A. Keyzers, P.T. Northcote, O.A. Zubkov, "Novel anti-inflammatory spongian diterpenes from the New Zealand marine sponge Chelonaplysilla violacea," *European Journal of Organic Chemistry*, *(2)*, 419-425, **2004**.

T.N. Gaitanos, R.M. Buey, F.J. Diaz, P.T. Northcote, P. Teesdale-Spittle, J.M. Andreu, J.H. Miller, "Peloruside A does not Bind to the Taxoid Site on β-Tubulin and Retains its Activity in Multidrug-Resistant Cell Lines", *Cancer Research*, **2004**, *64*(*15*), 5063.

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**.

## Rhian Salmon, PhD (*York University, Canada*), Senior Lecturer

*Science in Context: Scientist-centred communication, polar science, communication of climate change, interdisciplinary research*

Email – **rhian.salmon@vuw.ac.nz**

The Science in Context group is concerned with the relationship between science, scientists, and society, the history of science, and the communication of scientific ideas and issues to different audiences and through a range of media.

My training is as a polar atmospheric chemist. I have worked in education, outreach, and communication of polar and climate science since 2006, which fostered my research interest in public outreach by scientists. I believe that the science community needs to become more reflexive (and transparent) about why we do outreach, who we're trying to engage, and what we're trying to achieve. We need to develop accessible methods for reporting on, evaluating, and researching outreach, as well as appropriate systems to enable professional development and recognition in this field. There is much to learn in this area from other disciplines: especially science communication, social psychology, and science and technology studies. My current research seeks to inform the communication practice of scientists using knowledge taken from these disciplines so that best practices and theories can be integrated into science outreach efforts and that these experiences can further inform the field and practice as a whole. I remain active in scientist-centred outreach and have recently worked in different capacities with Our Far South, New Zealand IceFest, and Thin Ice Climate.

Selection of publications:

**Salmon, R.A.**, Carlson, D.J., Pauls, M., Zicus, S., Baeseman, J., Bautista Sparrow, E., ..., & Raymond, M. (2011). Education, outreach, and communication during the International Polar Year 2007-2008: Stimulation a global polar community. *The Polar Journal,* 1(2), 265-285.

**Salmon, R.A.**, & Carlson, D.J.(2007). International Polar Year – the Poles and the Planet. In S. Chris & A. Green (Eds.), EcoScience; *The lecture series of the 34th Harry Messel International Science School* (pp. 146-61). Australia: Science Foundation of Physics within the University of Sydney.

Carlson, D.J., **Salmon, R.A.** (2010). The Past and Present of Polar Science. In B. Kaiser (Ed.), *Polar Science and Global Climate - An International Resource for Education and Outreach* (Prelude, pp. 5-24). London, UK: Pearson.

Jones, A.E., Wolff, E.W., **Salmon, R.A.**, Bauguitte, S.J.-B., Roscoe, H.K., Anderson, P.S., ..., & Worton, D.R. (2008). Chemistry of the Antarctic Boundary Layer and the Interface with Snow: an overview of the CHABLIS campaign. *Atmospheric Chemistry and Physics*, 8(14), 3789-3803.

## Gerald Smith, PhD (*Canterbury*), Professorial Research Fellow

*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, Callaghan Innovation, 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**

“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**

# John Spencer, PhD *(Otago)*, FNZIC, Professor

*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.

An exciting area for development is new functional organometallic materials. We are designing and making new organometallic liquid-crystalline materials with unique physical properties.

A. Zayya, J. L. Spencer, Coordination Chemistry of a Bicyclic 3-aza-7-phosphabicyclo[3.3.1]nonan-9-one Ligand. *Organometallics,* 2012**, 31**, 2841-2853.

A. Zayya, R. Vagana, M. R. M. Nelson, J. L. Spencer, Synthesis and characterisation of 3-aza-7-phosphabicyclo[3.3.1]nonan-9-ones. *Tetrahedron Lett.* 2012**, 53**, 923-926.

T. F. Vaughan, D. J. Koedyk, J. L. Spencer, Comparison of the Reactivity of Platinum(II) and Platinum(0) Complexes with Iminophosphine and Phosphinocarbonyl Ligands. *Organometallics,* 2011**, 30**, 5170-5180.

S. A. Hoyte, J. L. Spencer, Mono- and Diphosphine Platinum(0) Complexes of Methylenecyclopropane, Bicyclopropylidene, and Allylidenecyclopropane. *Organometallics* 2011, **30**, 5415-5423

D. A. J.Herman, P. Ferguson, S. Cheong, I. F. Hermans, B. J. Ruck, K. M. Allan, S. Prabakar, J. L. Spencer, C. D. Lendrum, R. D. Tilley. Hot-injection synthesis of iron/iron oxide core/shell nanoparticles for T2 contrast enhancement in magnetic resonance imaging. *Chem. Commun.* **2011,** 9221-9223.

B. G. Anderson, S. A. Hoyte, and J. L. Spencer, “Synthesis and Characterisation of the Dinuclear Polyhydrides $[Os_2H_7(PPh^iPr_2)_4]$+ and $[Os_2H_6(PPh^iPr_2)_4]$” Inorg. Chem., 2009, 48, 7977 – 7983.

K. Allan and J. L. Spencer, “The synthesis and characterisation of novel o-substituted benzyldi-t-butylphosphine–boranes”, Tetrahedron. Lett., 2009, 50, 834 – 835.

X. Liu, C. W. Bumby, J. L. Spencer, W. M. Arnold, A. B. Kaiser, “Multi-walled carbon nanotubes synthesised from different catalysts: morphology, dielectrophoresis and conductance”, Int. J. Nanotechnol., 2009, 6, 329 – 343.

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.

## Bridget Stocker, PhD *(VUW)*, Senior Lecturer

*Immunoglycomics, bio-organic, green chemistry*

Email – **bridget.stocker@vuw.ac.nz**

My research interest lies at the interface of chemistry and biology, and in particular, focuses on understanding how carbohydrates influence the immune response. Through the development of chemical 'tools' or 'probes', we explore the role of carbohydrates in biological systems and then use this knowledge to develop more effective therapies for diseases such as cancer, tuberculosis and asthma.

I am currently supported by a Sir Charles Hercus Research Fellowship (2013-2017), and have an adjunct research position with the Malaghan Institute of Medical Research (MIMR). I also have strong research links with Dr Timmer (SCPS), and with others at MIMR and the School of Biological Sciences (SBS). Research in my group is ideally suited for those with an interest in both chemistry and biology.

(Bridget is also an Adjunct Research Fellow with the Malaghan Institute of Medical Research (MIMR))

Selected papers:

Khan, A. A.; Kamena, F.; Timmer, M. S. M.; Stocker, B. L. *'Development of a benzophenone and alkyne functionalised trehalose probe to study trehalose dimycolate binding proteins.' Org. Bio. Chem.* **2013**, *11*, 881-885.

Stocker, B. L.; Jongkees, S. A. K.; Win-Mason, A. L.; Dangerfield, E. M.; Withers, S. G.; Timmer, M. S. M. *'The 'mirror-image' postulate as a guide to the selection and evaluation of pyrrolidines as α-L-fucosidase inhibitors.' Carbohydrate Res.* **2013**, *367,* 29-32.

Sauvageau, J.; Foster, A. J.; Khan, A. A.; Chee, S. H.; Sims, I. M.; Timmer, M. S. M.; Stocker, B. L. *ChemBioChem* **2012**, *13*, 2416-2424*. 'Synthesis and Biological Activity of the LTA glycolipid anchor from Streptocossus sp. DSM 8747.'*

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Khan, A. A.; Chee, S. H.; McLaughlin, R. J.; Harper, J. L.; Kamena, F.; Timmer, M. S. M.; Stocker, B. L. *'Long chain lipids are required for innate immune recognition of trehalose diesters by macrophages.' ChemBioChem* **2011**, *17,* 2572-2576 [Featured on cover]

Win-Mason, A. L.; Dangerfield, E. M.; Tyler, P. C.; Stocker, B. L.; Timmer, M. S. M. *'Asymmetric Strecker and Carbamate Annulation Methodology for the Synthesis of Amino-imino-hexitols.'* [Personal invitation: Women who have made notable contributions to Organic Chemistry; Featured on cover], *Eur. J. Org. Chem.* **2011**, 4008-4014.

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

## 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 (MIMR), and in conjunction with Dr B. Stocker , 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*.

Corkran HM, Munneke S, Dangerfield EM, Stocker BL, Timmer MSM. *"Applications and Limitations of the I$_2$-mediated Carbamate Annulation for the Synthesis of Piperidines: 5- versus 6-membered Ring Formation." J. Org. Chem.* **2013**, *in press.*

Stocker BL, Timmer MSM. *"Chemical Tools to Study the Biological Function of Glycolipids." ChemBioChem* **2013**, *14*, 1164-1184.

Stocker BL, Jongkees SAK, Win-Mason AL, Dangerfield EM, Withers SG, Timmer MSM. *"The 'mirror-image' postulate as a guide to the selection and evaluation of pyrrolidines as $\alpha$-L-fucosidase inhibitors." Carbohydrate Res.* **2013**, *367,* 29-32.

Khan AA, Kamena F, Timmer MSM, Stocker BL. 'Development of a benzophenone and alkyne functionalised trehalose probe to study trehalose dimycolate binding proteins.' *Org. Bioorg. Chem.* **2013**, *11*, 881-885.

Sauvageau J, Foster AJ, Khan AA, Chee SH, Sims IM, Timmer MSM, Stocker BL. "*Synthesis and Biological Activity of the LTA glycolipid anchor from Streptococcus sp. DSM 8747*." *ChemBioChem*, **2012**, *13*, 2416-2424.

Sauvageau J, Ryan J, Lagutin K, Sims IM, Stocker BL, Timmer MSM. "*Isolation and Structural Characterisation of the Major Glycolipids from Lactobacillus plantarum*." *Carbohydr. Res*. **2012**, *357*, 151-156.

Khan AA, Chee SH, Stocker BL, Timmer MSM. "*The Synthesis of Long-Chain α-Alkyl-β-Hydroxy Esters Using Allylic Halides in a Fráter-Seebach Alkylation.*" *Eur. J. Org. Chem*. **2012**, 995-1002.

Stocker BL, Win-Mason AL, Timmer MSM. "*I2-mediated carbamate annulation: scope and application in the synthesis of azasugars*", *Carbohydr. Res*., **2012**, *356*, 163–171.

Dangerfield EM, Cheng JMH, Knight DA, Weinkove R, Dunbar PR, Hermans IF, Timmer MSM, Stocker BL. "*Specific Activity of Glycolipid Ligands for Invariant NKT Cells.*" *ChemBioChem* **2012**, *13*, 1349-1356.

Khan AA, Stocker BL, Timmer MSM. "*Trehalose Glycolipids - Synthesis and Biological Activities.*" *Carbohydr. Res*. **2012**, 356, 25-36.

# 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. A Heritage cluster incorporating Museum and Heritage Studies in a new integrated qualification, a Graduate Diploma Museum and Heritage Studies for Collections Care, for students seeking entry to the heritage sector (museums, art galleries and built heritage) has been established.

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 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.

## 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 503 – 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

* 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 503 plus HMSC 562

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 503 and 75 additional approved points as listed above under the MSc.

## COURSE INFORMATION INDEX

| Course code | Course reference number | Title | Points | Trimester |
|---|---|---|---|---|
| ↓ | ↓ | ↓ | ↓ | ↓ |
| **HMSC 502** | CRN 15191 | **HERITAGE MATERIALS SCIENCE** | **30 PTS** | **2/3** |

## HMSC COURSES

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|---|---|---|---|---|
| **HMSC 501** | CRN 15190 | **HERITAGE MATERIALS SCIENCE: PRINCIPLES** | **30 PTS** | **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 503** | CRN 26077 | **HERITAGE MATERIALS SCIENCE: TECHNIQUES AND MUSEUM ENVIRONMENT MONITORING** | **15 PTS** | **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 PTS** | **1/3** |

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 PTS** | **1/3** |

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

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|---|---|---|---|---|
| **HMSC 563** | **CRN 15196** | **DIRECTED INDIVIDUAL STUDY 2** | **15 PTS** | **2/3** |

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

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|---|---|---|---|---|
| **HMSC 580** | **CRN 15198** | **RESEARCH METHODS** | **15 PTS** | **1/3** |

Preparation for thesis research in Heritage Materials Science.

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|---|---|---|---|---|
| **HMSC 591** | **CRN 15189** | **THESIS** | **120 PTS** | **FULL YEAR/3** |

MSc Thesis in Heritage Materials Science.

## 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:
Dr Gerald Smith,
Programme Coordinator **gerald.smith@vuw.ac.nz**

## Gerald Smith, PhD (*Canterbury*), Professorial Research Fellow

*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, Callaghan Innovation, 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 properties 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 PTS** | **2/3** |

## 400-LEVEL COURSES

| **PHYS 411** | **CRN 9069** | **QUANTUM MECHANICS** | **15 PTS** | **1/3** |
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|---|---|
| Restrictions: | PHYS 322, 403 |
| Lecturers: | Eric Le Ru, Ben Ruck |
| Lectures: | Mon, Thur, TBA |

Non-relativistic quantum mechanics applied to atoms, molecules and nuclei.

| **PHYS 412** | **CRN 9070** | **THEORETICAL PHYSICS** | **15 PTS** | **2/3** |
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|---|---|
| Restriction: | PHYS 403 |
| Lecturers: | Shaun Hendy, Michele Governale |
| Lectures: | Mon, Thur, TBA |

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

| PHYS 413 | CRN 9071 | CONDENSED MATTER PHYSICS A | 15 PTS | 1/3 |
|---|---|---|---|---|

| | |
|---|---|
| Restriction: | PHYS 404 |
| Lecturers: | Shaun Hendy, Ulrich Zuelicke |
| Lectures: | Mon, Thur, TBA |

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

| PHYS 414 | CRN 9072 | CONDENSED MATTER PHYSICS B | 15 PTS | 2/3 |
|---|---|---|---|---|

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

Magnetism, electron transport in metals and semiconductors, superconductivity, semiconductor physics, optical and dielectric properties.

| PHYS 415 | CRN 9073 | ELECTROMAGNETISM | 15 PTS | 1/3 |
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| Restriction: | PHYS 410 |
| Lecturers: | Andy Edgar, John Lekner |
| Lectures: | Mon, Thur, TBA |

Static and dynamic solutions to Maxwell's equations including electromagnetic waves in materials and in confined geometries. Electromagnetic momentum and power flow, guided waves, scattering, and generation of radiation.

| PHYS 416 | CRN 9074 | RELATIVITY AND ELECTRODYNAMICS | 15 PTS | 2/3 |
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|---|---|
| Restriction: | PHYS 410 |
| Lecturers: | Ulrich Zuelicke |
| Lectures: | Mon, Thur, TBA |

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

| PHYS 417 | CRN 9075 | ASTROPHYSICS | 15 PTS | 2/3 |
|---|---|---|---|---|

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|---|---|
| Lecturers: | Denis Sullivan, Melanie Johnston-Hollitt |
| Lectures: | Mon, Thur, 12:00 – 12:50 LB408 |

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 PTS | 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 EARTH | 15 PTS | 2/3 |
|---|---|---|---|---|

Restriction: GPHS 405, 441, PHYS 406
Lecturers: Euan Smith (SGEES), Malcolm Ingham, Gillian Turner
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 PTS | 1/3 |
|---|---|---|---|---|

Restriction: GPHS 408, 442, 447, PHYS 442
Lecturers: Malcolm Ingham, Gillian Turner
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 PTS | 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 PTS | 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 PTS | 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 exactly 12 months, extension for up to three months (in full months) can be applied for to Associate Dean in Home Faculty, further extensions for exceptional circumstances may be approved by the Dean of FGR. 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 ranked best in terms of research activity among all New Zealand university physics research groups in the government's 2012 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 on the next page together with the names of staff supervisors (please consult the research summaries of individual staff members for more detailed information).

# 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. in collaboration with Callaghan Innovation, 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, in collaboration with GNS Science, Callaghan Innovation, 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, Ben Ruck, Franck Natali, Grant Williams, Callaghan Innovation and overseas laboratories collaboration]
- Novel conducting materials: graphene and carbon nanotubes - modelling of electronic properties, and use in thermoelectric composites. [Alan Kaiser, in collaboration with Natalie Plank and overseas laboratories]
- Novel conducting materials: measurement and modelling of electronic properties. [Ben Ruck, Joe Trodahl, in collaboration with Callaghan Innovation and overseas laboratories]
- Novel conducting materials: Carbon nanotubes – device fabrication and characterization for high sensitivity sensors and optoelectronic applications. [Natalie Plank
- Novel conducting materials: semiconducting nanowire films – inorganic nanowire synthesis and field effect transistor fabrication and characterization. [Natalie Plank]
- Implementation and fabrication of spintronics devices combining rare-earth nitrides and group-III nitrides including spin light emitting diodes, spin transistors and magnetic tunnel junctions in view of communication, logic, and storage operations [Franck Natali, Joe Trodahl, Ben Ruck, collaborations with Simon Granville from Callaghan Innovation and CNRS-France.]]

*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). [Eric Le Ru]

*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. [Petrik Galvosas]
- NMR studies of novel ordering and relaxation effects for elastomers under shear and extensional deformation. [Petrik Galvosas]

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 and Diffusion 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. [Petrik Galvosas]
- Low field NMR and Portable NMR. [Petrik Galvosas]
- The development of new magnet, data processing and probe technologies for use in novel NMR applications. [Petrik Galvosas]

*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]
- Electrically and optically-detected electron paramagnetic resonance in organic materials, OLEDs and photovoltaics. [Andy Edgar]

*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 dots, low-dimensional and nano-scale systems. [Michele Governale and Ulrich Zuelicke]
- Spin-dependent phenomena in semiconductor hetero- and nano-structures. [Ulrich Zuelicke]
- Emergent quasi-relativistic behaviour in condensed-matter systems. [Ulrich Zuelicke]
- Ultra-cold atom gases subject to synthetic gauge fields. [Ulrich 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. [Petrik Galvosas]
- Nuclear Magnetic resonance studies of contaminants and water in porous host systems as relevant to aquifiers, soils and water uptake in plants. [Petrik Galvosas]
- 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*

- Development of geomagnetic secular variation records from the remnant magnetization of volcanic rocks, archaeological materials and lake sediments. [Gillian Turner]
- Development of regional and global models of the geomagnetic secular variation over the past 10,000 years. [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

### Andrew Edgar, PhD (*Canterbury*), Associate Professor

*Glasses, Glass Ceramics, and Radiation Imaging and Dosimetry*

Email – **andy.edgar@vuw.ac.nz**

My research activity is centred on the optical properties of glasses and glass ceramics, particularly as they apply to radiation imaging and detection, and on organic opto-electronic materials. In the first program, we investigate the physics of 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 overseas laboratories in Canada and Germany.

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.

Edgar, A., C.R. Varoy, C. Koughia, G. Okada, G. Belev, and S. Kasap. "High-Resolution X-Ray Imaging with Samarium-Doped Fluoroaluminate and Fluorophosphate Glass." Journal of Non-Crystalline Solids, (2013): on-line.

Breukers, R., C.M. Bartle, and A. Edgar. "Transparent Lithium Loaded Plastic Scintillators for Thermal Neutron Detection." Nuclear Instruments and Methods A 71, (2013): 58-61.

Vahedi, S., E. Muzar, B. Morrell, G. Okada, C. Koughia, A. Edgar, C. Varoy, G. Belev, T. Wysokinski, D. Chapman, and S. Kasap. "Synchrotron X-Ray Induced Sm3+ to Sm2+ Conversion, and Thermally Induced Reverse-Conversion and Erasure in Fluoroaluminate Glasses for the Monitoring of High-Doses in Microbeam Radiation Therapy: The Effects of Annealing and Codoping with Eu2+." Journal of Applied Physics 112 no. 7 (2012): 073108

Dixie, L C., A. Edgar, and M. F. Reid. "Sm2+ Fluorescence and Absorption in Cubic Bacl2: Strong Thermal Crossover of Fluorescence between 4f6 and 4f55d1 Configurations." Journal of Luminescence 132, no. 10 (2012): 2775-2782.

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

**Petrik Galvosas, PhD *(Leipzig)*, Senior Research Fellow**
*NMR in Porous Media and Soft Matter*
Email – **petrik.galvosas@vuw.ac.nz**

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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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**

## Michele Governale, PhD *(Pisa)*, Associate Professor

*Quantum transport in nanostructures*

Email – **michele.governale@vuw.ac.nz**

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.

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M. Governale, M. G. Pala, and J. König, "Real-time diagrammatic approach to transport through interacting quantum dots with normal and superconducting leads", Phys. Rev. B 77, 134513 (2008).

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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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 use a combination of computer simulation and modeling to 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 scientists at Callaghan Innovation, the University of Canterbury, the London Centre for Nanotechnology, the University of Sydney, the Technical University of Dresden and the University of Tennessee.

S. Dhondi, G. G. Pereira and S. C. Hendy, "Effect of molecular size on the capillary absorption of polymer droplets", Langmuir 28 10256–10265 (2012).

D. Schebarchov, S. C. Hendy, E. Ertekin, and J. C. Grossman "Modelling the interaction between carbon nanotube caps and catalyst nanoparticles", Physical Review Letters 107 185503 (2011).

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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## Malcolm Ingham, PhD *(Edinburgh)*, Senior Lecturer

*Environmental physics, Geophysics*

Email – **malcolm.ingham@vuw.ac.nz**

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*

Email – **melanie.johnston-hollitt@vuw.ac.nz**

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. On the road to this telescope (which we are designing now) precursor telescopes which are powerful new instruments in their own right are being constructed. The first of these to be operational in June 2013 is the Murchison Widefield Array (MWA). VUW is a partner in the MWA project and hosts one of only 2 international MWA data centres. Students at VUW have the chance to work on MWA data which is opening up a new parameter space in the Southern Sky.

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, MWA, 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: 1) understanding the role environment plays on the generation and evolution of radio galaxies; 2) multiwavelength investigations of cluster dynamics (radio, X-ray & optical); and 3) science & technical requirements for next generation radio arrays.

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


Pratley, L., Johnston-Hollitt, M., Dehghan S. and Sun, M., Using head-tail galaxies to constrain the intracluster magnetic field: an in-depth study of PKS J0334-3900, Monthly Notices of the Royal Astronomical Society, 432, 243 (2013)

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Tingay, S.J. + 60 others including Johnston-Hollitt, M., The Murchison Widefield Array: The Square Kilometre Array at Low Radio Frequencies, Publications of the Astronomical Society of Australia, 30, e31 (2013)

Friedlander, A., Frean M., Johnston-Hollitt, M., Hollitt, C., Latent Dirichlet allocation for image segmentation and source finding in radio astronomy images, Association for Computer Machinery, New York, 429 (2013)

McKinley, B. + 51 others including Johnston-Hollit, M., Low-frequency Observations of the Moon with the Murchison Widefield Array, The Astronomical Journal, 145, 23, (2013)

Bearsdley, A.P., + 51 others including Johnston-Hollit, M., The EoR sensitivity of the Murchison Widefield Array, Monthly Notices of the Royal Astronomical Society: Letters, 429, 5 (2013)

## Alan Kaiser, PhD *(London)*, FRSNZ, Professorial Research Fellow

*Electronic properties of novel materials, especially nanoscale materials*

Email – **alan.kaiser@vuw.ac.nz**

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.

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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. Hrnèariková, 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, Professorial Research Fellow

*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.


Polarizability of two parallel conducting circular cylinders, *J. Electrostatics* 71, 910-914 (2013)

Universal properties of electromagnetic beams, *PIERS Proceedings*, Taipei (2013), 464-469

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Identities arising from two-cylinder electrostatics, *Int. J. of Math. Analysis* 7 (2013) 1411-1417

Electrostatics of two charged conducting spheres, *Proc. Roy. Soc. A* 468 (2012) 2829-2848

Electrostatic calibration of sphere-sphere forces, *Meas. Sci. Technol.* 23 (2012) 085007 (4pp)

Construction of accelerating wavepackets, *Applied Mathematics and Computation* 218, 10990-10997 (2012) [with H. Nguyen]

Electrostatic force between two conducting spheres at constant potential difference, *J. App. Phys.* 111, 076102 (2012)

Level curves for the sum of the squares of the normals to an ellipse, *J. Geometry* 102, 115-122 (2011) [published online 13 March 2012]

Nurturing genius: the childhood and youth of Kelvin and Maxwell, *NZ Science Review* 69 (1) 7-13 (2012)

Near approach of two conducting spheres: enhancement of external electric field, *J. Electrostatics* 69, 559-563 (2011)

Polarizability of two conducting spheres, *J. Electrostatics* 69, 435-441 (2011)

Confluent Heun functions and separation of variables in spheroidal coordinates, *J. Math. Phys.* 52, 073517 (2011) [with R. Boyack]

Non-existence of separable spheroidal beams, *J. Opt.* 13, 085701 (2011) [with R. Boyack]

Axisymmetric scattering of scalar waves by spheroids. *J. Acoust. Soc. Am.* 129, 3465-3469 (2011) [with R. Boyack]

Capacitance coefficients of two spheres. *J. Electrostatics* 69, 11-14 (2011)

## Eric Le Ru, PhD (*Paris*), Associate Professor

*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. Lacharmoise, E. C. Le Ru, and P. G. Etchegoin, **ACS Nano** 3, 66 (**2009**).*

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*P. G. Etchegoin, P. D. Lacharmoise, and E. C. Le Ru, **Anal. Chem.** 81, 682 (**2009**).*

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*D. Pristinski, E. C. Le Ru, S. Tan, S. Sukhishvili, and H. Du., **Optics Express** 16, 20117 (**2008**).*

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*P. G. Etchegoin and E. C. Le Ru, **Phys. Chem. Chem. Phys. (feature article)** 10, 6079 (**2008**).*

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*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 behaviours 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 colloidal systems, polymers and proteins. 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 and the possible resultant emerging behaviour..

**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*, (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).

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## Franck Natali, PhD (*University of Nice, France*), Senior Lecturer

*Novel materials for electronic and optoelectronic applications*

Email – **franck.natali@vuw.ac.nz**

Most of my scientific research spans from semiconductor material science, including ultra-high vacuum technology, epitaxial growth, structural, electrical and optical characterizations, to the fabrication of devices such as light emitting diodes and transistors. My work on the description-comprehension of the epitaxial growth processes as well as the understanding-control of materials properties is driven with the aim of technological progresses in the electronic (powerful transistors for broadcast communications, etc.) and optoelectronics (energy savings) sectors.

I am currently particularly interested in the growth of rare earth nitride thin films by molecular beam epitaxy and their characterisations toward the implementation of a number of prototype device structures for spintronic applications. I am also interested in the growth and characterizations of rare-earth silicides which have a central role to play in the next-generation of CMOS devices (interconnects, contacts, source/drain area etc.).

H. Warring, B. J. Ruck, H. J. Trodahl, and **F. Natali**, 'Electric field and photo-excited control of the carrier concentration in GdN', Appl. Phys. Lett., 102, 132409 (2013).

**F. Natali**, B. J. Ruck, N. O. V. Plank, H. J. Trodahl, S. Granville, C. Meyer, and W. R. L. Lambrecht, 'Rare earth mononitrides', Progress in Materials Science 58, 1316 (2013).

**F. Natali,** B. J. Ruck, H. J. Trodahl, Do Le Binh, S. Vezian, B. Damilano, Y. Cordier, F. Semond, and C. Meyer, 'Role of magnetic polarons in ferromagnetic GdN', Phys. Rev. B, 87, 035202 (2013).

B. Damilano, T. Trad, J. Brault, P. Demolon, **F. Natali**, and J. Massies, 'Color control in monolithic white light emitting diodes using a (ga,in)n/gan multiple quantum well light converter', Phys. Stat. Sol. (a), Applications and Materials Science, 209 (3) (2012).

N.O.V. Plank, **F. Natali**, J. Galipaud, J. H. Richter, M. Simpson, B.J. Ruck, and H.J. Trodahl. 'Enhanced Curie temperature in N-deficient GdN', Appl. Phys. Lett. 98, 112503 (2011).

**F. Natal**i, N.O.V. Plank, J. Stephen, M. Azeem, B.J. Ruck, H.J. Trodahl, and L. Hirsch. "Epitaxial samarium disilicide films on silicon (001) substrates: growth, structural and electrical properties'. Journal of Physics D: Applied Physics 44, 135404 (2011).

**F. Natali,** N.O.V. Plank, J. Galipaud, B.J. Ruck, H.J. Trodahl, F. Semond, S. Sorieul, and L. Hirsch, 'Epitaxial growth of GdN on silicon substrate using an AlN buffer layer', J. Cryst. Growth, 312, 3583 (2010).

**F. Natali**, Y. Cordier, J. Massies, S. Vézian, B. Damilano, and M. Leroux, 'Signature of monolayer and bilayer fluctuations in (Al,Ga)N/GaN quantum well width', Phys. Rev. B, 79, 035328 (2009) .

For more information visit
**http://www.victoria.ac.nz/scps/about/staff/franck-natali**
**http://www.victoria.ac.nz/scps/research/research-groups/spintronics**

## Natalie Plank, PhD (*Edinburgh*), Senior Lecturer

*Electronic structure of nanomaterials*

Email – **natalie.plank@vuw.ac.nz**

My research interests are in the area of nanomaterial device fabrication and the characterisation of novel materials. My current work focuses on nanomaterial device platforms for sensing technology and photovoltaics and this work is done in collaboration with other researchers within the MacDiarmid Institute and at VUW. I have previously worked extensively on carbon nanotubes (CNTs) and ZnO nanowires (NWs) for nanodevice applications. I am particularly interested in low cost fabrication techniques that allow for high throughput of devices whilst maintaining the particular material properties of the unique material system. This has been particularly important for device fabrication for both CNTs and ZnO NWs, where nanoscale effects are non-negligible.

**Natalie O V Plank**, H Y Zheng, Satya Agarwal, Dayna Kivell, Gideon Gouws and Jadranka Travas-Sejdic, *Facile synthesis of Poly(methylsilsesquioxane) and MgO nanoparticle composite dielectrics*, Journal of Materials Research, **28**, 1490 (2013).

**N. O.V. Plank**, I. Howard, A. Rao, M.W.B. Wilson, C. Ducati, R. S. Mane, J. S. Bendall, R.R.M. Louca, N.C. Greenham, H. Miura, R.H. Friend, H.J. Snaith and M. E. Welland, *Efficient ZnO nanowire solid-state dye-sensitized solar cells using organic dyes and core-shell nanostructures*, Journal of Physical Chemistry C, 113, 18515 (2009)

Nan Wang, K. Yano, C. Durkan, **N. Plank**, M.E. Welland, Yan Zhang, H.E. Unalan, M. Mann, G.A.J. Amaratunga and W.I. Milne, *Direct measurement of charge transport through helical poly(ethyl propiolate) nanorods wired into gaps in single walled carbon nanotubes*, Nanotechnology, 20, 105201 (2009)

**N.O.V. Plank**, H. J. Snaith, C. Ducati, J. S. Bendall, L. Schmidt-Mende and M. E. Welland, *A simple low temperature synthesis route for ZnO/MgO core/shell nanowires*, Nanotechnology, 19, 465603 (2008)

J. S. Bendall, G. Visimberga, M. Szachowicz, **N.O.V. Plank**, S. Romanov, C.M. Sotomayor-Torres, M. E. Welland, *An investigation into the growth conditions and defect states of laminar ZnO nanostructures*, Journal of Materials Chemistry, 18, 5259 (2008)

**N.O.V. Plank**, M.E. Welland, J.L. MacManus-Driscoll and L. Schmidt-Mende, *The backing layer dependence of open circuit voltage in ZnO/polymer composite solar cells*, Thin Solid Films, 516, 7218 (2008)

**N.O.V. Plank**, Masahiko Ishida and R. Cheung, *Positioning carbon nanotubes using soft-lithography for electronics applications*, Journal of Vacuum Science and Technology B, 23, 3178 (2005)

## Rebecca Priestley, PhD (*Canterbury*), Senior Lecturer

*Science in Context: History of science, Science communication, Creative science writing*

Email – **rebecca.priestley@vuw.ac.nz**

The Science in Context group is concerned with the relationship between science, scientists, and society, the history of science, and the communication of scientific ideas and issues to different audiences and through a range of media.

My training is in earth sciences and the history and philosophy of science. My current research focus is the history of science, with particular areas of research including:

- nuclear and radiation histories
- Ernest Marsden and his contributions to 20th century science
- scientists' communication and outreach practices over the last 100 years
- Antarctic science history
- the contribution of science to New Zealand's wider history.

I remain active in the practice of creative science writing and science communication. I write a weekly column about science for the *New Zealand Listener* and communicate a range of other science stories through print, blogs and radio broadcasts. I have a strong interest in the links between the arts and sciences and I am an affiliate of the Allan Wilson Centre for Molecular Ecology and Evolution.

Selection of publications:

**Priestley, R.** (2012). *Mad on Radium: New Zealand in the Atomic Age*. Auckland, New Zealand: Auckland University Press.

**Priestley, R.**, & Callaghan, Sir P. (Eds.). (2012). *Journal of the Royal Society of New Zealand 42(2) - special issue to celebrate the 2012 transit of Venus*.

**Priestley, R.** (2011). A Line in the Ocean. In G. O'Brien & B. Golder (Eds), *Kermadec: nine artists explore the South Pacific*. Wellington, New Zealand: The Pew Environment Group.

**Priestley, R.** (2011). *The Art of Science: The private portrait collection of the Royal Society of New Zealand*. Wellington, New Zealand: The Royal Society of New Zealand.

Crozier, M., & **Priestley, R.** (2011). *Charles Cotton: New Zealand's most influential geomorphologist*. New Zealand Geographer 67(2), 79-89.

**Priestley, R.** (2010). *A Survey of the History of Science in New Zealand 1769–1992*. History Compass, 8(6), 474-490.

**Priestley, R.** (Ed.). (2008). *The Awa Book of New Zealand Science*. Wellington, New Zealand: Awa Press. *Winner, Royal Society of New Zealand, 2009 Science Book Prize*

Meduna, V., & **Priestley, R.** (2008). *Atoms, dinosaurs & DNA: 68 great New Zealand scientists*. Auckland, New Zealand: Random House. *Winner, Elsie Locke award for non-fiction, 2009 LIANZ Children's Book Awards.*

**Priestley, R.** (2006). *The search for uranium in 'nuclear free' New Zealand: prospecting on the West Coast, 1940s to 1970s*. New Zealand Geographer, 62(2), 121-134.

**Priestley, R.** (2006). *Ernest Marsden's nuclear New Zealand*. Journal of the Royal Society of New South Wales, 139(419-420), 23-28.

**Priestley, R.** (2006). Introduction. In T. Barnes, P. Callaghan, H. Campbell, et al., *The Elegant Universe of Albert Einstein*. Wellington, New Zealand: Awa Press.

**Priestley, R.** (Last updated Mar. 2012.). *Radioactive Minerals*. In Te Ara – The Encyclopedia of New Zealand.

**Priestley, R.** (Last updated Sep. 2011). *Geomorphology – a history*. In Te Ara – The Encyclopedia of New Zealand.

## 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 electronic and magnetic 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.

H. Warring, B.J. Ruck, H.J. Trodahl, and F. Natali, *Electric field and photo-excited control of the carrier concentration in GdN*, Appl. Phys. Lett. **102**, 132409 (2013).

F. Natali, B.J. Ruck, H. J. Trodahl, Do Le Binh, S. Vezian, B. Damilano, Y. Cordier, F. Semond, and C. Meyer, *Role of magnetic polarons in ferromagnetic GdN*, Phys. Rev. B **87**, 035202 (2013).

E.-M. Anton, B.J. Ruck, C. Meyer, F. Natali, H. Warring, F. Wilhelm, A. Rogalev, V.N. Antonov, and H. J. Trodahl, *Spin/orbit moment imbalance in the near-zero moment ferromagnetic semiconductor SmN*, Phys. Rev. B **87**, 134414 (2012).

P.P. Murmu, J. Kennedy, G.V.M. Williams, B. J. Ruck, S. Granville, and S.V. Chong, *Observation of magnetism, low resistivity and magnetoresistance in the near-surface region of Gd implanted ZnO*, Appl. Phys. Lett. **101**, 082408 (2012).

J.H. Richter, B.J. Ruck, M. Simpson, F. Natali, N.O.V. Plank, M. Azeem, H.J. Trodahl, A.R.H. Preston, B. Chen, J. McNulty, K.E. Smith, A. Tadich, B. Cowie, A. Svane, M. van Schilfgaarde, and W.R.L. Lambrecht, *Electronic structure of EuN: growth, spectroscopy, and theory*, Phys. Rev. B **84**, 235120 (2011).

D.A.J. Herman, P. Ferguson, S. Cheong, I.F. Hermans, B.J. Ruck, K.M. Allan, S. Prabakar, J.L. Spencer, C.D. Lendrum, and R.D. Tilley, *Synthesis and functionalization of iron/iron oxide core/shell nanoparticles for T2 contrast enhancement in magnetic resonance imaging*, Chem. Comm. **47**, 9221 (2011).

B. J. Ruck, H.J. Trodahl, J. Richter, J. Criginski-Cezar, F. Wilhelm, A. Rogalev, V. Antonov, Do Le Binh, F. Natali, Claire Meyer, *The magnetic state of EuN; X-Ray magnetic circular dichroism at the Eu M4,5 and L2,3 absorption edges*, Phys. Rev. B **83**, 174404 (2011).

N.O.V. Plank, F. Natali, J. Galipaud, J. H. Richter, M. Simpson, H. J. Trodahl, and B. J. Ruck, *Enhanced Curie temperature in N-deficient GdN*, Appl. Phys. Lett. **98**, 112503 (2011).

S. Granville, B.J. Ruck, F. Budde, H.J. Trodahl, and G.V.M. Williams, *Nearest-neighbour antiferromagnetic interactions in high Mn content GaMnN films*, Phys. Rev. B **81**, 184425 (2010).

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).

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).

## Denis Sullivan, PhD (*ANU*), Professor

*Astrophysics*

Email – **denis.sullivan@vuw.ac.nz**


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 EC\,20058--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, pp 982-998 **(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*), Assoc Professor

*Palaeomagnetism, Geomagnetism*

Email – **gillian.turner@vuw.ac.nz**

Palaeomagnetism is the study of the Earth's magnetic field through the magnetic records preserved in rocks, sediments and other materials from the time of their formation. My major current project, Unlocking the Secrets of the Geodynamo: the SouthWest Pacific key, funded by a grant from the Royal Society of New Zealand's Marsden Fund, is focused on building up high resolution records of the changes in the strength and direction of the magnetic field over the SW Pacific region in the past 10,000 years. This will enable development of detailed regional and global models of the processes in the liquid iron core of the planet – the source of the magnetic field. Different strands of the project involve the records carried by long cores of lake and marine sediment, volcanic rocks and lava flows, and a novel experiment in which we are measuring the magnetization acquired by hangi stones as they cool. On a longer timescale we are also studying the enigmatic phenomenon of geomagnetic polarity reversals when the magnetic north and south poles switch positions, which, in recent geological time has occurred two or three times per million years. Palaeomagnetic methods may also be applied to a range of problems in earth, environmental and archaeological science. Current applied projects include a study of the rotation of tectonic plates and microplates and the determination of emplacement temperatures of volcanic materials,

We enjoy close collaborations with researchers in the School of Geography, Earth and Environmental Sciences and the School of Maori Studies here at Victoria University, with Auckland and Otago Universities, and with the Australian National University, Liverpool University (UK) and Utrecht University in the Netherlands.

Selected publications:

Turner, G.M., Michalk, D.M. & Little, T.A., 2012. Paleomagnetic constraints on Cenozoic deformation along the northwest margin of the Pacific-Australian plate boundary zone through New Zealand. *Tectonics*, 31. doi:10.1029/2011TC002931.

Turner, G.M., Ingham, M.R., Bibby, H. & Keys, H. 2011. Resistivity Monitoring of the tephra barrier at Crater lake, Mt Ruapehu, New Zealand. *Journal of Applied Geophysics*, doi:10.1016/ j.jappgeo.2011.01.006.

Turner, Gillian, 2010. North Pole South Pole. The epic quest to understand the great mystery of Earth's magnetism. Awa Press, Wellington 274pp.

Ingham, M. & Turner, G., 2008. Behaviour of the geomagnetic field during the Matuyama-Brunhes polarity transition. *Physics of the Earth and Planetary Interiors*, 168, 163-178.

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

G.M.Turner, J.L.Rasson and C.V.Reeves. 2007. Article title: Observation and Measurement Techniques, Schubert, G. (ed) Treatise on Geophysics. Volume 5 (Geomagnetism) pp 93-146. Oxford: Elsevier Ltd. (my contribution writing 70%, editing 100%).

For more information visit:
**http://www.victoria.ac.nz/scps/about/staff/gillian-turner** and **http://www.victoria.ac.nz/scps/research/research-groups/enviro-phys-geo/geomagnetism**

## 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, CI, 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:

G. V. M. Williams, S. Janssens, C. Gaedtke, S. G. Raymond, and D. Clarke, "*Observation of photoluminescence and radioluminescence in Eu and Mn doped $NaMgF_3$ nanoparticles*", J. Lumin.**143**, 219 (2013).

D. Rybicki, T. Meissner, G. V. M. Williams, S. Chong, M. Lux, and J. Haase, "*$^{75}As$ NMR study of overdoped $CeFeAsO_{0.8}F_{0.2}$*", Journal of Physics: Condensed Matter (in press).

S. Janssens, G. V. M. Williams, and D. Clarke, "*Synthesis and characterization of rare earth and transition metal doped $BaMgF_4$ nanoparticles*", J. Lumin. **134**, 277 (2013).

J. Leveneur, D. Sanchez, J. Kennedy, P. L. Grande, G. V. M. Williams, J. Metson, and B. C. C. Cowie, "*Iron-based bimagnetic core/shell nanostructures in $SiO_2$ : a TEM, MEIS, and energy-resolved XPS analysis*", Journal of Nanoparticle Research **14**, 1149 (2012).

P. P. Murmu, J. Kennedy, G. V. M. Williams, B. J. Ruck, S. Granville, and S. Chong, "*Observation of magnetism, low resistivity, and magnetoresistance in the near-surface region of Gd implanted ZnO*", Appl. Phys. Lett. **101**, 082408 (2012).

C. Gaedtke, G. V. M. Williams, S. Janssens, S. G. Raymond, D. Clarke, and, "*The effect of ionizing radiation on the luminescence properties of $Eu^{3+}$ and $Sm^{3+}$ doped $LaF_3$ nanoparticles* ", Physica Status Solidi (c) **9**, 2247 (2012).

J. Kennedy, J. Leveneur, Y. Takeda, G. V. M. Williams, S. Kupe, D. R. G. Mitchell, A. Markwitz, and J. Metson, "*Evolution of the structure and magneto-optical properties of ion beam synthesized ion nanoclusters*", Journal of Materials Science **47**, 1127 (2012).

P. P. Murmu, J. Kennedy, B.J. Ruck, G.V.M. Williams, A. Markwitz, S. Rubanov, and A. A. Suvorova, "*Effect of annealing on the structural, electrical and magnetic properties of Gd-implanted ZnO thin films*", J. Mater. Sci. **47**, 1119 (2012).

For more information please visit

**http://www.macdiarmid.ac.nz/our-people/principal-investigators/dr-grant-williams; http://www.vuw.ac.nz/xray/**;
http://www.victoria.ac.nz/scps/research/research-groups/spintronics/default.aspx

## Ulrich Zuelicke, PhD (*Indiana*), FNZIP, Professor

*Theoretical condensed matter physics*

Email – **uli.zuelicke@vuw.ac.nz**

My background and professional expertise is in theoretical condensed-matter physics. I am particularly interested in the description of mesoscopic and strongly correlated many-particle systems that are typically found in semiconductor heterostructures, complex/unconventional materials (such as graphene), and trapped ultra-cold atom gases. My current research is focused on the theory and modelling of functional nanostructures, nano-electronic transport and spin-electronic devices, with applications in quantum information theory. In addition to working on purely theoretical problems, I enjoy collaborating with experimentalist colleagues on projects of mutual interest.


R.P. Tiwari, U. Zülicke, and C. Bruder, “Majorana fermions from Landau quantization in a superconductor and topological-insulator hybrid structure”, *Physical Review Letters* **110**, 186805:1-5, 2013.

T. Kernreiter, M. Governale, and U. Zülicke, “Carrier-density-controlled anisotropic spin susceptibility of two-dimensional hole systems”, *Physical Review Letters* **110**, 026803:1-5, 2013.

M. Governale and U. Zuelicke, “Viewpoint: Spins made to order in low dimensions”, *Physics* 5, **34**, 2012.

O. Fialko, J. Brand, and U. Zuelicke, “Soliton magnetization dynamics in spin-orbit coupled Bose-Einstein condensates”, *Physical Review A* **85**, 051605(R):1-5, 2012.

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.

M. Jääskeläinen, M. Lombard, and U. Zülicke, “Refraction in spacetime”, *American Journal of Physics* **79**, 672-677, 2011.

R. Winkler and U. Zülicke, “Invariant expansion for the trigonal band structure of graphene,” *Physical Review B* **82**, 245313:1-9, 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.

## 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.

This equipment is used to aid other large research projects that happen outside the School via access to major national facilities such as the Australian Synchrotron and the Murchison Widefield Array (MWA), Microlensing Observations in Astrophysics group (MOA) etc.

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

Microscopy
2 Transmission electron microscopes
2 Scanning electron microscopes (including high resolution cryo SEM)
2 Atomic force microscopes (multimode and bioscope)
A range of optical microscopes

Spectroscopy
2 Raman
Micro Raman
2 Fluorescence
2 Infrared
Visible / Ultraviolet
Atomic absorption
Ultrafast laser spectroscopy
High resolution mass spectrometer

X-ray diffraction
Powder XRD
Laue XRD
Small-Angle X-ray scattering

Irradiation
Frequency-doubled (Ar/BBO) visible/UV laser
2 X-ray generators
Amplified Ti:Sapphire femotosecond laser

Surface area
BET surface area

Clean Room Facility
Karl Suss Mask Aligner
Sputter coater
Thermal and electron-beam thin film evaporator
Reactive Ion Etching
Dektak – surface measurement tool
Spin coaters

Rheology
Controlled stress and controlled strain rheometers

Particle size
Laser based particle size analyser (both SLS and DLS, and zeta potential)

Furnace
Radio frequency induction furnace
Other electrically heated furnaces

Thermal analysis
Differential scanning calorimeter (DSC)
Thermal gravimetric analysis (TGA)

Palaeomagnetic laboratory
Including spinner and cryogenic rock magnetometers, thermal and alternating field demagnetizers, facilities for palaeointensity determination, pulse magnetizer, and a range of magnetic susceptibility meters and sensors. Field equipment includes electric and petrol-fuelled drills, and lake sediment corers, and archaeomagnetic sampling kit.

Ellipsometry
Ellipsometer

Astronomy
Frame-Transfer CCD photometer

Photovoltaic characterization
Spectrally resolved photocurrent
Source measurement unit

4 Gloveboxes

Materials growth equipment
2 ultra high vacuum deposition systems

***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 and PhD courses. Master's by thesis courses have progress reports due after three and eight months, respectively. 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/

# WHO TO CONTACT

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/studentservice/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<br>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.

Patricia Stein manages all postgraduate (PG) students:
patricia.stein@vuw.c.nz 04-463 5982

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|---|---|---|
| **Johan Barnard** | Manager, Student and Academic Services | 04-463 5980 |
| **Shona de Sain** | Associate Dean (Students & PG Research) | 04-463 5092 |

## TE RŌPŪ ĀWHINA

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|---|---|
| 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.