



Department of Physics and Astronomy

Honours Program 2012

Prospectus

August 30, 2011

From the Head of Department



I am delighted to introduce you to the Honours year in the Department of Physics and Astronomy at Macquarie University.

As the first encounter with a research project in physics of significant scale, Honours is an exciting and challenging year that our students invariably find rewarding and memorable. Working closely and in-depth with active researchers is a unique opportunity to understand more deeply the nature and practise of cutting-edge science. In addition, our coursework program provides advanced studies in a range of areas, and is tailored to suit the research discipline of each student.

This prospectus provides details on all aspects of the Honours program at Macquarie. I encourage you to read it and then to contact both the Honours convenor, A/Prof. Mike Steel, and prospective supervisors for the research projects listed in Chapter 5 that take your interest. Further information about the teaching and research programs of the Department of Physics and Astronomy is available from the websites listed in Section 1.7.

I sincerely hope to see you in the 2012 Honours class.

A handwritten signature in black ink that reads "D Coutts". The signature is written in a cursive, flowing style.

Associate Professor David Coutts
Head, Department of Physics and Astronomy

Contents

1 Overview	7
1.1 Introducing Honours at Macquarie	7
1.1.1 What is Honours?	7
1.1.2 Why study Honours?	7
1.1.3 Why study Honours at Macquarie?	8
1.2 How is the Honours course structured?	9
1.3 How is the Honours year assessed?	10
1.4 How is the Honours program administered?	10
1.5 I'm interested, but I need to know more	10
1.6 Sign me up!	11
1.7 Important Documents and Websites	11
2 Coursework Modules	13
2.1 Choosing coursework modules	13
2.2 Typical coursework programs	14
2.3 Physics coursework modules on rotation	14
3 Research Project	19
3.1 Timetable for the research project	19
3.2 Developing a project	20
3.2.1 Selecting a project	20
3.2.2 Research project proposals	21
3.3 Conduct of research project	21
3.4 Project development unit PHYS411	22
3.4.1 Assessment criteria	22

3.5	Major Tasks	24
3.5.1	Literature Review	24
3.5.2	Research group seminar and progress report	25
3.5.3	Project thesis	25
3.5.4	Final seminar	26
3.6	Time management	26
4	Assessment	29
4.1	Mark breakdown	29
4.1.1	Coursework assessment	29
4.1.2	Project assessment	30
4.2	Full breakdown of marks	32
4.3	Honours assessment procedures	32
4.3.1	University medal	33
5	Research projects on offer for 2012	35
5.1	Research in Astronomy and Astrophysics	35
5.1.1	Astronomy and Astrophysics projects	36
5.2	Research in Photonics	41
5.2.1	Photonics projects	41
5.3	Research in Quantum Science	50
5.3.1	Quantum science projects	50
6	Contact information	55
6.1	Key staff	55
6.2	How to Apply	56
6.2.1	Entry requirements	56
6.2.2	Application	56
6.2.3	Enrolment	56

Chapter 1

Overview

1.1 Introducing Honours at Macquarie

1.1.1 What is Honours?

The Department of Physics offers one-year Honours programs in *Physics*, *Astronomy and Astrophysics*, and *Photonics* to suitably qualified candidates. The Honours program is a separate one-year full-time program offered after a 3 year Bachelor degree. It consists of a set of advanced coursework modules and a personal research project in approximately a 3:5 ratio.

These programs offer you an opportunity to develop your research expertise and to do focused coursework to a more advanced level than that provided in the 3-year Bachelors degree.

1.1.2 Why study Honours?

We aim to provide you with valuable research experience, and through the coursework program, to broaden and deepen your skills and knowledge in your chosen discipline. Research experience and training offers benefits to Honours graduates in many ways: the successful conduct of a research project requires a depth of understanding of the problem and the background; mastery of particular techniques (whether experimental, computational or theoretical); and the ability to communi-

cate clearly the results and insight obtained in the project work both in writing and speaking. In addition, successfully meeting the deadlines imposed during Honours requires good organisational skills, and a high level of maturity, independence and self-motivation. Through the mentoring provided by individual supervisors as well as more general skills training provided by the Department as a whole, we aim to help you to develop the research skills needed to successfully complete an Honours degree.

The Honours Programs thus serve two main purposes. If you are seeking a career in industry, the additional coursework and the independent work required for a research project and thesis provide you with a stronger qualification and valuable experience. If you wish to undertake research, the Honours degree is the standard entry point to a postgraduate research degree such as a Master or Doctorate in Australia or the UK. It is recognised as equivalent to the entry requirements for graduate schools in the USA and Europe.

Finally, it is a challenging and unique opportunity to test your limits and discover what you can achieve.

1.1.3 Why study Honours at Macquarie?

The Department of Physics and Astronomy is a prominent member of the physics research community in Australia. We perform world class research in Photonics, Quantum Science, Condensed Matter Physics, and Astronomy & Astrophysics. In the first round of the federal government's Excellence for Research in Australia evaluation scheme, the department's performance was ranked as either above world standard or well above world standard in all its research disciplines. We are a large group with approximately 25 continuing academics, 30 postdoctoral researchers and around 90 postgraduate students. Our graduates have gone on to pursue hugely varying careers, including academic research in physics and astronomy, industrial and defence research, management, government and teaching. The Department hosts four University Research Centres: MQ Photonics Research Centre, the Quantum Science and Technology Research Centre (QSciTech), the Research Centre for Astronomy, Astrophysics and Astrophotonics, and the MQ BioFocus Research Centre. In addition, we host nodes of two major Australian Research Council Centres of Excellence: the Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS) and the Centre for Engineered Quantum Systems (EQuS) as well as major items of fabrication and characterisation equipment that form part of the Australian National Nanofabrication Facility (ANNF).

Our Honours students are embedded in a research group and experience the full range of research activities from the first week and throughout the year. The coursework we offer at Honours level offers a deeper coverage of topics in Physics, Astronomy and Astrophysics, and Photonics than is possible in our 3 year degree. Thus some units are designed to fill omissions in the undergraduate curriculum, or to treat subject material in a more sophisticated way, compatible with the research expectations we have of our Honours students. Additionally, units are designed to improve skills and techniques needed in research, such as analytical or interpretive skills.

At Macquarie, we take our Honours program extremely seriously. For staff, guiding students through their first major research experience is an enjoyable and intellectually rewarding experience. Honours is one of the pillars of our teaching program and the entire Department is involved in the design, administration, assessment and review of the Honours course. We recognise that a creative and vigorous Honours program plays a key role in our recruitment of postgraduate students and in enhancing our external reputation, and is therefore critical to the future health of the Department.

1.2 How is the Honours course structured?

The course runs the full academic year from mid-February to early December. Students must complete a total of 24 credit points, comprised of 9 credit points for coursework and 15 credit points for the research project.

The coursework component is broken into six lecture modules of around 15 lectures each on advanced physics and mathematics topics delivered by various staff members. In general, coursework is completed in first semester. Each student's coursework program is tailored to their research interests.

The research project is conducted within one of the Department's research groups under the supervision of two or more research staff members. The project runs the full year with a 100% focus in second semester. Aside from experimental and/or theoretical work, the project includes preparation of a literature review, practice in scientific presentation skills and participation in the activities of your research group. It culminates in the preparation of a major thesis (around 25000 words) and delivery of a research talk to the entire department.

1.3 How is the Honours year assessed?

The weighting of marks in the program reflects the division of time. Currently the coursework component accounts for $3/8$ of the final grade, and the research project accounts for the remaining $5/8$. Coursework marks are determined by the individual lecturers based on assignments and a final exam (either formal, oral or take-home). The project performance is assessed by the supervisors based on the entire year's work, and by two additional staff members who provide a mark report based on the project thesis alone. The three grades are averaged. The final research talk also contributes to the project grade, and is assessed by the entire department.

The total mark determines the class of Honours awarded: *First class, Second class Division I, Second class Division II* or *Third class*. The final determination of marks is the responsibility of the whole department.

In cases of exceptional performance, the Faculty of Science may recommend the award of a University Medal to one student based on exceptional performance throughout their undergraduate program. This recommendation is forwarded to the University Medals committee for evaluation.

Full details of the assessment procedures are provided in chapter 4.

1.4 How is the Honours program administered?

At Macquarie, delivery, administration and assessment of the Honours program is the responsibility of the Physics Honours Committee, which consists of the entire academic staff of the Physics department. The committee meets on a number of occasions during the year to review projects, exam results and thesis assessments. Chairing of these meetings and day-to-day administration is the responsibility of the Physics Honours Convenor. Contact details for the Convenor and other key people are provided in section 6.1 of this booklet.

1.5 I'm interested, but I need to know more

First thing, come and have a chat with the Honours convenor. Second, talk to some of the staff in the department. This could be staff members who are offering research projects that sound interesting. Or you might have developed a relationship with a staff member through your undergraduate courses, and would value their advice.

Staff members are always keen to talk to potential students, so don't be shy about approaching them.

1.6 Sign me up!

Admission to the Honours program is by consent of the Head of Department based on sufficient performance in undergraduate courses. For Macquarie students, a minimum GPA of 2.5 is required. For students from other universities, performance roughly at the level of a Credit average is required. Greater weight is placed on later years of the degree.

The application procedure is described in section 6.2 of this booklet. We welcome applications from students studying relevant courses at other universities.

1.7 Important Documents and Websites

The following resources provide important information about our research programs, the structure of the Honours year,

- This prospectus.
(Online at physics.mq.edu.au/undergrad/honours/prospectus.pdf)
- The formal Honours handbook which defines the course and assessment policies.
(Online at physics.mq.edu.au/undergrad/honours/handbook.pdf)
- Key Department of Physics and Astronomy webpages

Department homepage

www.physics.mq.edu.au

Staff directory

physics.mq.edu.au/directory

Honours program page

physics.mq.edu.au/undergrad/honours

Astronomy and Astrophysics research

www.astronomy.mq.edu.au

Photonics research

web.science.mq.edu.au/groups/mqphotonics

Quantum Science research

www.qscitech.info

Chapter 2

Coursework Modules

Each student must complete six coursework modules from the selection of courses on offer. Summaries of recent offerings are detailed in section 2.3. The courses on offer differ from year to year depending on enrolments, staffing availability and the topic area of the research projects undertaken by Honours students in that year.

Normally, all modules will be completed in the first semester of the program, with three modules in each half semester. This may vary in some years for certain students to accommodate staffing and timetabling issues.

2.1 Choosing coursework modules

The following section details the courses that have been taught in recent years. Not all courses are offered in any one year.

All students take Mathematical Methods I and Mathematical Methods II, and the remaining four courses are selected from those on offer in consultation with the candidate's supervisor.

In some cases, it may be possible to take a unit from the undergraduate physics program that the candidate has not previously taken. Additional assessment tasks will be assigned to bring the unit to a 400-level standard. If this applies to you, then you should consult with the lecturer concerned to confirm your place in the unit. Later you will have to book a seat at the Examinations section for the examination

for that unit. Examinations for Physics 400-level modules are conducted within the department.

In addition, MAPH 420 (Mathematical Physics: Mathematical Methods in Quantum Mechanics) and other 400-level Mathematics units are offered by the Mathematics department. Copies of unit summaries (lecturers, lists of topics, references, assessment) for each unit can be obtained from the mathematics department.

2.2 Typical coursework programs

Some typical coursework programs for different types of Honours students are as follows:

Experimental Physics

Mathematical Methods 1, Mathematical Methods 2,
plus four of:
Classical mechanics, Statistical mechanics, Solid state physics, Nonlinear optics, Modern experimental atomic and optical physics, Molecular spectroscopy.

Theoretical Physics

Mathematical Methods 1, Mathematical Methods 2,
plus four of Statistical mechanics, Advanced quantum theory, Nonlinear optics, Quantum field theory, Advanced general relativity, Solid state physics

Experimental Photonics

Mathematical Methods 1, Mathematical Methods 2, Solid state physics, Modern experimental atomic and optical physics, Nonlinear optics, Molecular spectroscopy

Astronomy and astrophysics

Mathematical Methods 1, Mathematical Methods 2, Astrophysics 1, Astrophysics 2, Classical mechanics, plus one of Molecular spectroscopy, Statistical mechanics, Advanced general relativity, Nonlinear optics

2.3 Physics coursework modules on rotation

The following are descriptions of courses taught in recent years. Note that the content may differ slightly as lecturers change or the direction of the module evolves.

Mathematical Methods I [A/Prof. Alexei Gilchrist]

This unit aims to develop students' understanding of the mathematical methods used in physics. It will cover methods for solving the differential equations that typically occur in the physical sciences. The primary focus is on ordinary differential equations covering topics from first order equations and how to classify and solve them, through to higher order equations and more general techniques such as reduction of order, Laplace transforms, Green functions and series solutions. In each case the aim is to develop effective problem solving strategies, and where possible, the examples will be taken from the physical sciences.

Mathematical methods II [A/Prof. Gavin Brennen]

This course is an introduction to the theory of classical groups. We begin with defining a group and making a connection to symmetries such as spatial and dynamical symmetries. Discrete groups are covered in some detail. We begin with the symmetric group S_n and define cosets, classes, and invariant subgroups. Symmetry and group representations are discussed and we cover irreducible representations, unitary representations, Shur's Lemma, and orthogonality relations. We conclude discrete groups with some examples of representations of S_n and a discussion of particle statistics. In the second half we cover continuous Lie groups beginning with Lie algebras and their representations. We describe some compact and non-compact Lie groups and work through several examples making the connection between symmetries and conservation laws, e.g. space-time symmetries and the Poincare group.

Classical Mechanics [A/Prof. Mike Steel]

This course presents an introduction to the formal theory of classical mechanics using Lagrangian and Hamiltonian formalisms. After introducing the calculus of variations, we postulate Hamilton's Principle as the key axiom of Lagrangian mechanics and so derive Newton's laws of motion. We examine the central force problem, deriving Kepler's laws and key results on oscillations in arbitrary potentials. Returning to the development of the formalism, we introduce conjugate variables and show how canonical transformations provided added power to the Hamiltonian formalism. The equations of motion are expressed in terms of Poisson brackets which illustrates the conceptually small differences between classical and quantum mechanics. Finally, we re-express mechanics in terms of the Hamilton-Jacobi partial differential equation, and show how it brings the formalism full circle to our starting point.

Astrophysics I: The Astrophysics of Gaseous Nebulae [Prof. Quentin A Parker]

This half unit (18 lecture equivalent via a mainly reading programme together with a presentation, assignments and individual tuition/lectures) is designed to give students an understanding of the physical processes involved in gaseous nebulae. The course aims to give a broad underpinning of the key concepts and physics of line formation in a gaseous nebula in a range of astrophysical phenomena such as HII regions and Planetary nebulae. Key fundamental physical principles, theories and observational diagnostic techniques are covered. These fall into 4 broad categories. (1) Photoionization Equilibrium covering: Photoionization of a pure Hydrogen nebula; Photoionization of heavy elements and Charge exchange reactions. (2) Thermal Equilibrium; covering Photoionization energy input; Recombination energy losses; Free-Free radiation and Collisionally excited line radiation energy loss. (3) Determination of emitted spectrum covering: Optical recombination lines; Continuum radiation; Radiative transfer effects and the Bowen-Fluorescence mechanism for OIII Collisional Excitation. (4) Comparison of Observation and theory including: Temperature measurements from emission lines; Electron densities; Ionising radiation from stars and Abundances.

Astrophysics II [*Prof. Mark Wardle*]

This module serves as an introduction to astrophysical shock waves. We begin with a discussion of shock waves, then derive the fluid equations and find the linear wave modes. Shock jump relations are derived, and detailed models of shocked, cooling interstellar gas are discussed. Magnetic fields are introduced, and the equations describing magnetohydrodynamics and the associated dispersion relation for MHD waves are derived. Finally, we discuss jump relations across MHD shock waves and the different classes of MHD shock wave.

Modern Experimental Optical and Atomic Physics [*A/Prof. Judith Dawes, Dr Richard Mildren*]

We introduce Bose-Einstein statistics and high resolution atomic spectroscopy as a basis for laser trapping and cooling, and finish with a discussion of recent developments in Bose Einstein condensation. These are some of the topics that have won recent Nobel Prizes in Physics, and we explore some of the exciting new developments in modern experimental optics and atomic physics. In particular, we review lineshapes and line-broadening, linewidth limits, frequency combs, atomic beam spectroscopy, Doppler free saturation spectroscopy, Zeeman and laser Stark spectroscopy, and Raman crossing. We also consider techniques for laser cooling and optical molasses, and laser trapping using magnetic traps, evaporative cooling and atom optics.

Molecular Spectroscopy [*A/Prof. David Coutts and A/Prof. Richard Mildren*]

This course presents an introduction to molecular spectroscopy including spectral broadening processes and modern spectroscopic techniques such as sub-Doppler spectroscopy. Building on the atomic physics material covered in PHYS303 we will cover the quantum physics of molecules and their interaction with light including, microwave (rotational), infrared (vibrational), Raman and Electronic spectroscopy of diatomic and polyatomic molecules. The course also takes an in-depth look at line broadening mechanisms and the ultra-high resolution Nobel-prize-winning experiments on the hydrogen atom that have been used to test fundamental theories in physics. It is intended to be particularly useful for photonics, astronomy and astrophysics students, as well as general physics honours students.

Solid state physics [*Prof. Deb Kane*]

This course provides a discussion of current research in condensed matter physics based on advanced materials based. The material includes advanced topics in semiconductor physics and devices including the physics of nanostructures: quantum wells, super lattice, rectangular barrier, quantum mechanics of heterostructures, quantum wires, and quantum dots (boxes and pyramidal). We investigate applications of quantum heterostructures: laser diode active layers, QWIP structures, cascade laser structures, resonant tunnelling diodes as well as aspects of magnetism: magnetic materials (diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic), magnetisation (Hunds rules, permanent dipole in a magnetic field), conduction electron paramagnetism, giant magnetoresistance. Finally we examine superconductivity through an introduction to BCS theory, experimental support for BSC theory, Type I and type II superconductors and applications including superconducting magnets in the Large Hadron Collider.

Statistical mechanics and thermal physics [*A/Prof. Gavin Brennen*]

This course presents an introduction to thermodynamics and statistical physics. In the first half, we begin with a definition of state functions and macroscopic variables such as temperature, pressure, volume, and magnetisation which characterise the state of system, as well as the quantities heat and work which do not, and introduce the concept of the equation of state which connects thermodynamic state functions. Entropy is introduced via an information theoretic argument and applied to counting microstates of a system. We define the zeroth through the third laws of Thermodynamics and introduce the TdS relations. A derivation of Maxwell's relations is given and the concepts of reversible and irreversible engine and refrigeration cycles are covered in some detail. We cover the ideal gas law and first order corrections for the Van der Waals gas. In the second half we introduce thermodynamical equilibrium as a postulate of statistical mechanics and derive conditions for equilibrium. We derive the partition function via the principle of

maximum entropy. The Gibbs paradox is described as are macro, micro and grand canonical ensembles with examples using the ideal gas and Van der Waals gas. A short introduction is given to quantum statistical mechanics and Fermi-Dirac and Bose-Einstein distributions are derived.

Honours quantum mechanics [A/Prof. James Cresser, Prof. Jason Twamley, A/Prof. Daniel Terno]

This course continues the development of quantum mechanics with the aim in mind to introduce to students the wide range of mathematical and physical concepts that underlie quantum mechanics. The topics will be drawn from the following: the Schrödinger and Heisenberg pictures; Feynman path integral formulation; Local gauge invariance and the electromagnetic field in quantum mechanics; Semiclassical theory of atom EM field interaction; Time-independent perturbation theory; Time-dependent perturbation theory (the interaction picture, Fermi's Golden rule, the Wigner-Weisskopf approximation, the Einstein B-coefficient); Symmetry and invariance principles in quantum mechanics; Angular momentum in quantum mechanics; Identical particles and quantum fields; Quantisation of the EM field. Note that topics in quantum mechanics more relevant to quantum information theory are presented in a separate module.

Chapter 3

Research Project

The research project represents the majority of the year's work. A project of this scale is for most students a completely new experience, challenging and rewarding.

3.1 Timetable for the research project

Work on the research project continues throughout the year with different workload emphases. In normal circumstances, the project occupies approximately 25% of the first semester, and 100% of the second semester. This may vary for certain students according to the scheduling of coursework.

The key events and milestones for the project are as follows:

Choose a project

Discussion with potential supervisors should take place in October-November based on the projects offered in the prospectus.

Project commencement

Work begins with background reading around the middle of February.

Literature review

A 10-page review of key papers for your project is due in late April.

Research group talk

You deliver a 20 minute progress talk to your research group in mid June following the examination period.

Draft thesis

A draft thesis is prepared by mid September for your supervisor and returned with comments. A revised draft is due with the convenor in mid-October.

Final thesis

A final thesis is submitted to the department in early November for assessment and formal comments.

Departmental talk

The final major event is a 25 minute presentation of your project to the entire department in mid-November.

Assessment

The department finalises assessment at the start of December. Unofficial grades are available about a week later once approved by the Faculty of Science.

3.2 Developing a project

Constructing a project has two stages: selecting a project and supervisors, and a formal process for developing the project plan.

3.2.1 Selecting a project

Scientific research is constantly evolving therefore the research projects on offer change annually. There is a list of descriptions of projects for the coming year in the next chapter.

You should read these descriptions as a guide, and then discuss possible projects with at least two staff members, before making a decision about your project and supervisor. Your potential supervisor may adapt a project to suit your interests and abilities. You may also consult the Honours Convener. You should be considering projects in October-December and advise the honours convenor of your final decision (with the emailed agreement of a supervisor) by the end of January. You should have commenced work with your supervisor by mid-February.

3.2.2 Research project proposals

Your Honours program (Research project and selection of coursework units) must be approved by the Physics Honours Committee early in the Honours year. To this end, your supervisors will prepare a Research Project Proposal of about 2 pages, listing your name, your supervisors and any associate supervisors, and project title. The proposal describes the aims of the project, the methods and techniques to be employed, some goals (at various levels of attainment), the resource requirements of the project. Finally it should also include your coursework plan.

Your supervisor, in combination with the Honours Committee in a review role, will determine an appropriate scope for your project, so that it is intellectually challenging and but can reasonably be accomplished within the limited time available for Honours research. If this review (conducted around week two of first semester), identifies problems, the proposal must be appropriately revised before it is adopted.

3.3 Conduct of research project

Your Honours research begins with a literature survey, in which you need to read about the field of your project. With your supervisors help, you will have access to computer-based literature search methods, and to inter-library loans. Your essay will describe your findings and list the references you consulted, so you should keep careful notes throughout your project on what you read, and what it means. As you begin working on the problem, you should be particularly careful to keep lab notebooks up-to-date and clear, so that when you return to write it up several months later, it is still clear what you did and what it meant. (It also helps to have meetings with your supervisor about the results while they are fresh in your mind). You should keep backup copies of important computer files, as computers always fail when you dont want them to!

Everyone hits problems during their Honours year. You should expect to encounter lots! This is the nature of research, but successful researchers do try to work creatively and to work persistently to address problems. Try to choose a research project that really interests you, so that as you pursue it and grapple with the inherent problems, your interest deepens. This helps you to keep your enthusiasm for your project, even when things are not working. Remember that even if the project does not have the outcome you expected or hoped for, as an Honours student, your approach and techniques you learn in working on the project are much more important.

3.4 Project development unit PHYS411

In first semester, the project work is formally contained in the unit PHYS411. While most of the work is focused directly on your research and literature review with your supervisor, PHYS411 also contains a skills development component. This is conducted as an informal module involving all students together with a range of lecturers, typically the convenor and some of the supervisors. The purpose of the unit is two-fold:

- Ensure the research project gets off to a smooth start, with realisable milestones. It can be easy to let coursework push project work to one side.
- Develop skills in different aspects of practising and communicating science: preparing literature reviews, reviewing articles for colleagues, presenting a scientific talk, assessing the work of peers.

During the year, activities will include a workshop on essay and thesis writing, and one on seminar speaking. The first workshop is on essay and thesis writing, and is scheduled before the essay is due. Since we began offering these workshops, we have found a significant improvement in the quality of writing in theses submitted for Honours. In the workshop, you will study some examples of writing and identify how they could be improved. Developing a critical and constructive approach to a piece of writing is valuable in improving the quality of your own drafts. The second seminar is on speaking, and includes many suggestions for making clear and professional presentations.

Within the Faculty of Science, Computing also offers a series of seminars on these topics, which you are welcome to attend.

You will also meet individually with the honours convenor twice during first semester to discuss your progress and any problems. If problems are identified, a strategy to resolve them will be developed in consultation with your supervisors and yourself.

3.4.1 Assessment criteria

PHYS411 is assessed on a pass/fail basis. Provided you participate in group activities and meet the initial (modest) milestones for the project, including the literature review, and provided your supervisor is happy with your progress, you can expect to pass with full marks. Note that the level of *performance* demonstrated in these tasks does not affect the assessment. It is the *participation* that is emphasised. This

policy is intended to provide an opportunity for students to try new activities and take some risks in their attempts without worrying about marks. For example, informal presentations and seminars are done without notes.

Some elements of 411 will be common to all students, while other activities will be peculiar to each project. Progress will be assessed through a checklist filled out twice a semester by the supervisor, and based on participation in the regular group meetings with convenor. We are looking to see indications of a relevant subset of the following:

Literature review

Is the student:

- finding the right papers? (broad enough, deep enough, sensible number)
- learning to use databases (Web of Science etc) effectively?
- showing initiative in pursuing different aspects of the literature?
- developing understanding of the context of their project?
- able to convert a mass of literature into sensible different topics to communicate in writing?

Integration into research life

Does the student:

- prepare for and attend regular meetings with supervisor?
- perform items of work requested by supervisor in timely fashion (subject to vagaries of coursework demands)?
- develop necessary relationships with key junior research staff: postdoc/PhDs on the same equipment etc?
- attend suitable fraction of meetings or seminars of research grouping?

Core project progress

Does the student:

- manage to make reasonable, if not rapid, progress on the research project in first semester?
- get in the lab? Fiddle with equipment? Pump down the chamber? Align the laser? Re-derive the fundamental equations etc.
- show initiative or imagination in their response to the material?

-
- ask expected questions?
 - ask unexpected questions?!
 - show ability to plan work?

Time and project management

- Does the student manage the competing demands of Honours and the shifting work loads effectively?
- Are coursework-related delays to the research project acceptable and under control?

3.5 Major Tasks

While you will work consistently on the project throughout the year, a number of major tasks are due at different times. These are detailed below.

3.5.1 Literature Review

Literature reviews of around 5000 words (10 pages) are due, typically in mid-April, after students have performed a few months of work in the Honours program. The review should provide a thorough survey of the field of interest of the research project, including a description of the main findings combined with some analysis or critical evaluation of why such results are important. The essays are not assessed, but serve as a general practise run for writing the longer thesis. In addition, in many cases, the essay, suitably modified, forms the first chapter of the final thesis.

The literature review should conclude with an additional 1 page distillation of the approved research plan and its broad milestones and time line, as well as a summary of progress so far.

Copies of the essays are circulated among the Physics staff before the first seminars, so that all staff have the opportunity to read and comment on the essays. This is an important source of feedback for Honours students, as it can indicate poor explanations or logical inconsistencies for example.

3.5.2 Research group seminar and progress report

After the literature reviews are submitted and circulated, you have the opportunity to present a progress report and a brief literature survey in a 20 minute seminar to your research group. Honours students and physics staff from other groupings may also attend, but the content should be pitched to your research group. An additional period is allowed for questions following the seminar.

In the seminar, you should aim to present the background and general nature of your project, showing its relevance to the field of your research. In your progress report, you should describe your specific research goals and the techniques you will use in the project, and indicate the progress to date. This seminar is not assessable, but serves to give you practice in presenting your work. The seminar and question period helps to identify or perhaps clarify problems in your research, as you will receive valuable feedback from the audience.

You should perform a number of practice talks before presenting your seminar, including at least one with your supervisors.

3.5.3 Project thesis

Your Honours thesis is the culmination of the whole project and describes your research achievements at a level suitable for your fellow Honours students, or for an academic staff member not in the specific research field. It plays a key role in the assessment of the year, and you should devote considerable time and care to its preparation.

Most theses begin with a survey of the field of the research, describing and discussing the significance of the results in the literature. Subsequent chapters should deal with methods and techniques, results and discussion of the results in the light of the information in chapter 1. A final chapter should list conclusions and suggestions for future work. References are usually listed at the end of the thesis, in one of the styles described in the section on essays above. Any supplementary material, such as software or programming information or lists of data, should be provided in appendices. Note that appendices are not an opportunity to detail additional core work that could not be contained in the main page limit. They are intended to provide supporting data for the material in the core thesis.

There are strict page limits for the thesis. It should be no more than 25,000 words, ie about 50 single-spaced pages in length, and should include figures, graphs, tables and references as appropriate. References, acknowledgements, and appendices are

not included in the word limit, but aside from computer codes or data printouts, the total length must not exceed 80 pages. You are encouraged to read some past Honours theses to gain ideas on typical formatting and style.

Note that the deadline for submitting the draft thesis to your supervisor refers to submission of the entire document. You should expect multiple rounds of drafts and feedback from the supervisor on each chapter. Four or more revisions on certain chapters is not uncommon.

3.5.4 Final seminar

The final seminar is delivered to the entire department. There is a time limit of 25 minutes with 10 minutes question time. This seminar is a description of your project, the problems you addressed, and your achievements, hopefully accentuating the positive! It is assessed by all members of staff present and contributes to the final project mark. It is scheduled after the theses have been read by examiners, and may be helpful in clarifying questions that the examiners or other staff members have after reading through your thesis. To that end, a clear, professional presentation and a competent understanding of the issues raised during question time are important.

3.6 Time management

The combination of coursework and project work, and the various deadlines throughout the year make time management a critical factor in success. This is particularly so in the first half of the year when project and coursework compete for time. Roughly speaking, each coursework module should occupy 25% of your time in the five weeks that each module runs and in the following week when working on final assignments. This means that under a normal program, for most of the first semester you will only be spending 25 % of the time on project work. This includes time devoted to the literature review, research group seminar and group activities conducted within PHYS411.

Of course from week to week, the proportion of your time spent on each activity may vary. In some weeks, a rush of coursework assignments may reduce the time you can devote to your project. In other weeks, a critical phase of experimental work or a multi-day research workshop might require almost complete devotion to your project. In general, coursework lecturers will listen sympathetically to requests for assignment extensions. But equally, supervisors must be aware of the limited claim

they have on your time and should assign project work accordingly.

It is your responsibility to manage these week to week variations in time allocation and to keep your supervisor informed about any significant variations in how you are using your time. In the event that a confluence of project deadlines and coursework assignments lead to an unreasonable workload, you should alert your supervisor and lecturers to the problem and propose reasonable extensions to resolve the conflict.

As a full-time student, the Department expects you to work at least the standard 35 hour week. As is the case for postgraduate students and academic staff, most honours students will devote considerably more than this to their work.

Chapter 4

Assessment

This chapter defines the assessment procedures for Honours. In addition to the information here, Honours is assessed in accord with the University's assessment policy. In particular, your work is assessed in terms of demonstrated standard of achievement, not by normalising against a standard curve.

4.1 Mark breakdown

The Honours year is a 24 credit point program, comprised of 9 credit points of coursework and 15 credit points of project. In forming the final grade for the year, marks are allocated for these two components in proportion:

Coursework: $3/8 = 37.5\%$

Project: $5/8 = 62.5\%$

This allocation also reflects the approximate proportion of time you should devote to each component of the course, though this will depend on your particular talents.

4.1.1 Coursework assessment

Coursework accounts for 9 of the 24 credit points required to complete the honours year. Candidates must complete six modules each worth 1.5 credit points which

equates to 6.25% of the final grade for the year. Together the modules thus represent $6 \times 6.25\% = 37.5\% = 3/8$ of the final grade.

Assessment tasks are set by the lecturer and will be equivalent in workload to two formal home-work assignments. Marked assignments will be returned within two weeks, and before any final exam. *No assignment will be due later than the Monday of the examination study week.*

Each module will normally have a final examination, worth no more than 60 % of the module. The exam may take one of the following forms:

- A formal exam of maximum length 90 minutes.
- An oral exam of maximum length 30 minutes.
For all oral exams, at least one academic staff member other than the module lecturer will be present, and the examiners will take detailed notes recording performance of the candidate and justifying the mark awarded.
- A take home exam of maximum length 24 hours.

Students taking an undergraduate unit will sit the exam at the university timetabled session.

Your result for each module (or equivalent unit) is determined as a standardised mark and the marks for the six modules attempted are summed and averaged to give a coursework mark out of 100. The standardised marks assigned for grades are as follows:

<i>Grade</i>	<i>Mark</i>
High distinction	85-100
Distinction	75-84
Credit	65-74
Pass	50-64

4.1.2 Project assessment

Thesis component

Two thesis examiners are usually chosen from the staff of the Physics department, but may be external people with appropriate expertise in your field of research. Such

external examiners would have a minimum academic qualification of Bachelor (Honours) themselves. They each prepare a one page report on the thesis, judging it according to three considerations. These are the delineation of the topic in the context of current knowledge, the analysis of the results of the research, including the actual results obtained, and finally its quality as a literary presentation.

Examiners recommend a grade of Honours for the thesis component alone. In addition, your supervisors prepare a report on both the thesis (according to the criteria above) and your performance throughout your research project. This may include your ability to work independently, your carefulness and persistence in your work, a creative approach to difficulties, and any problems that were beyond your control during the year.

The recommended grades from the examiners and supervisors are weighted equally but considered as advisory by the Honours Committee. Any significant discrepancies are discussed carefully before a final grade is awarded.

Seminar component

The final seminar delivered to the Department in November contributes 10 % of the project mark. The talk is assessed by all members of academic staff present who complete standard score sheets with marks for several criteria. These criteria are

Quality of science; Project content and outcomes This addresses both how well you understand the material of the research topic, and the degree to which you made real progress in your project.

Logical sequence of argument and effective talk structure This includes the ability to communicate your ideas to an audience that is not expert in the research topic, and produce a talk with a sequence of ideas and development of the subject and your work.

Presentation and poise This includes the degree to which you have produced an attractive and interesting presentation, and communicate your ideas in a confident and lucid manner. In particular, it includes your ability to respond intelligently to questions from the audience. (It is not expected that you will necessarily know the answers to all questions.)

4.2 Full breakdown of marks

Based on the above, the complete breakdown of marks for the year is as follows:

Coursework:		
	6 modules (each)	6.25
	Subtotal	37.5
Project:		
	Thesis and research (90 %)	56.25
	Seminar (10 %)	6.25
	Subtotal	62.5
Total:		100.0

4.3 Honours assessment procedures

The Honours grades are determined at a meeting of the Physics Honours Committee. Honours supervisors, lecturers of Honours modules, Honours thesis examiners, the Head of Department and the Convenor are expected to attend, and other staff are encouraged to attend. The Honours Convenor chairs the meeting, and is responsible for collating, in advance, all the required information. At this meeting, coursework results, supervisors reports and thesis examiners reports are considered, before the grade for each student is determined by consensus or, in difficult cases, by majority vote of those present.

The grades determined at this meeting are reviewed by a meeting of the academic members of the Faculty, and are then presented to the University Senate for official approval. The marks for coursework and for research, as determined below, are averaged for each student to give a final mark and grade for Honours. The ranking of students, for purposes of prize awards or scholarships, is based on these marks. Each students results are considered individually in this process, but records of previous students and the results of the current class are also reviewed to ensure consistency both within the year and with previous years.

The final agreed marks are standardised and reported according to the Universitys guidelines as follows:

<i>Grade</i>	<i>Mark</i>
High First class	96+
Mid First class	90-95
Low First class	85-89
Second class Division 1	75-84
Second class Division 2	65-74
Third class	50-64

4.3.1 University medal

Nomination for a University medal, awarded for students who demonstrate exceptional performance, requires a mark of at least 90. The award of University Medals is discussed in Senate regulations 91/303 and 91/304. Recommendations are made by the Faculty concerned on the advice of the Head of Department. Evaluations are based on the candidates Honours performance and overall undergraduate performance as well as the candidates performance in Honours in comparison with that of top First class Honours students over a number of years. Decisions on the award of University Medals are made by the University Medals Committee which advises the University Senate.

Chapter 5

Research projects on offer for 2012

Research in the Department falls under three broad categories: Astronomy and Astrophysics, Photonics and Quantum Science. The following sections introduce the research programs in each area and then list available Honours projects for the coming year.

Each project includes names and contact information for the supervisors offering the project. Once you have selected projects that are potentially interesting to you, you *must* contact the lead supervisors to discuss them in detail before making a final choice and informing the Honours convenor.

5.1 Research in Astronomy and Astrophysics

Astronomy research at Macquarie University is coordinated within our new Macquarie University Research Centre for Astronomy, Astrophysics and Astrophotonics (MQ AAAstro). We form a highly active, rapidly growing centre of astronomical research with a current group size of about 40, including 5 faculty, 6 postdocs and 25 PhD, masters and honours students. Macquarie is in close proximity to both the Anglo-Australian Observatory and Australia Telescope National Facility. This has enabled the development of joint appointments creating strong links, valuable synergies and excellent opportunities for collaborations in astronomy and astronomical in-

strumentation/astrophotonics (which is a new emerging area at Macquarie). Current research strengths include: wide-field astronomy, optical, infrared and radio studies of planetary nebulae and supernova remnants, binary stars, Galactic archaeology, theoretical studies of shock-waves, star formation and black holes and astrophotonics.

5.1.1 Astronomy and Astrophysics projects

Astro-1: From Red Giants to Planetary Nebulae

Supervisor(s): *Dr David Frew and Prof. Quentin Parker*

[david.frew@mq.edu.au, E7A 322]

Research area: *Astronomy & Astrophysics*

Research groupings: *MQ AAAstro*

A planetary nebula is a short-lived, glowing shroud around a dying low-mass star. It is formed when a bloated red giant star ejects its outer layers, revealing a very hot, contracting stellar core. A high velocity wind and intense ultraviolet radiation from this stellar remnant can sculpt and ionize the shed layers of gas, as the core becomes a white dwarf. However, the transition between the end of the red giant phase and the onset of nebular ionization is still poorly understood. Current images of the ejecta of stars going through this so-called pre-planetary nebula (PPN) phase are strikingly heterogeneous. This suggests there may be a range of physical mechanisms that govern the bizarre and differing morphologies of these objects, making it a highly topical area for study.

In this project, the student will begin by determining new distances to a large sample of PPNs by modelling their spectral energy distributions. This is via established techniques and will use extensive published and unpublished multi-wavelength data across a broad range of the electromagnetic spectrum. This new distance information will allow the student, for the first time, to generate a robust volume-limited sample of PPNs in order to facilitate a powerful statistical study based on a careful evaluation of the derived energy distributions and other properties such as morphology and location. The results from this important study will provide fresh insights into this intriguing astrophysical phenomenon.

Astro-2: Celestial wheat from chaff: Cleaning Planetary Nebulae catalogues of contaminants and improving the scientific integrity for current and future studies.

Supervisor(s): *Prof. Quentin Parker*

[quentin.parker@mq.edu.au, E7A 206]

Research area: *Astrophysics*

Research groupings: *MQ AAAstro*

Planetary nebulae (PN) are the mysterious glowing shrouds of dying low mass stars. PN play a major role in the ecology and evolution of our Galaxy, they are of key importance in understanding late-stage stellar evolution, have considerable power as kinematic tracers (shedding light on dark matter), are unrivalled laboratories of plasma physics and provide potent cosmo-

logical distance indicators. This significant astrophysical potential of PN is currently seriously undermined by the presence of PN mimics that contaminate earlier samples and bias any scientific analysis and interpretation. Indeed, we have recently shown that $\sim 20\%$ of objects accepted as nearby PN (eg. Hewett et al. 2003) are actually ionised regions in the interstellar medium around unrelated hot white dwarf or sub-dwarf stars (eg. Frew & Parker 2006; Frew et al. 2010) while we have also shown via mid infra-red and radio comparisons that 47% of known pre-MASH PN at very low Galactic latitudes are actually compact HII regions (Cohen et al. 2010 submitted). We have tested and adopted a range of criteria to eliminate such contaminants. Only the recent on-line availability of imaging surveys and other multi-wavelength data has enabled these clear discrimination tools to be developed (Frew & Parker 2010).

In this project the student will undertake a careful multi-wavelength study of the ~ 1000 PN in the ESO Catalogue of Galactic Planetary Nebulae using the newly developed diagnostic photometric and spectroscopic criteria of Frew & Parker (2010) and via the recent availability of large-scale multi-wavelength sky surveys. The work involves spectroscopic and line ratio measurement and analysis (including determination of temperature, density and where possible crude abundances) and multi-photometric comparison across optical, near to mid infrared and radio data. The very latest data from the WISE space telescope will also be incorporated. The results will be the robust identification of PN contaminants and separation into their interesting classes that will be a legacy of considerable value to the astronomical community.

Astro-3: Polarized emission from the massive black hole at the Galactic centre

Supervisor(s): *Mark Wardle*

[mark.wardle@mq.edu.au, C5C 367]

Research area: *Astronomy & Astrophysics*

Research groupings: *MQ AAAstro*

Radio, infrared, and X-ray emission from the 4 million solar mass black hole at the Galactic centre have been comprehensively monitored in a bid to understand the physics of accretion flows onto supermassive black holes. The radiation emerging in the radio and sub-millimetre part of the electromagnetic spectrum is broadly understood to be synchrotron emission from relativistic ($kT_e \sim 10 MeV$) electrons participating in a disk-like, magnetised flow spiralling into the hole. Sporadic flaring is interpreted as arising from the rapid acceleration of electrons during magnetic reconnection events, followed by expansion of the over-pressured region in the accretion flow.

Preliminary work suggests that the flares should have measurable time-varying polarisation, and this may have already been detected in the sub-millimetre. This project will explore the evolution of polarised synchrotron emission in flares with the aim of suggesting observational tests of competing flare models. The student will construct physically-motivated models of the evolving relativistic electron population and magnetic field in the source region and compute the time variation of the integrated Stokes parameters. The results will be compared with existing polarisation data and used to motivate further observations.

Astro-4: Magnetohydrodynamic shock waves in dense interstellar clouds

Supervisor(s): *Mark Wardle*

[mark.wardle@mq.edu.au, C5C 367]

Research area: *Astronomy & Astrophysics*

Research groupings: *MQ AAAstro*

Detailed models of the physical and chemical processes occurring in shock waves have been used to infer conditions in interstellar clouds and to understand violent events such as the interactions of jets from newly-formed stars with their surrounding host cloud. Weak shock waves, on the other hand, have been hardly considered, despite their critical role in dissipating turbulence within the clouds. One complication is that the presence of magnetic fields means that there are three distinct types of weak shock. The goal of this project is to understand their physical and chemical effects, and to identify observational consequences of energy dissipation in weak shock waves. This will be achieved by computing the physical and chemical structure of the the three distinct classes of weak MHD shock waves.

Astro-5: Calibration for Compact Astronomical Spectrographs for Planet Search

Supervisor(s): *Dr Mike Ireland*

[michael.ireland@mq.edu.au, E7A 201]

Research area: *Astrophotonics*

Research groupings: *MQ AAAstro , MQ Photonics Research Centre*

Calibration of astronomical spectrographs is a key part in achieving the meter per second Doppler velocity precision needed to detect planets around other stars. The difficulties in calibration have driven US-based planet search teams to use lossy Iodine absorption cells, and European teams to make very expensive vacuum spectrographs calibrated by complex frequency-comb lasers.

In this project, you will trial and model different cost-effective methods for calibrating the single-mode spectrograph to be used for planet search at Macquarie University observatory. These methods will include the traditional Th-Ar reference lamp, temperature-controlled glass cavities and a Fabry-Perot cavity locked to a stabilized laser. Results from this project will have the potential to drive the technology for the next generation of planet searches.

Astro-6: Direct Detection of Exoplanets around Intermediate Mass Stars

Supervisor(s): *Dr Mike Ireland*

[michael.ireland@mq.edu.au, E7A 201]

Research area: *Astronomy*

Research groupings: *MQ AAAstro*

This year (2011) has seen the first two detections of faint companions at a solar-system scale, most likely planets in the process of formation, around the stars T Cha and LkCa15. These detections are part of larger aperture-masking interferometry projects using the world's largest telescopes to detect planets still glowing red hot from their formation around stars of a variety of masses.

In this project, you will analyze a large proprietary aperture-masking data set looking for young planets around 2-5 solar-mass stars in the young Scorpius-Centaurus OB2 association. This is the only data set in the world capable of determining the frequency of massive planets at 5-50 AU separations around this type of star - any detection will be a high impact science result.

Astro-7: Structure and Substructure in Andromeda's Halo

Supervisor(s): *Dr. Daniel Zucker*

[daniel.zucker@mq.edu.au, E7A 317]

Research area: *Astronomy and Astrophysics*

Research groupings: *MQ AAAstro*

In the current view of galaxy formation, large galaxies like our own Milky Way and the neighbouring Andromeda galaxy (M31) formed through the merger and accretion of smaller systems. Evidence for these processes can be seen today in the stellar populations of each galaxy, and is most readily apparent in these galaxies' outer regions, or halos. Generally speaking, the evidence can be found in three forms: the underlying smooth structure of a galaxy's halo, formed long ago by small stellar systems which are now thoroughly mixed; stellar streams and clumps, formed by satellites which are being, or have been, disrupted by the parent galaxy's tidal forces; and stellar satellites, which have survived to the present, but whose days as distinct objects are likely numbered.

The Sloan Digital Sky Survey (SDSS) has mapped roughly a quarter of the sky to date. A special SDSS scan along the major axis of M31 has yielded two new ultra-low luminosity M31 dwarf satellites, as well as a number of other stellar structures. However, the potential of this unique dataset for studying M31's halo remains largely unexplored (and unexploited). The project will involve the analysis of the SDSS M31 photometric data and images to study the stellar structure and substructure of M31's halo; the use of other photometric databases (such as 2MASS), and data from follow-up observations with Gemini and Subaru telescopes is also possible.

Astro-8: Chemical Analysis of Open Clusters and Moving Groups

Supervisor(s): *Dr. Daniel Zucker and Dr. Gayandhi De Silva (Australian Astronomical Observatory)*

[daniel.zucker@mq.edu.au/gdesilva@aa0.gov.au, E7A 317]

Research area: *Astronomy and Astrophysics*

Research groupings: *MQ AAAstro*

Open clusters and moving groups (the dispersed remnants of star clusters) are ideal tools for probing our Galaxy's chemical evolution. Since the member stars of a cluster are believed to be born from the same parent gas cloud, we expect the stars in an open cluster or moving group to be chemically identical – that is, to have the same abundances of elements heavier than hydrogen. However, to date only a handful of open clusters and moving groups have been studied via high-resolution spectroscopy. We have obtained spectra of stars in a number of open clusters and moving groups, whose analysis will constitute part of this project. Observationally establishing chemical homogeneity is a vital requirement for large-scale studies of the Galaxy's stars – such as the planned million-star HERMES survey – in order to unravel its formation and evolutionary history.

5.2 Research in Photonics

Photonics research occurs under the umbrella of the MQ Photonics Research Centre, which brings together approximately a dozen academics and over fifty postdoctoral researchers and graduate students. We perform experimental and theoretical research in guided wave photonics, laser sources, ultrafast phenomena, biophotonics and sensing, nanophotonics and plasmonics, condensed matter research and astrophotonics. Many of our projects are explicitly cross-disciplinary and designed to develop the role of photonics in communications, defence, biology, medicine and astronomy. MQ Photonics hosts a node of the Australian Research Council Centre of Excellence for Ultrahigh-bandwidth Devices for Optical Systems (CUDOS), which was recently renewed until 2018. It is also the coordinating node for the OptoFab component of the Australian National Fabrication Facility (ANFF). A number of photonics researchers are also engaged in the University's MQ BioFocus Research Centre which involves inter-disciplinary studies in biological, physical and chemical systems.

5.2.1 Photonics projects

Photonics-1: Magnetic semiconductors for spintronic applications - magnetic properties

Supervisor(s): *Dr James Downes*

[james.downes@mq.edu.au, E7A.202]

Research area: *Experimental condensed matter physics*

Research groupings: *MQ Photonics Research Centre*

Spintronics uses the intrinsic spin of the electron to process and store information much faster, and using much less power, than conventional electronics, which uses the charge of the electron to perform the same functions. Research in spintronics is rapidly expanding but a key problem is the lack of a suitable magnetic semiconductor material to construct devices from. We have recently developed several suitable materials and are currently exploring their key electronic and magnetic properties. In this project you will grow thin-film samples of one of these materials using vacuum deposition equipment and will then study their detailed magnetic properties using neutron scattering techniques. The neutron scattering portion of this project will be performed at the OPAL nuclear reactor south of Sydney, access to which will require a routine background check.

Photonics-2: All-optical fabrication of organic electronic devices

Supervisor(s): *Dr James Downes*

[james.downes@mq.edu.au, E7A.202]

Research area: *Experimental condensed matter physics*

Research groupings: *MQ Photonics Research Centre*

Organic electronics promises us an age of thin, light, inexpensive but highly functional electronic devices - an example of this is the AMOLED screen used in several mobile phones currently. The full potential of organic electronics will only be realised if a very low cost but highly effective technique to 'pattern' or print these devices can be developed. By combining the optical techniques used to produce current silicon integrated circuits and recently developed photo-sensitive organic semiconductor materials, we are developing an all-optical technique to fabricate organic electronic devices. In this project you will use clean-room facilities to produce organic precursor thin films which you will then process into organic electronic devices using ultraviolet light. You will then use lab-based instruments to characterise and attempt to understand the operation and properties of the devices you have fabricated.

Photonics-3: Magnetic semiconductors for spintronic applications - electronic properties

Supervisor(s): *Dr James Downes*

[james.downes@mq.edu.au, E7A.202]

Research area: *Experimental condensed matter physics*

Research groupings: *MQ Photonics Research Centre*

Spintronics uses the intrinsic spin of the electron to process and store information much faster, and using much less power, than conventional electronics, which uses the charge of the electron to perform the same functions. Research in spintronics is rapidly expanding but a key problem is the lack of a suitable magnetic semiconductor material to construct devices from. We have recently developed several suitable materials and are currently exploring their key electronic and magnetic properties. In this project you will grow thin-film samples of one of these materials using vacuum deposition equipment and will then study their electronic properties using synchrotron-based x-ray techniques. The synchrotron portion of this project will be performed at the Australian Synchrotron in Melbourne, the travel to which will be covered by the facility.

Photonics-4: Experimental Chaos in Laser Dynamics

Supervisor(s): *Prof. Deb Kane*

[deb.kane@mq.edu.au, E7A 203]

Research area: *Laser Physics/Nonlinear Science*

Research groupings: *MQ Photonics Research Centre*

Recent successes in developing the tools for analysis of chaotic time series derived from experiment are supporting a new wave of investigation of the nonlinear dynamics of such systems. Nonlinear laser systems such as semiconductor lasers with optical or optoelectronic feedback, optical injection, or modulation are excellent sources of high dimensional chaotic output on which to explore new understanding of nonlinear dynamics and complexity in these systems using the new tools. The systems in turn are used in many applications. Projects can be tailored to involve experimental investigations of the laser systems, analysis of time series for mapping the dynamics of a laser system, or some combination of both to meet student interests. The project will involve laser physics, optics, nonlinear dynamics, and/or computational methods.

1. J P Toomey, D M Kane, S Valling, A M Lindberg (2009). Automated correlation dimension analysis of optically injected solid state lasers, pp17. *Optics Express* 17(9), 7592-7608.
2. J P Toomey, D M Kane, M W Lee, K A Shore (2010). Nonlinear dynamics of semiconductor lasers with feedback and modulation, *Optics Express* 18(16), 16955-16972.
3. D M Kane and J P Toomey (2011). Variable pulse repetition frequency output from an optically injected solid state laser. *Optics Express*, 19(5), 4692-4702.

Photonics-5: Optics of Transparent Spider Webs

Supervisor(s): *Professor Deb Kane*

[deb.kane@mq.edu.au, E7A 203]

Research area: *Bio-optics/Biomaterials*

Research groupings: *MQ Photonics Research Centre*

The transparent orb webs of certain spiders are a sophisticated optical and mechanical device used for prey capture. The mechanical properties of spider silk are much studied but we are the first to highlight these transparent webs; and the nano-composite, multi-layered optical materials of which they are constructed; as biomaterials and device designs with biomimetic potential. The optics of naturally occurring optical proteins is a research field at its very beginnings. Projects can be tailored to be predominantly experimental optics on web elements, biomaterials based, theoretical modeling and simulations, or combinations of these. We collaborate with A/Prof Mariella Herbersteins group in Biological Sciences on spider biology, and colleagues in CBMS/APAF on protein analysis.

1. D M Kane, A M Joyce, G R Staib and M E Herberstein (2010). Optical surface profiling of orb-web spider capture silks, *Bioinspir. Biomim.* 5 036004, pp. 5.
2. D. M Kane, N Naidoo and G R Staib (2010). AFM of Orb-Spider-Web-Silks to Measure Surface Nanostructuring & Evaluate Silk Fibers per Strand", *J Applied Physics* 108, 073509, pp.5.
3. D. M Kane, G R Staib, N Naidoo and M E Herberstein (2011). The Optics of Spider Orb Webs, *SPIE Vol 7975, 79750G* (13 pp).

Photonics-6: Lasers and Nanoscience in Conservation of Aboriginal Art and Cultural Heritage

Supervisor(s): *Professor Deb Kane, Dr Alex Fuerbach*

[deb.kane@mq.edu.au, E7A 203]

Research area: *Laser Physics/Nanoscience*

Research groupings: *MQ Photonics Research Centre*

Laser cleaning and processing has long been used in art and cultural heritage conservation, internationally. We are carrying out pioneering research on laser conservation, and related nanoscience, to Aboriginal bark paintings and other items of cultural heritage significance in the Australasian and Oceania context. In cooperation with the Australian Museum we are aiming to address the major conservation problems in the preservation of Aboriginal bark paintings. If significant Aboriginal bark paintings are to be in a similar condition as they are today, in a thousand years time, there is much to be done. Projects can be tailored to be predominantly experimental laser processing and/or analysis of the materials (pigments, consolidants, bark, other organic matter).

1. D M Kane and A J Fernandes (2008). Pulsed Laser Cleaning—Comparing Science with Art & Cultural Heritage Applications, in Phipps CR (ed), High-Power Laser Ablation VII, , Proceedings of SPIE Vol.7005 (SPIE, Bellingham, WA,) 700513, pp 1-10. ISBN 9780819472069. (Invited paper).

2. A J Fernandes and D M Kane (2009). Laser removal of protective coatings from aboriginal bark paintings, COLA 2009, 10th International Conference on Laser Ablation, Singapore, Nov. 2009.

3. D M Kane, G Palmer, B F Johnston, S Haefner, A T Bilicki, A Fuerbach and A J Fernandes (2011). Laser Removal of Consolidants and Protective Coatings from Australian Aboriginal Bark Paintings, Lasers in the Conservation of Artworks, LACONA IX, 7–10 Sept. 2011, British Museum and University College London.

Photonics-7: Laser beam manipulation using adaptive optics

Supervisor(s): *A/Prof. Michael Withford and A/Prof. Mike Steel*

[michael.withford@mq.edu.au, E7A 211]

Research area: *Photonics*

Research groupings: *MQ Photonics Research Centre, CUDOS*

The CUDOS group at Macquarie is internationally recognised for its research on femtosecond laser inscribed microphotronics. This capability has enabled us to pursue unique opportunities not possible using conventional lithographic techniques. Examples include novel waveguide lasers in speciality glasses and 3D photonics for applications in stellar astronomy.

The proposed project will add to this capability by developing new adaptive optical techniques. In particular, the project will explore laser beam wavefront manipulation using state-of-the-art computer controlled spatial light modulators (SLMs), which are typically pixellated liquid crystal devices used to introduce localised phase changes to the wavefront of a laser beam. The project includes both an experimental, for example reproducing and correcting optical aberrations, and theoretical components, for example understanding Zernike polynomials and their role in optics. The end goal of the project will be the demonstration of new adaptive optic methods to femtosecond laser inscribed microphotronics.

Photonics-8: Ultraviolet lasers using cerium

Supervisor(s): *Dr David Spence and A/Prof. David Coutts*

[david.spence@mq.edu.au, E7A 214]

Research area: *Laser physics*

Research groupings: *MQ Photonics Research Centre*

There are many established types of laser, but very few that operate in the ultraviolet region of the spectrum: this region is vital for many applications in chemistry, biology, and defence, such as remote detection of pathogens. Cerium lasers are a unique way to generate tunable laser output in this UV region, and can generate continuous-wave or pulsed output. In principle output pulses could even be as short as a few femtoseconds, challenging the dominance of the Ti:Sapphire laser. We have recently mode locked cerium lasers for the first time, generating picosecond output pulses, and taking the vital first step towards achieving few-femtosecond operation. In this honours project, you will design and build a new UV laser system to exploit the capabilities of this material, and will use numerical models to understand and optimise your designs.

Photonics-9: Four wave mixing in Photonic Crystal Fibres

Supervisor(s): *A/Prof. David Coutts, Dr David Spence*

[david.coutts@mq.edu.au, E7A 201]

Research area: *Nonlinear optics*

Research groupings: *MQ Photonics Research Centre*

Optical fibres display many nonlinear optical phenomena including four wave mixing where a pump laser is converted into two new longer wavelengths. The wavelengths produced are controlled by dispersion in the fibre which in turn depends on the fibre properties including external factors which we can control such as the temperature and strain in the fibre. This project aims to explore how we can tune the generated wavelengths to target specific applications such as nonlinear microscopy. This primarily experimental project would suit someone with interests in lasers and photonics, nonlinear optics and spectroscopy.

Photonics-10: Ultra-high speed imaging

Supervisor(s): *A/Prof. David Coutts, Dr David Spence*

[david.coutts@mq.edu.au, E7A 201]

Research area: *Photonics*

Research groupings: *MQ Photonics Research Centre*

To image fast events you need fast pulses of light or a very fast camera. This project explores using a train of short pulses of light at different visible wavelengths such that the wavelength changes in time (equivalent to an optical chirp). By recording digital colour images of fast events illuminated with such pulses one can produce a colour coded strobe with an equivalent frame rate of megahertz and beyond. We will develop these techniques and use them to image ultrahigh speed events such as tracing droplet trajectories from an exploding wire. This experimental project would suit someone with interests in lasers, photonics and image science.

Photonics-11: Etching of diamond by 2-photon ultraviolet laser desorption

Supervisor(s): *A/Prof. Rich Mildren*

[rich.mildren@mq.edu.au, E7B156]

Research area: *Materials science, optics, photonics*

Research groupings: *MQ Photonics Research Centre*

Etching of diamond using an ultraviolet laser beam enables us to remove surface atoms with unprecedented precision, without graphite contamination and with a host of other interesting properties. The technique, which was developed this year here at Macquarie, is potentially interesting for a creating range of devices including creating waveguides, metamaterials and micro-optics from diamond. However, several key details of the technique are not well understood such as the importance of surface reactions with air and the spatial resolution limits of structures. This largely experimental project will aim to learn more about the new technique by analysing the etched morphology and the detailed characteristics of the process. The experiments aim to understand the mechanism for how carbon atoms are ejected from the surface using fluorescence data and by investigating the effects of environmental parameters on the etch rate. The outcomes of the project will enable us to better model the process and better predict the extent to which the process can be used in manufacturing micro-diamond devices.

Photonics-12: Miniature waveguide Raman lasers

Supervisor(s): *A/Prof. Rich Mildren*

[rich.mildren@mq.edu.au, E7B 165]

Research area: *Lasers/Photonics*

Research groupings: *MQ Photonics Research Centre*

Lasers based of stimulated Raman scattering are versatile devices with a large range of applications spanning medicine, telecommunications, defence and environmental sensing. The project will investigate novel methods for creating miniature and efficient Raman lasers that take advantage of recent advances in waveguide technologies and Raman laser materials (including diamond). Major challenges include the creation of low-loss waveguide structures, and the coupling into and out of these structures. The ideal candidate will have an interest in optical waveguides (including whispering gallery mode resonators), nonlinear optics, lasers and their underpinning theories.

Photonics-13: Nanofluidic device for protein separation by isoelectric gradient focusing

Supervisor(s): *David Inglis, Ewa Goldys*

[ewa.goldys@mq.edu.au, david.inglis@mq.edu.au, E7A 204]

Research area: *Bio-photonics*

Research groupings: *MQ BioFocus Research Centre*

Proteomics is concerned with discovering and detecting proteins that may be used to deepen our understanding of biology, or provide early indication of disease. To improve resolution of protein detection, mass spectroscopy (MS), the workhorse of proteomics, is often preceded by isoelectric point (IP) focussing of proteins using a fairly cumbersome technology known as a gel strip. IP focussing separates proteins by their isoelectric point on a pH gradient. There are currently no methods that combine in a streamlined way the IP separation and MS on a single device. The student will fabricate and build nanofluidic devices that are suitable for integration with a commercial MS chip. The student will adapt existing devices and develop new fabrication know-how to demonstrate separation and concentration of proteins on a pH gradient. In the course of the project the student will familiarize themselves with the basics of proteomic analyses, and will gain hands-on experience in nanofluidic fabrication, microscopy and electrophoresis. Project may result in generation of highly significant intellectual property

Photonics-14: Microbial detection on a mobile phone

Supervisor(s): *Prof. Ewa Goldys, Dr Russell Connally*

[ewa.goldys@mq.edu.au, E7A 204]

Research area: *Bio-photonics*

Research groupings: *MQ BioFocus Research Centre*

Mobile phone as a scientific tool burst on the scene as recently as 2010, and since then new opportunities have been provided by the Android developer toolbox. The purpose of this project is to explore the capabilities of the mobile phone for rapid, field-deployable detection of specific microorganisms. Students will be building and exploring the capabilities of lens-based and lensless designs with a view to determine the scope for rapid and specific microbial detection in complex media. The project will combine optics design, image analysis, sample preparation and molecularly specific targeting strategies. Programming is not designed to be part of this project, however some aspects may be incorporated depending on student's interest. The target applications will include medical and/or forensic diagnostics. At the conclusion of the project we will evaluate the suitability of the device for future commercialisation, and target partnerships with the Australian Federal Police and DSTO. Dr Connally brings unique expertise to the project as one of the leading inventors and entrepreneurs at the University.

Photonics-15: Retroemission by a glass bead monolayer for high-sensitivity, long-range fluorescence imaging

Supervisor(s): *A/Prof. Andrei Zvyagin*

[andrei.zvyagin@mq.edu.au, E7A 212]

Research area: *Optical Biomedical Imaging and Sensing*

Research groupings: *MQ BioFocus Research Centre*

We have introduced a retroemitter device comprising a planar glass beads placed on a fluorescent material substrate, which converges an excitation beam into a set of foci (voxels) immediately below the beads. This technology is facile, yet, enabling interesting fundamental optics and practical applications. For example, the relative positions of the voxels sample the incident wavefront. Fluorescence light excited at the voxels is collimated by the beads, and propagate upstream, to some degree, replicating the incident wavefront. We have been able to confirm this effect by sending a collimated plane wave, and detecting a fluorescent quasi-plane wave upstream at a long distance of 2 metres, which demonstrated this technology potential for practical readout applications.

This honours project will centre on setting up a facile retroemitter device aiming to demonstrate the fluorescent wavefront backwards conversion, or even imaging (!). This project will help to develop skills in experimental physical optics, and provide insights into optical imaging. A practically-minded student may be interested to look into the commercialisation potential of this technology.

Photonics-16: A simple optical method for measurement of nanoparticle emission quantum yield

Supervisor(s): *co-supervisors: A/Prof. Andrei Zvyagin, Prof. Ewa Goldys*

[andrei.zvyagin@mq.edu.au, E7A 212]

Research area: *Optical Biomedical Imaging and Sensing*

Research groupings: *MQ BioFocus Research Centre*

We have an arsenal of luminescent nanoparticles developed towards various biophotonics and nanophotonics applications. Characterisation of these nanoparticles, such as their emission yield determination, is in continuous and pressing demand. Following on the success of the summer student project (in collaboration with the National Measurement Institute, Linfield), we wish to extend a method developed for the measurement of the nanoparticle concentration in solutions to determination of the luminescent nanoparticle emission quantum yield.

An honours student will work with two optical instruments both based on the light scattering phenomena. In addition, a software algorithm (partly developed by the summer project student) will be extended to return a measurement value from the measured data set. This project will help to develop skills in optics, nanotechnology, and optical instrumentation. A practically-minded student may be interested to look into the commercialisation potential of this technology.

Photonics-17: Photonics at the Nanoscale: Switching Plasmons with Electric Fields

Supervisor(s): *A/Prof. Judith Dawes*

[judith.dawes@mq.edu.au, E7A205]

Research area: *Nanophotonics*

Research groupings: *MQ Photonics Research Centre, CUDOS*

Surface plasmons are compact optical-electronic excitations that can propagate in metallic planar or channel waveguides. They offer a bridge between photonics and electronics, in which the metallic nanostructures confine the optical fields to the scale of electronic devices, and permit fast information processing. Plasmonics is a promising approach to manipulating light at the nanoscale, but is at an early stage of technology development. In CUDOS, we propose to create plasmonic structures that channel light for particular functions. Because surface plasmons involve electronic as well as optical excitation, they may be influenced by electric fields. We will investigate the interaction of surface plasmons with the electric field in an electro-optic crystal as substrate.

This project will involve fabrication and optical characterisation of surface plasmon waveguides on various crystalline substrates to investigate surface plasmon propagation and switching with the application of electric fields to the structures. These results will be compared with modeling predictions. Surface plasmon propagation in the waveguides will be observed using our near field scanning optical microscope.

5.3 Research in Quantum Science

Quantum science research takes place in the Research Centre in Quantum Science and Technology (QSciTech) and also involves members of the MQ Photonics Research Centre. Our theoretical research interests include quantum information and computing, circuit-based quantum electrodynamics, nonlinear quantum optics and quantum gravity. In addition, we have experimental programs in quantum plasmonics, nanodiamond physics and integrated quantum photonics. From July 2011, we also host a major node of the Australian Research Council's Centre of Excellence for Engineered Quantum Systems (EQuS).

5.3.1 Quantum science projects

Quantum-1: Nano-particles of ruby: Production methods and optical properties

Supervisor(s): *A/Prof. James Rabeau, Dr Andrew Edmonds and Dr Torsten Gaebel*

[james.rabeau@mq.edu.au, E7A 208]

Research area: *Nanoscience and biophotonics*

Research groupings: *QSciTech, MQ Photonics Research Centre*

The imaging of biological processes at the molecular scale is a critical step in the quest to understand the behaviour of living systems at their most fundamental level, which ultimately could feed into technology enabling the early detection and investigation of diseases. To aid in achieving this goal, research is under way to develop and understand the properties of nanometer sized bio-probes, which can be attached to biological macromolecules such as proteins, permitting tracking of the entity by single-particle fluorescence. Conventional fluorescent labels are not optimal for such applications due to problems of cytotoxicity, pH sensitivities, brightness or photostability, and we are currently investigating new and superior alternatives.

Bioagents based on functionalised nanoparticles of crystalline ruby are an exciting candidate for bio-imaging, due to their biocompatibility, bright fluorescence and long fluorescence lifetime. Although the optical properties of ruby are well understood at the macro-scale (ruby is commonly employed in lasers), the properties of the material at the nanoscale remain largely unexplored, as are the production methods at this scale. In this physics-based project the emphasis will be on the development of different methodologies to reliably produce bright, well-dispersed nanoparticles of ruby that are below 100 nm in size and investigate, using single-particle confocal microscopy, the effect of the local environment on the fluorescence.

Quantum-2: Diamond growth and characterisation

Supervisor(s): *A/Prof. James Rabeau, Dr Torsten Gaebel, Dr Andrew Edmonds*

[james.rabeau@mq.edu.au, E7A 208]

Research area: *Quantum and condensed matter physics*

Research groupings: *QSciTech, MQ Photonics Research Centre*

Diamond, and especially certain defects inside the diamond crystal, has recently generated great interest in a diverse range of scientific disciplines. It is possible to measure isolated defects locked in the crystal, like a single nitrogen atom, with a confocal microscope and use them as a source of single photons, e.g. to perform secure quantum cryptography (see: www.abc.net.au/catalyst/stories/2519671.htm). They can be used as bright labels for biological tracking, as well as quantum bits for quantum technology. The controlled growth of diamond in a plasma reactor allows us to modify and tweak the defects present in the diamond according to the requirements of a specific application.

This Honours project involves the use of a new state of the art plasma reactor to grow diamond with different types of defects and measure their properties. This will include modifying the growth conditions and "seeding" techniques to optimise the material and optical properties, and using microscopy and spectroscopy to characterise these properties.

Quantum-3: Photons as a gravity probe?

Supervisor(s): *A/Prof. Daniel Terno*

[daniel.terno@mq.edu.au, C5C 349]

Research area: *General Relativity/Quantum Information*

Research groupings: *QSciTech*

Electromagnetic waves—visible light and other bands of the spectrum—are our prime source of information about the Universe. Since measurement of the light deflection near the Sun in 1919 their propagation is used to test general relativity (GR). The basic equations that govern the change in polarization as light propagates in an external gravitational field were established a long time ago. However, there are still huge differences in the predicted values of the resulting polarization rotation.

Part of the reason for these discrepancies is in improper definition of standard polarizations. My group developed a framework to overcome this difficulty, and we obtained interesting results showing that the effect in the near-Earth environment is stronger than it was usually thought. If it is so, it may serve as a basis for future gravity probes.

In this project you will calculate polarization rotation for various photon trajectories, using our analytical results and doing numerical simulations. The quantum-informational part of the project begins when what happens to polarization of a single photon is understood. Once this information is obtained, you will be able to use the techniques of quantum metrology to design possible experiments that will test predictions of GR.

Quantum-4: Exploiting loss for Bell inequalities

Supervisor(s): *Dr Dominic Berry and Prof. Jason Twamley*

[dmwberry@gmail.com, C5C 362]

Research area: *Quantum information*

Research groupings: *QSciTech*

Any local realistic (classical) theory must satisfy Bell inequalities. Experimental violation of these inequalities provides powerful evidence that local realistic theories are inadequate, and quantum mechanics is needed. A major problem in experimental violations of Bell inequalities is loss. There is a possibility of the measurement failing, which means that the Bell inequality can be violated even for local realistic theories.

We have recently developed a new approach where, for the Clauser-Horne-Shimony-Holt form of the Bell inequality, the loss is exploited to enhance the violation of the Bell inequality possible using quantum mechanics. This enables greater loss tolerance than would otherwise be possible. In this honours project you will explore other Bell inequalities, to determine how the loss may be exploited to enhance violation of the inequality, and improve the loss tolerance.

Quantum-5: Quantum algorithms for partial differential equations

Supervisor(s): *Dr Dominic Berry and Prof. Jason Twamley*

[dmwberry@gmail.com, C5C 362]

Research area: *Quantum information*

Research groupings: *QSciTech*

Quantum computers would use parallelism and quantum interference to solve problems more quickly than normal classical computers. For example, a quantum computer would enable breaking of the cryptography that is used to secure internet transactions, whereas this is not feasible on classical computers. Possibly the most important application of computers is large systems of differential equations. In fact, most of the applications of supercomputers are in the form of differential equations.

Recently we developed an algorithm to solve sparse systems of differential equations on a quantum computer, where the solution is encoded in the amplitudes of a quantum state. Large systems of sparse differential equations are commonly produced by discretisation of partial differential equations, which describe many physical systems. In this honours project you will examine the discretisation of partial differential equations as a basis to efficiently solve these equations on a quantum computer.

Quantum-6: Quantum Computational Phases of Matter

Supervisor(s): *A/Prof. Gavin Brennen*

[gavin.brennen@mq.edu.au, C5C 356]

Research area: *Quantum Computing/Strongly Correlated Systems*

Research groupings: *QSciTech*

There are several models for quantum computation which are equivalent in ability to simulate each other but which differ in how they operate. For example, in the measurement based model one begins with a special resource state (a 2D lattice of entangled spins with one spatial axis representing position on the computational register, the other time) and then performs adaptive single spin measurements on the remaining correlated spins to process a quantum computation. This project will investigate how to prepare and process good resource states which are stable ground states of many-body interactions—i.e. computational phases of matter. The scope will include some or all of the following: theoretical modelling of the information flow in this model, applying renormalization techniques to identify stable computational phases of matter, and analysis of the effect of errors (excitations) in such protocols and how to correct them.

Quantum-7: Dynamically tunable integrated quantum circuits

Supervisor(s): *A/Prof. Michael Withford, A/Prof. Mike Steel, Dr Graham Marshall*

[michael.withford@mq.edu.au, E7A 211]

Research area: *Photonics*

Research groupings: *MQ Photonics Research Centre, CUDOS, QSciTech*

Quantum optics and quantum information science is currently undergoing a miniaturization revolution akin to the silicon revolution that transformed electronics. To deal with the increasing complexity of experiments in quantum entanglement, quantum cryptography and quantum computing, numerous groups are developing techniques to manipulate non-classical states of lights in integrated waveguides. The CUDOS group at Macquarie is focusing on developing quantum devices that can exploit our ability to write complex 3D waveguide circuits.

A key step in this development is to enable these circuits to be dynamically adjusted in real time. This would allow a single circuit to perform multiple functions or be tuned through various settings. This is vital to implement quantum state tomography or flexible photon state preparation, for example. In this project, the student will design, model, fabricate and characterise a tunable Mach Zehnder device based on thermal tuning using resistive heating. The work will include sophisticated numerical modelling, use of high-power femtosecond laser systems and device characterisation at the single-photon level using our correlated two-photon source.

Quantum-8: Transmission of entangled photons through nano-holes

Supervisor(s): *Gabriel Molina-Terriza*

[gabriel.molina-terriza@mq.edu.au, C5C 350]

Research area: *Quantum optics*

Research groupings: *MQ Photonics Research Centre, QSciTech*

One of the most interesting light sources that have been implemented in the last decades is entangled photon sources. Photons in an entangled state represent a highly non-classical state of light capable of implementing completely secure algorithms (quantum cryptography), computing complex functions (quantum computing) and providing ultra-sensitive measurements (quantum metrology). This kind of states is in principle capable of beating the diffraction limit and thus provides information of certain nanoparticles. The student will study the possibilities of using momentum entangled quantum photons to measure nano-holes in metallic films.

The student will start by modelling the classical transmission of electromagnetic fields through a nano-hole with standard numerical techniques. Then, the student will participate in the experimental and the theoretical developments regarding the transmission of entangled photons.

Chapter 6

Contact information

6.1 Key staff

The following people are your best source of information regarding the Honours program.

Honours convenor

A/Prof. Mike Steel E7A 207 9850 8916 michael.steel@mq.edu.au

Head of Department

A/Prof. David Coutts E7A 217 9850 8970 david.coutts@mq.edu.au

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Astronomy/Astrophysics

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Advanced Science

A/Prof. Gavin Brennen C5C 356 9850 4445 gavin.brennen@mq.edu.au

6.2 How to Apply

6.2.1 Entry requirements

The Physics, Astronomy and Photonics Honours programs are open to undergraduates of Macquarie University or elsewhere who have qualified for a B.A., B.Sc. or B.Tech. with a major in Physics or Optics. The normal admission requirement as specified in the University calendar is a GPA of at least 2.5 overall and at least 2.5 in 300-level units or the equivalent performance at another University. Since Honours grades are determined on the performance in the Honours year alone it is possible for you to take a break in your studies after completing a pass degree at Macquarie or elsewhere before enrolling in the Honours Program.

6.2.2 Application

If you are interested in pursuing an Honours degree, ideally you should be planning towards it in the final semester of third year or in the year before commencing Honours. This includes speaking to prospective Honours supervisors to determine an appropriate research topic and then applying for admission to the Honours program.

Please also let the Honours convenor know you are thinking about Honours as early as possible. This gives us the best opportunity to help you find the ideal project and supervisor.

To formally apply you need to fill out an application from the University web site at www.studentadmin.mq.edu.au/honours. By the time you apply for admission, you must have spoken with the Honours convenor. It is also advisable but not essential that you have spoken to your preferred supervisor and selected a project.

The deadline for applications for Honours admission to the Registrar is several months before the beginning of the Honours year. It is typically October 31 for the following February commencement and May 31 for commencement in the following July. Late applications may be considered.

6.2.3 Enrolment

After receipt of a letter of offer you need to enrol in February or July in PHYS490 (the Honours program) but it is not necessary to enrol separately in your coursework units. If you intend to take a 300-level unit, but do not enrol in it formally, then

you should see the lecturer concerned to confirm your place in the unit. (Records of coursework units are maintained within the department and not by the University Registrar for the Honours program. Your academic transcript thus shows only the final Honours grade and not separate unit results.)