PHTN702

Advanced Photonics

S2 Day 2018

Dept of Physics and Astronomy

Contents

General Information

Unit convenor and teaching staff
Lecturer, Convenor
Robert Williams
robert.williams@mq.edu.au
Contact via email
6 Science Road (E8B) 311
By appointment

Credit points
4

Prerequisites
Admission to MRes

Corequisites

Co-badged status

Unit description
We explore the origin of nonlinear optical effects, and how they are used in modern optics to convert and control light. We derive the hierarchy of nonlinear effects, such as simple frequency doubling and mixing and enhancement using periodic materials; the Kerr effect and its applications in ultrafast lasers; Raman scattering and Brillouin scattering and their relevance to all-optical switching; and high-harmonic generation for generating XUV light and attosecond pulses. Advanced topics may include using the nonlinear Schrodinger equation to investigate nonlinear effects in fibres, such as soliton formation, super continuum generation. We establish how to use light-matter interactions to detect and study atoms and molecules. We determine the form of their excitation spectra, the factors that determine the shape and width of the spectral features, and how to measure them using infrared to ultraviolet excitation wavelengths. We will study more complex techniques that may include enhancements such as cavity ring down and Doppler-free methods; Raman spectroscopy and techniques such as CARS; and enhancement of Raman scattering using nanostructures and the quest for single molecule detection.

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at https://www.mq.edu.au/study/calendar-of-dates

Learning Outcomes

On successful completion of this unit, you will be able to:

Develop advanced photonics laboratory research skills in an authentic context.
Learn how to use sophisticated photonic instrumentation effectively for research and good science.
Identify and articulate how a research project fits within the context of, and contributes to, a wider field of research.
Understand and articulate concepts and theory that underpin advanced photonic devices and/or techniques.
Develop the skills of analysing, interpreting and presenting new experimental results correctly and coherently, and as an aid to understanding the physics involved.
Develop or improve skills for written communication of scientific research.
Demonstrate an advanced knowledge of research principles and methods in photonics.

General Assessment Information

Students will be assessed on a final written report consisting of four sections:

1. Literature review (25%)
2. Introduction and theory (25%)
3. Methods, results and analysis (40%)
4. Conclusions and outlook (10%)

The report is expected to be no longer than 20 pages in length.

Students will hand in a draft of each section of the report at different stages throughout the semester, and receive detailed feedback.

Assessment Tasks

Name	Weighting	Hurdle	Due
Literature review	25%	No	Week 13
Introduction and theory	25%	No	Week 13
Method, results and analysis	40%	No	Week 13
Conclusions and outlook	10%	No	Week 13

Literature review

Due: **Week 13**
Weighting: **25%**

Students will perform a limited literature review of the field of research, reviewing in detail approximately three key papers. In this section, students are expected to identify the overarching

motivations for the field and the key current directions (e.g. what key challenges exist or are being addressed in recent years). This review should provide a clear context for the student's research project. Finally, this section should articulate the aim of the project and how it is expected to advance the field (i.e. address one or more of the challenges identified above).

Approximately 3-4 pages. Draft due week 4.

On successful completion you will be able to:

- Identify and articulate how a research project fits within the context of, and contributes to, a wider field of research.

Introduction and theory

Due: **Week 13**
Weighting: **25%**

This section should briefly outline the approach of the project, including what techniques will be used, and then provide a detailed explanation of the principles of operation and theoretical underpinnings of one (or possibly two) key components of the research project.

Approximately 4-5 pages. Draft due week 6.

On successful completion you will be able to:

- Understand and articulate concepts and theory that underpin advanced photonic devices and/or techniques.
- Develop or improve skills for written communication of scientific research.

Method, results and analysis

Due: **Week 13**
Weighting: **40%**

Clearly and accurately describe the experimental apparatus and techniques used for performing experiments and collecting data. Present, analyse and explain experimental data, and any accompanying modelling or calculations, with appropriate use of texts, graphs, images, tables, etc. Present a coherent discussion/interpretation of the experimental results that demonstrates a robust understanding of the physics involved in the experiments, including a critical analysis of the quality of the experimental data.

Approximately 5-8 pages. Draft due week 9.

On successful completion you will be able to:

- Develop advanced photonics laboratory research skills in an authentic context.
- Learn how to use sophisticated photonic instrumentation effectively for research and good science.

- Develop the skills of analysing, interpreting and presenting new experimental results correctly and coherently, and as an aid to understanding the physics involved.
- Develop or improve skills for written communication of scientific research.
- Demonstrate an advanced knowledge of research principles and methods in photonics.

Conclusions and outlook

Due: **Week 13**
Weighting: **10%**

Articulate the outcome of the project with respect to the aim(s) identified at the end of the literature review. Identify the next steps (short term) for further advancing the field building on the results of the project. Identify and articulate how this project contributes to the long-term direction of the field.

Approximately 1-2 pages. Draft due week 10.

On successful completion you will be able to:

- Identify and articulate how a research project fits within the context of, and contributes to, a wider field of research.
- Develop or improve skills for written communication of scientific research.
- Demonstrate an advanced knowledge of research principles and methods in photonics.

Delivery and Resources

This unit focusses on learning advanced concepts and acquiring important generic and technical research skills in photonics within the context of a research project. Delivery of the unit is therefore primarily through supervised laboratory experiments and independent reading, with weekly meetings for discussion, feedback and guidance with the unit convenor, and additional consultation as required. Laboratory projects are placed within an active research group in the department, and students will work closely in the lab with senior PhD students, postdocs and/or academics from that research group.

Laboratory projects will consist of fifteen days in the laboratory spread over the semester, e.g. a day per week for ten weeks with a one-week block during semester break. Timetabling of laboratory days will be arranged between the student and the supervising research group.

Students will be provided with relevant reading material including scientific papers and text book chapters, and will also conduct literature searches to supplement their reading.

Regular meetings with the unit convenor for progress updates, discussion of reading materials, theory, etc., will be arranged between the student and the unit convenor.

Classes

15 days of laboratory experiments, spread over the semester and arranged for mutually-agreeable days between students and laboratory supervisors.

Weekly meetings with unit convenor for discussion of project progress, theory, research context, experimental aspects, etc., starting from week 2.

Required and Recommended Texts and/or Materials

Research papers, textbook chapters, or other reading material as advised by unit convenor and laboratory supervisors.

Part of the unit will involve online searching and accessing of current literature.

Unit Schedule

The unit will begin in week 2 with an introduction to the unit and the research projects available. By the end of week 2 students will be allocated to research projects, be introduced to laboratory supervisors, and be given initial reading material. Weekly research days (totalling 15) will be organised between the students and the supervising researchers, to be one day per week for most of the semester with a larger block timetabled for in or around the mid-semester break. Weekly individual meetings with the unit convenor will be arranged to start in week 3. Additional classes may be arranged where necessary to cover common topics or questions.

Draft sections of the written report are due in Week 4 (Literature review), Week 6 (Introduction and theory), Week 9 (Methods, results, analysis) and Week 10 (Conclusions, outlook, future work). Detailed feedback and guidance on each section will be provided by the unit convenor in the following week.

Final report due in Week 13.

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central). Students should be aware of the following policies in particular with regard to Learning and Teaching:

- Academic Appeals Policy
- Academic Integrity Policy
- Academic Progression Policy
- Assessment Policy
- Fitness to Practice Procedure
- Grade Appeal Policy
- Complaint Management Procedure for Students and Members of the Public
- Special Consideration Policy *(**Note:** The Special Consideration Policy is effective from 4 December 2017 and replaces the Disruption to Studies Policy.)*

Undergraduate students seeking more policy resources can visit the Student Policy Gateway (https://students.mq.edu.au/support/study/student-policy-gateway). It is your one-stop-shop for the

key policies you need to know about throughout your undergraduate student journey.

If you would like to see all the policies relevant to Learning and Teaching visit Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central).

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: https://students.mq.edu.au/study/getting-started/student-conduct

Results

Results shown in *iLearn*, or released directly by your Unit Convenor, are not confirmed as they are subject to final approval by the University. Once approved, final results will be sent to your student email address and will be made available in eStudent. For more information visit ask.mq.edu.au.

Student Support

Macquarie University provides a range of support services for students. For details, visit http://students.mq.edu.au/support/

Learning Skills

Learning Skills (mq.edu.au/learningskills) provides academic writing resources and study strategies to improve your marks and take control of your study.

- Workshops
- StudyWise
- Academic Integrity Module for Students
- Ask a Learning Adviser

Student Services and Support

Students with a disability are encouraged to contact the Disability Service who can provide appropriate help with any issues that arise during their studies.

Student Enquiries

For all student enquiries, visit Student Connect at ask.mq.edu.au

IT Help

For help with University computer systems and technology, visit http://www.mq.edu.au/about_us/offices_and_units/information_technology/help/.

When using the University's IT, you must adhere to the Acceptable Use of IT Resources Policy. The policy applies to all who connect to the MQ network including students.

Graduate Capabilities

PG - Discipline Knowledge and Skills

Our postgraduates will be able to demonstrate a significantly enhanced depth and breadth of knowledge, scholarly understanding, and specific subject content knowledge in their chosen fields.

This graduate capability is supported by:

Learning outcomes

- Develop advanced photonics laboratory research skills in an authentic context.
- Learn how to use sophisticated photonic instrumentation effectively for research and good science.
- Understand and articulate concepts and theory that underpin advanced photonic devices and/or techniques.
- Develop the skills of analysing, interpreting and presenting new experimental results correctly and coherently, and as an aid to understanding the physics involved.
- Demonstrate an advanced knowledge of research principles and methods in photonics.

Assessment tasks

- Introduction and theory
- Method, results and analysis
- Conclusions and outlook

PG - Critical, Analytical and Integrative Thinking

Our postgraduates will be capable of utilising and reflecting on prior knowledge and experience, of applying higher level critical thinking skills, and of integrating and synthesising learning and knowledge from a range of sources and environments. A characteristic of this form of thinking is the generation of new, professionally oriented knowledge through personal or group-based critique of practice and theory.

This graduate capability is supported by:

Learning outcomes

- Identify and articulate how a research project fits within the context of, and contributes to, a wider field of research.
- Develop the skills of analysing, interpreting and presenting new experimental results correctly and coherently, and as an aid to understanding the physics involved.

Assessment tasks

- Literature review

- Method, results and analysis
- Conclusions and outlook

PG - Research and Problem Solving Capability

Our postgraduates will be capable of systematic enquiry; able to use research skills to create new knowledge that can be applied to real world issues, or contribute to a field of study or practice to enhance society. They will be capable of creative questioning, problem finding and problem solving.

This graduate capability is supported by:

Learning outcomes

- Develop advanced photonics laboratory research skills in an authentic context.
- Learn how to use sophisticated photonic instrumentation effectively for research and good science.
- Identify and articulate how a research project fits within the context of, and contributes to, a wider field of research.
- Develop the skills of analysing, interpreting and presenting new experimental results correctly and coherently, and as an aid to understanding the physics involved.
- Demonstrate an advanced knowledge of research principles and methods in photonics.

Assessment tasks

- Literature review
- Method, results and analysis
- Conclusions and outlook

PG - Effective Communication

Our postgraduates will be able to communicate effectively and convey their views to different social, cultural, and professional audiences. They will be able to use a variety of technologically supported media to communicate with empathy using a range of written, spoken or visual formats.

This graduate capability is supported by:

Learning outcomes

- Understand and articulate concepts and theory that underpin advanced photonic devices and/or techniques.
- Develop the skills of analysing, interpreting and presenting new experimental results correctly and coherently, and as an aid to understanding the physics involved.
- Develop or improve skills for written communication of scientific research.

Assessment tasks

- Introduction and theory
- Method, results and analysis
- Conclusions and outlook

PG - Engaged and Responsible, Active and Ethical Citizens

Our postgraduates will be ethically aware and capable of confident transformative action in relation to their professional responsibilities and the wider community. They will have a sense of connectedness with others and country and have a sense of mutual obligation. They will be able to appreciate the impact of their professional roles for social justice and inclusion related to national and global issues

This graduate capability is supported by:

Learning outcomes

- Learn how to use sophisticated photonic instrumentation effectively for research and good science.
- Identify and articulate how a research project fits within the context of, and contributes to, a wider field of research.
- Develop the skills of analysing, interpreting and presenting new experimental results correctly and coherently, and as an aid to understanding the physics involved.

Assessment tasks

- Literature review
- Method, results and analysis
- Conclusions and outlook

Changes from Previous Offering

Unit has been significantly restructured from previous offerings. There will be few or no traditional lectures and no final exam. Instead the unit delivery is based primarily on individual supervised research projects with guided reading of theory and literature review related to the project. Assessment consists of a final written report (divided into four sections) covering theory, literature review and the experimental research project.