PHTN702

Advanced Photonics

S2 Day 2014

Physics and Astronomy

Contents

General Information

Unit convenor and teaching staff	Lecturer David Spence david.spence@mq.edu.au Contact via david.spence@mq.edu.au E6B 2.709 By appointment Convenor Michael Withford michael.withford@mq.edu.au Contact via 7056 Lecturer Michael Steel michael.steel@mq.edu.au Contact via 8916 E6B 2.708
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:

- Describe how simple molecules interact with radiation across the electromagnetic spectrum.
- Analyse molecular spectra to determine physical parameters of simple molecules.
- Describe line broadening mechanisms and apply the knowledge to explain the details of measured atomic and molecular spectra.
- Understand the experimental requirements for laser-based high resolution measurement of optical spectra and be able to evaluate the experimental approaches.
- Explain how high resolution spectroscopy can be applied to address major problems in other fields such as cosmology and quantum electrodynamics.
- Explain the origin of optical nonlinearities and be able manipulate and interpret the mathematical descriptions of nonlinear phenomena.
- Understand and describe the principles and methods for advanced photonics topics such as laser structuring of materials and terahertz generation and applications.
- Demonstrate an advanced knowledge of research principles and methods in photonics.

Assessment Tasks

Name	Weighting	Due
Assignments	30%	Biweekly
Midsemester Exam	35%	At end of mid-semester break
Exam	35%	Exam week

Assignments

Due: **Biweekly**
Weighting: **30%**

The assignments will comprise of 3-4 questions designed to engage the students with the material as it's covered. The difficulty of the questions will be set so that the assignment would take on average around 7 hours to complete.

On successful completion you will be able to:

- Describe how simple molecules interact with radiation across the electromagnetic spectrum.
- Analyse molecular spectra to determine physical parameters of simple molecules.
- Describe line broadening mechanisms and apply the knowledge to explain the details of measured atomic and molecular spectra.
- Understand the experimental requirements for laser-based high resolution measurement of optical spectra and be able to evaluate the experimental approaches.
- Explain how high resolution spectroscopy can be applied to address major problems in other fields such as cosmology and quantum electrodynamics.
- Explain the origin of optical nonlinearities and be able manipulate and interpret the mathematical descriptions of nonlinear phenomena.
- Understand and describe the principles and methods for advanced photonics topics such as laser structuring of materials and terahertz generation and applications.
- Demonstrate an advanced knowledge of research principles and methods in photonics.

Midsemester Exam

Due: **At end of mid-semester break**
Weighting: **35%**

A take home exam covering the material in the first half of the course. You will be given 24 hours to complete this open-book exam.

On successful completion you will be able to:

- Demonstrate an advanced knowledge of research principles and methods in photonics.

Exam

Due: **Exam week**
Weighting: **35%**

An exam covering the second half of the course.

On successful completion you will be able to:

- Demonstrate an advanced knowledge of research principles and methods in photonics.

Delivery and Resources

Classes

Mixed lectures, tutorials and discussion, with 4 timetabled hours per week.

The timetable for classes can be found on the University web site at: http://www.timetables.mq.edu.au/

Required and Recommended Texts and/or Materials

Recommended Text

As advised by lecturers.

Unit Web Page

Lecture notes will be available online at iLearn.

Teaching and Learning Strategy

The theoretical aspects of this unit are taught in lectures and tutorials with fortnightly assignments to strengthen the understanding of the material. The material is mathematical in nature and true understanding can only be achieved through testing and refining understanding through problem solving.

Schedule of topics

A plan of topics is under Unit Schedule. Lecturers for each part of the course will provide an outline of that part.

What has changed?

- This unit was previously offered as the Honours course in Modern Experimental Optical and Atomic Physics. The first half of this unit corresponds to some elements of this course, and the second half to new material on nonlinear optics, lasers, and laser applications.

- There are many changes from the offering last year. We will therefore appreciate your feedback contributions through the unit questionnaires, and any individual comments you may have.

Unit Schedule

Week 1: Introduction to Photonics at Macqaurie

Week 2 - 4: Atomic and molecular spectroscopy

Weeks 5 - 7: Advanced spectroscopy techniques

Week 8: Lasers and material interactions

Week 9-11: Nonlinear optics

Week 12: THz physics

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central. Students should be aware of the following policies in particular with regard to Learning and Teaching:

Academic Honesty Policy http://mq.edu.au/policy/docs/academic_honesty/policy.html

Assessment Policy http://mq.edu.au/policy/docs/assessment/policy.html

Grading Policy http://mq.edu.au/policy/docs/grading/policy.html

Grade Appeal Policy http://mq.edu.au/policy/docs/gradeappeal/policy.html

Grievance Management Policy http://mq.edu.au/policy/docs/grievance_management/policy.html

Disruption to Studies Policy http://www.mq.edu.au/policy/docs/disruption_studies/policy.html *The Disruption to Studies Policy is effective from March 3 2014 and replaces the Special Consideration Policy.*

In addition, a number of other policies can be found in the Learning and Teaching Category of 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/support/student_conduct/

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://informatics.mq.edu.au/help/.

When using the University's IT, you must adhere to the Acceptable Use 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

- Describe how simple molecules interact with radiation across the electromagnetic spectrum.
- Analyse molecular spectra to determine physical parameters of simple molecules.
- Describe line broadening mechanisms and apply the knowledge to explain the details of measured atomic and molecular spectra.
- Understand the experimental requirements for laser-based high resolution measurement of optical spectra and be able to evaluate the experimental approaches.
- Explain how high resolution spectroscopy can be applied to address major problems in

other fields such as cosmology and quantum electrodynamics.
- Explain the origin of optical nonlinearities and be able manipulate and interpret the mathematical descriptions of nonlinear phenomena.
- Understand and describe the principles and methods for advanced photonics topics such as laser structuring of materials and terahertz generation and applications.
- Demonstrate an advanced knowledge of research principles and methods in photonics.

Assessment tasks

- Assignments
- Midsemester Exam
- Exam

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

- Analyse molecular spectra to determine physical parameters of simple molecules.
- Describe line broadening mechanisms and apply the knowledge to explain the details of measured atomic and molecular spectra.
- Explain how high resolution spectroscopy can be applied to address major problems in other fields such as cosmology and quantum electrodynamics.
- Explain the origin of optical nonlinearities and be able manipulate and interpret the mathematical descriptions of nonlinear phenomena.

Assessment tasks

- Assignments
- Midsemester Exam
- Exam

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

- Analyse molecular spectra to determine physical parameters of simple molecules.
- Explain how high resolution spectroscopy can be applied to address major problems in other fields such as cosmology and quantum electrodynamics.
- Explain the origin of optical nonlinearities and be able manipulate and interpret the mathematical descriptions of nonlinear phenomena.

Assessment tasks

- Assignments
- Midsemester Exam
- Exam

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

- Describe how simple molecules interact with radiation across the electromagnetic spectrum.
- Describe line broadening mechanisms and apply the knowledge to explain the details of measured atomic and molecular spectra.
- Explain how high resolution spectroscopy can be applied to address major problems in other fields such as cosmology and quantum electrodynamics.
- Explain the origin of optical nonlinearities and be able manipulate and interpret the mathematical descriptions of nonlinear phenomena.
- Understand and describe the principles and methods for advanced photonics topics such as laser structuring of materials and terahertz generation and applications.

Assessment tasks

- Assignments
- Midsemester Exam
- Exam