PHYS303

Quantum Mechanics and Atomic Physics

S1 Day 2017

Dept of Physics and Astronomy

Contents

General Information

Unit convenor and teaching staff
Lecturer
Daniel Terno
daniel.terno@mq.edu.au
Contact via email
E6B-7 Wally's Walk 2.715
by appointment

Convenor, lecturer
Dominic Berry
dominic.berry@mq.edu.au
Contact via email
E6B-7 Wally's Walk 2.408
2-5pm Tuesday-Friday

Credit points
3

Prerequisites
MATH235 and PHYS201 and PHYS202

Corequisites
PHYS301

Co-badged status

Unit description
This unit deals with the fascinating world of quantum physics, providing a modern introduction to quantum mechanics and its applications. As well as being the theory that underlies most of modern physics, it also provides a viewpoint about the nature of the physical world that is completely at odds with our everyday intuition. The material covered here provides an introduction to the basic physical principles of quantum mechanics and the mathematical language that is needed to describe the new physics. We will study the three most important exactly-solvable models in quantum theory: the potential well, harmonic oscillator, and hydrogen atom. The quantum mechanics of angular momentum is also introduced and explored. These principles are developed further in the context of atomic physics in the second half of the unit, demonstrating the origin of the unique energy-level diagrams for each atom in the periodic table, consequently the unique spectrum of frequencies of electromagnetic radiation that can be emitted and/or absorbed. Physics of multi-electron systems, origins of the periodic properties of the elements, and interactions with electromagnetic fields are explored, as well as current topics like laser manipulation of atoms, optical lattices, and cold atomic gases.

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:

Acquisition of an understanding of the mathematical formalism of quantum mechanics and the physical motivations behind this formalism.

Ability to Identify and use standard solutions of Schrodinger equation [free, infinite well, step, harmonic oscillator, Coulomb potential].

Basic proficiency with formalism of orbital angular momentum and spin. Ability to use these quantities in analysis of various physical problems

Knowledge of basic properties of atomic structure and properties

Familiarity with the basic rules of the atomic transitions and physical principles behind them. Ability to apply them in spectral analysis.

Awareness of approximate methods in quantum mechanics and experience in their applications in atomic physics

Assessment Tasks

Name	Weighting	Hurdle	Due
Assignments	20%	No	Weekly
Mid-session examination	30%	No	TBA
End-of-session examination	50%	No	University Examination Period

Assignments

Due: **Weekly**
Weighting: **20%**

Assignments will be set and marked for assessment purposes and issued approximately once a week. The best four assignments [unless agreed otherwise] in each half of the course (i.e. 4+4) will be selected to contribute to the assignment grade.

Informal group discussion regarding the assignment problems is encouraged, but students should present their own solutions and should explicitly acknowledge those they have worked with on the assignment. Do not hesitate to seek help if you are having difficulties with the assignment problems.

Extension Requests: Given the importance we place on assignments as a key aid to learning we expect assignments to be submitted on time. In turn, we undertake to return your assignments (provided they were submitted on time), marked and with feedback within two weeks of their due date. This will allow us to provide you feedback in time to aid your ongoing learning through the course. Extensions will only be considered if requested with valid reasons **prior to the due date**.

If for any reason a student is unable to submit an assignment by the due date, the student should contact the relevant staff member as soon as possible, explain the situation, and request an extension. If such contact is not made, then the student will be penalised 20% for each working day that the assignment is late (i.e. an assignment due on a Friday and handed in on a Monday is penalised as if it is one day late). As complete solutions for an assignment are usually handed out to the class a week after the assignment is due, an extension beyond a week is generally not possible, and in any case would receive a grade of zero.

On successful completion you will be able to:

- Acquisition of an understanding of the mathematical formalism of quantum mechanics and the physical motivations behind this formalism.
- Ability to Identify and use standard solutions of Schrodinger equation [free, infinite well, step, harmonic oscillator, Coulomb potential].
- Basic proficiency with formalism of orbital angular momentum and spin. Ability to use

these quantities in analysis of various physical problems
- Knowledge of basic properties of atomic structure and properties
- Familiarity with the basic rules of the atomic transitions and physical principles behind them. Ability to apply them in spectral analysis.
- Awareness of approximate methods in quantum mechanics and experience in their applications in atomic physics

Mid-session examination

Due: **TBA**
Weighting: **30%**

There will be two 50 minute mid-session exams. There is some flexibility in setting the test times and the selected material. Please use the dedicated iLearn discussion forum to make suggestions for the alternative times.

The form of these test tasks is the following. Students can prepare their own hand written summary notes on the topic(s) of the summary test to take into the test. Students can use these notes freely to complete the test question(s) which will have been broadly defined prior to the test.

The summary notes and the test script will be collected and assessed to ensure the notes were independently prepared and for the quality/ correctness of the test answer(s). Summary notes are limited to one A4 sheet (both sides).

Weight of each test: 15%.

On successful completion you will be able to:
- Acquisition of an understanding of the mathematical formalism of quantum mechanics and the physical motivations behind this formalism.
- Ability to Identify and use standard solutions of Schrodinger equation [free, infinite well, step, harmonic oscillator, Coulomb potential].
- Basic proficiency with formalism of orbital angular momentum and spin. Ability to use these quantities in analysis of various physical problems
- Knowledge of basic properties of atomic structure and properties
- Familiarity with the basic rules of the atomic transitions and physical principles behind them. Ability to apply them in spectral analysis.
- Awareness of approximate methods in quantum mechanics and experience in their applications in atomic physics

End-of-session examination

Due: **University Examination Period**
Weighting: **50%**

There will be a 3 hour end-of-session exam to be held in the University Examination Period.

This will be a closed-book examination. All the necessary physical and mathematical formulas will be provided. You should have a scientific calculator for use during the final examination. Note that calculators with text retrieval are not permitted for the final examination.

You are expected to present yourself for the final examination at the time and place designated in the University examination timetable (https://iexams.mq.edu.au/timetable). The timetable will be available in draft form approximately eight weeks before the commencement of examinations and in final form approximately four weeks before the commencement of examinations.

If you apply for Disruption to Study for your final examination, you must make yourself available for the week of July 24 – 28, 2017. If you are not available at that time, there is no guarantee an additional examination time will be offered. Specific examination dates and times will be determined at a later date.

On successful completion you will be able to:

- Acquisition of an understanding of the mathematical formalism of quantum mechanics and the physical motivations behind this formalism.
- Ability to Identify and use standard solutions of Schrodinger equation [free, infinite well, step, harmonic oscillator, Coulomb potential].
- Basic proficiency with formalism of orbital angular momentum and spin. Ability to use these quantities in analysis of various physical problems
- Knowledge of basic properties of atomic structure and properties
- Familiarity with the basic rules of the atomic transitions and physical principles behind them. Ability to apply them in spectral analysis.
- Awareness of approximate methods in quantum mechanics and experience in their applications in atomic physics

Delivery and Resources

Mixed Lecture and Tutorial/discussion

Lecture materials, additional reading and assignments will be posted to iLearn.

The timetable for classes can be found on the University web site at:

https://timetables.mq.edu.au/2017/

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_2016.html

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

Complaint Management Procedure for Students and Members of the Public http://www.mq.edu.au/policy/docs/complaint_management/procedure.html

Disruption to Studies Policy (in effect until Dec 4th, 2017): http://www.mq.edu.au/policy/docs/disruption_studies/policy.html

Special Consideration Policy (in effect from Dec 4th, 2017): https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policies/special-consideration

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/

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

Discipline Specific Knowledge and Skills

Our graduates will take with them the intellectual development, depth and breadth of knowledge, scholarly understanding, and specific subject content in their chosen fields to make them competent and confident in their subject or profession. They will be able to demonstrate, where relevant, professional technical competence and meet professional standards. They will be able to articulate the structure of knowledge of their discipline, be able to adapt discipline-specific knowledge to novel situations, and be able to contribute from their discipline to inter-disciplinary solutions to problems.

This graduate capability is supported by:

Learning outcomes

- Acquisition of an understanding of the mathematical formalism of quantum mechanics and the physical motivations behind this formalism.
- Ability to Identify and use standard solutions of Schrodinger equation [free, infinite well, step, harmonic oscillator, Coulomb potential].
- Basic proficiency with formalism of orbital angular momentum and spin. Ability to use these quantities in analysis of various physical problems
- Knowledge of basic properties of atomic structure and properties
- Familiarity with the basic rules of the atomic transitions and physical principles behind them. Ability to apply them in spectral analysis.
- Awareness of approximate methods in quantum mechanics and experience in their applications in atomic physics

Assessment tasks

- Assignments
- Mid-session examination
- End-of-session examination

Critical, Analytical and Integrative Thinking

We want our graduates to be capable of reasoning, questioning and analysing, and to integrate and synthesise learning and knowledge from a range of sources and environments; to be able to critique constraints, assumptions and limitations; to be able to think independently and systemically in relation to scholarly activity, in the workplace, and in the world. We want them to have a level of scientific and information technology literacy.

This graduate capability is supported by:

Learning outcomes

- Acquisition of an understanding of the mathematical formalism of quantum mechanics and the physical motivations behind this formalism.
- Ability to Identify and use standard solutions of Schrodinger equation [free, infinite well, step, harmonic oscillator, Coulomb potential].
- Basic proficiency with formalism of orbital angular momentum and spin. Ability to use these quantities in analysis of various physical problems
- Knowledge of basic properties of atomic structure and properties
- Familiarity with the basic rules of the atomic transitions and physical principles behind them. Ability to apply them in spectral analysis.
- Awareness of approximate methods in quantum mechanics and experience in their applications in atomic physics

Assessment tasks

- Assignments
- Mid-session examination
- End-of-session examination

Problem Solving and Research Capability

Our graduates should be capable of researching; of analysing, and interpreting and assessing data and information in various forms; of drawing connections across fields of knowledge; and they should be able to relate their knowledge to complex situations at work or in the world, in order to diagnose and solve problems. We want them to have the confidence to take the initiative in doing so, within an awareness of their own limitations.

This graduate capability is supported by:

Learning outcomes

- Acquisition of an understanding of the mathematical formalism of quantum mechanics and the physical motivations behind this formalism.
- Ability to Identify and use standard solutions of Schrodinger equation [free, infinite well, step, harmonic oscillator, Coulomb potential].
- Basic proficiency with formalism of orbital angular momentum and spin. Ability to use these quantities in analysis of various physical problems
- Knowledge of basic properties of atomic structure and properties
- Familiarity with the basic rules of the atomic transitions and physical principles behind them. Ability to apply them in spectral analysis.

- Awareness of approximate methods in quantum mechanics and experience in their applications in atomic physics

Assessment tasks

- Assignments
- Mid-session examination
- End-of-session examination

Changes from Previous Offering

This is a new offering, containing material on quantum mechanics from the previous PHYS301 and PHYS303 units.