PHYS304

Advanced Quantum Mechanics and Quantum Optics

S2 Day 2018

Dept of Physics and Astronomy

Contents

General Information

Unit convenor and teaching staff
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Credit points
3

Prerequisites
PHYS303

Corequisites

Co-badged status

Unit description
Quantum mechanics is perhaps the most fundamental of all theories of modern physics. While its consequences are most readily seen in the microscopic world of elementary particles, atoms and molecules; quantum mechanics provides a set of rules that apply to all physical phenomena: the universe as a whole is governed by its laws. This unit looks at quantum mechanics in greater depth than PHYS303 and from a more foundational perspective. After introducing the postulates of quantum theory, we consider the basic mathematical structures including Hilbert Space, the Dirac notation, linear operators, spectral theory and measurements. Tools for the description of multiple systems and statistical combinations of systems are introduced allowing the exploration of entanglement - arguably the most dramatic departure from classical physics. In the second half of the unit Quantum Optics is introduced, which has widespread applications and has played a central role in testing quantum mechanics and exploring its meaning. In this section we cover quantization of the optical field, introduce coherent states and describe the physics behind the quantum interaction of light and atoms.

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:

Obtain a more advanced understanding of the workings of the quantum world
Be able to use the acquired knowledge to solve problems in quantum mechanics
Understand applications of quantum science to more advanced topics e.g quantum optics.

Assessment Tasks

Name	Weighting	Hurdle	Due
Weekly Exercises	25%	No	From week 2
Test	25%	No	Week 7
Final Examination	50%	No	post week 13

Weekly Exercises

Due: **From week 2**
Weighting: **25%**

1 moderate question each week to stay current with the lecture material

On successful completion you will be able to:

- Obtain a more advanced understanding of the workings of the quantum world
- Be able to use the acquired knowledge to solve problems in quantum mechanics
- Understand applications of quantum science to more advanced topics e.g quantum optics.

Test

Due: **Week 7**
Weighting: **25%**

An in-class test covering the material first half of the semester. The final grade will be either the weighted combination of test and exam or only the exam depending on which is higher.

On successful completion you will be able to:

- Obtain a more advanced understanding of the workings of the quantum world
- Be able to use the acquired knowledge to solve problems in quantum mechanics
- Understand applications of quantum science to more advanced topics e.g quantum optics.

Final Examination

Due: **post week 13**
Weighting: **50%**

Final Exam covering all of the material

On successful completion you will be able to:

- Obtain a more advanced understanding of the workings of the quantum world
- Be able to use the acquired knowledge to solve problems in quantum mechanics
- Understand applications of quantum science to more advanced topics e.g quantum optics.

Delivery and Resources

Material will be delivered by a combination of lectures, tutorials, online notes and exercises. The emphasis will be on learning to use quantum mechanics to model simple systems, so problem solving and calculation will be an integral part of the unit and the lectures will be informal, including tutorial aspects in addition to the unit tutorial.

Unit Schedule

This unit looks at quantum mechanics in greater depth than PHYS303 and from a more foundational perspective. After an introduction to the postulated of quantum theory, we consider the basic mathematical structure of quantum mechanics including Hilbert Space, the Dirac notation, linear operators, spectral theory and measurements in quantum mechanics. Tools for the description of multiple systems and statistical combinations of systems are introduced allowing the exploration of entanglement - arguably the most dramatic departure from classical physics. The Harmonic Oscillator is covered in some detail using both the position, momentum and operator methods. In the second half of the unit Quantum Optics is introduced, a topic which has widespread applications, and in this section we cover quantization of the optical field, introduce coherent states and describe the physics behind the quantum interaction of light and atoms.

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

Creative and Innovative

Our graduates will also be capable of creative thinking and of creating knowledge. They will be imaginative and open to experience and capable of innovation at work and in the community. We want them to be engaged in applying their critical, creative thinking.

This graduate capability is supported by:

Learning outcomes

- Obtain a more advanced understanding of the workings of the quantum world
- Be able to use the acquired knowledge to solve problems in quantum mechanics
- Understand applications of quantum science to more advanced topics e.g quantum optics.

Capable of Professional and Personal Judgement and Initiative

We want our graduates to have emotional intelligence and sound interpersonal skills and to demonstrate discernment and common sense in their professional and personal judgement. They will exercise initiative as needed. They will be capable of risk assessment, and be able to handle ambiguity and complexity, enabling them to be adaptable in diverse and changing environments.

This graduate capability is supported by:

Learning outcome

- Understand applications of quantum science to more advanced topics e.g quantum optics.

Commitment to Continuous Learning

Our graduates will have enquiring minds and a literate curiosity which will lead them to pursue knowledge for its own sake. They will continue to pursue learning in their careers and as they participate in the world. They will be capable of reflecting on their experiences and relationships

with others and the environment, learning from them, and growing - personally, professionally and socially.

This graduate capability is supported by:

Learning outcomes

- Obtain a more advanced understanding of the workings of the quantum world
- Be able to use the acquired knowledge to solve problems in quantum mechanics
- Understand applications of quantum science to more advanced topics e.g quantum optics.

Assessment tasks

- Weekly Exercises
- Test
- Final Examination

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

- Obtain a more advanced understanding of the workings of the quantum world
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Assessment tasks

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- Final 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

- Obtain a more advanced understanding of the workings of the quantum world
- Be able to use the acquired knowledge to solve problems in quantum mechanics
- Understand applications of quantum science to more advanced topics e.g quantum optics.

Assessment tasks

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- Test
- Final 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

- Obtain a more advanced understanding of the workings of the quantum world
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Assessment tasks

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- Final Examination

Effective Communication

We want to develop in our students the ability to communicate and convey their views in forms effective with different audiences. We want our graduates to take with them the capability to read, listen, question, gather and evaluate information resources in a variety of formats, assess, write clearly, speak effectively, and to use visual communication and communication technologies as appropriate.

This graduate capability is supported by:

Learning outcomes

- Obtain a more advanced understanding of the workings of the quantum world
- Be able to use the acquired knowledge to solve problems in quantum mechanics
- Understand applications of quantum science to more advanced topics e.g quantum optics.

Engaged and Ethical Local and Global citizens

As local citizens our graduates will be aware of indigenous perspectives and of the nation's historical context. They will be engaged with the challenges of contemporary society and with knowledge and ideas. We want our graduates to have respect for diversity, to be open-minded, sensitive to others and inclusive, and to be open to other cultures and perspectives: they should have a level of cultural literacy. Our graduates should be aware of disadvantage and social justice, and be willing to participate to help create a wiser and better society.

This graduate capability is supported by:

Learning outcome

- Understand applications of quantum science to more advanced topics e.g quantum optics.

Socially and Environmentally Active and Responsible

We want our graduates to be aware of and have respect for self and others; to be able to work with others as a leader and a team player; to have a sense of connectedness with others and country; and to have a sense of mutual obligation. Our graduates should be informed and active participants in moving society towards sustainability.

This graduate capability is supported by:

Learning outcome

- Understand applications of quantum science to more advanced topics e.g quantum optics.