PHYS8910

Engineering Quantum Matter

Session 2, Special circumstance 2020

Department of Physics and Astronomy

Contents

Notice

As part of Phase 3 of our return to campus plan, most units will now run tutorials, seminars and ot her small group learning activities on campus for the second half-year, while keeping an online ver sion available for those students unable to return or those who choose to continue their studies onli ne.

To check the availability of face-to-face and onlin e activities for your unit, please go to timetable vi ewer. To check detailed information on unit asses sments visit your unit's iLearn space or consult yo ur unit convenor.

General Information

Unit convenor and teaching staff
Gavin Brennen
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Credit points
10

Prerequisites
Permission by special approval

Corequisites

Co-badged status
PHYS8910

Unit description
This unit teaches fundamentals and emerging topics in engineered quantum materials. As originally envisioned by Feynman, quantum simulation is a process where one set of controllable quantum systems can be made to simulate a complex quantum system that is too hard to model classically. In this unit we will explain how quantum simulators work to mimic natural and unnatural, or synthetic, materials. Theoretical skills taught will be standard techniques from condensed matter, as well as tools used in quantum information. You will learn how a quantum system can be programmed to simulate another either via an analogue simulation using an engineered Hamiltonian, or via a digital gate-based quantum simulation. We will cover the physics of experimental quantum simulation architectures including trapped ions and neutral atoms, and colour centres in diamond. Applications of synthetic quantum matter for quantum error correction and sensing will be covered. To better understand the physics of many body quantum systems you will learn numerical techniques including quantum simulation code and approximation methods known as tensor networks in order to simulate ground states and dynamics of many body quantum systems.

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:

ULO1: Apply essential skills for solving problems in quantum many body physics.

ULO2: Model quantum simulations using Hamiltonian based and gate based approaches.
ULO3: Explain how to use the toolbox of interactions in an experimental architecture to perform a quantum simulation.
ULO4: Numerically model the physics of entangled many body systems via tensor network algorithms and quantum simulation software.
ULO5: Effectively communicate ideas in quantum engineering.

Assessment Tasks

Name	Weighting	Hurdle	Due
Problem based assignments	40%	No	Weeks 4,7,10,12
Report	20%	No	Week 13
Final examination	40%	No	Exam Period

Problem based assignments

Assessment Type [1]: Problem set
Indicative Time on Task [2]: 24 hours
Due: **Weeks 4,7,10,12**
Weighting: **40%**

A set of problems based on lecture content

On successful completion you will be able to:

- Apply essential skills for solving problems in quantum many body physics.
- Model quantum simulations using Hamiltonian based and gate based approaches.
- Explain how to use the toolbox of interactions in an experimental architecture to perform a quantum simulation.
- Effectively communicate ideas in quantum engineering.

Report

Assessment Type [1]: Report
Indicative Time on Task [2]: 16 hours
Due: **Week 13**
Weighting: **20%**

Report on computational project.

On successful completion you will be able to:

- Apply essential skills for solving problems in quantum many body physics.
- Model quantum simulations using Hamiltonian based and gate based approaches.
- Explain how to use the toolbox of interactions in an experimental architecture to perform a quantum simulation.
- Numerically model the physics of entangled many body systems via tensor network algorithms and quantum simulation software.
- Effectively communicate ideas in quantum engineering.

Final examination

Assessment Type [1]: Examination
Indicative Time on Task [2]: 20 hours
Due: **Exam Period**
Weighting: **40%**

Final examination covering all course content

On successful completion you will be able to:

- Apply essential skills for solving problems in quantum many body physics.
- Model quantum simulations using Hamiltonian based and gate based approaches.
- Explain how to use the toolbox of interactions in an experimental architecture to perform a quantum simulation.
- Effectively communicate ideas in quantum engineering.

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[1] If you need help with your assignment, please contact:

- the academic teaching staff in your unit for guidance in understanding or completing this type of assessment
- the Writing Centre for academic skills support.

[2] Indicative time-on-task is an estimate of the time required for completion of the assessment task and is subject to individual variation

Delivery and Resources

Classes

Mixed Lecture and Tutorial/discussion.

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

https://timetables.mq.edu.au/2020/

Required and Recommended Texts

Material will be provided in lecture notes during the course, but some recommended texts are :

- "Quantum Computation and Quantum Information", Isaac Chuang and Michael Nielsen
- "Condensed Matter Field Theory" by Alexander Altland and Ben Simons.

Teaching and Learning Strategy

The theoretical aspects of this unit are taught in lectures and tutorials with 4 assignments to strengthen the understanding of the material. In addition there is a computational project which can be done using software of the student's choice (e.g. Python, Matlab, Mathematica).

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.)*

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 published on platform other than eStudent, (eg. iLearn, Coursera etc.) 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 or if you are a Global MBA student contact globalmba.support@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 help you improve your marks and take control of your study.

- Getting help with your assignment
- Workshops
- StudyWise
- Academic Integrity Module

The Library provides online and face to face support to help you find and use relevant information resources.

- Subject and Research Guides
- Ask a Librarian

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

If you are a Global MBA student contact globalmba.support@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.