MATH60018/MATH70018 **Term 2, 2025**

Quantum Mechanics II

Instructor: Dr Ryan Barnett
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Assessment Basis: Course Work: 10%
Examination: 90%

Module meetings:

Mondays 3pm Huxley 139, Tuesdays 11am Huxley 139, and Fridays 3pm Huxley 139

Module materials:

Additional module materials will be made available on blackboard. These include lecture notes and pre-recorded videos covering module material.

Office hours:

Fridays 4-5pm, or by appointment.

Course Work:

We will have two assessed problem sheets during the term which will be due on 19 Feb 2025 and 18 Mar 2025. The problem sheets will be available two weeks before these due dates.

Lecture Attendance:

I generally expect that students will attend all lectures in person.

Module Description:

Quantum mechanics is an amazingly successful theory of our physical world. It is very practical, and has many applications in industry (the design/development of lasers, transistors, drug design, ...). Yet its mathematical structure is interesting in its own right. The theory also introduces many physically unintuitive consequences like entanglement (at least to our classical intuition!).

This module is aimed at students who have already had some exposure to quantum mechanics, like that given in Quantum Mechanics I. An intended chronological list of topics covered is the following.

- A review/overview of basics of QM. Position and momentum revisited.
- The different pictures of quantum mechanics: Schrodinger, Heisenberg, Interaction.
- Symmetries in Quantum mechanics. Discrete and continuous unitary symmetries and their relation to degeneracy. Anti-unitary symmetries (time reversal).
- Angular momentum and spin. The addition of spin.
- Elements of Quantum Technologies including quantum computation.
- Perturbation theory (time dependent, time independent) and applications.
- Adiabatic processes. Berry's phase.
- Identical particles. Bosons and Fermions. Second quantisation.
- Lattice models: Tight-binding Hamiltonians. Magnetism.
- Additional topics (depending on time and student interest). Some possibilities are: Feynman path integral, WKB approximation, superconductivity/superfluidity.

References:

The primary material for this module will be presented in lecture. I intend to also provide typed notes summarising the material covered during lecture.

I also recommend the following textbooks:

- R Shankar, *Principles of Quantum Mechanics, 2nd Edition*, Plenum Press (2011).
- David Griffiths, *Introduction to Quantum Mechanics, 2nd Edition*, Cambridge University Press (2016).
- Leslie Ballentine, *Quantum Mechanics : A Modern Development*, World Scientific Publishing Company (2014).
- Michael Nielsen and Isaac Chuang, *Quantum Computation and Quantum Information*, American Association of Physics Teachers (2010).