PH5002 - Foundations of Quantum Mechanics

Credits: 15.0  Semester: 1
Number of Lectures: 27  Lecturer: Dr Kong Wan
Academic Year: 2018-19

Overview
This module introduces students to the modern Hilbert space formulation of quantum mechanics and to relativistic quantum mechanics.

Aims & Objectives
The emphasis is on developing a good understanding of the mathematical and conceptual foundations of the subject. Hilbert spaces, operators, the spectral theorem and the basic postulates of quantum mechanics are discussed in detail. The theory is illustrated by a detailed study of harmonic oscillator, orbital and spin angular momenta. An introduction of relativistic quantum mechanics is presented.

Learning Outcomes
Having taken the module students should have gained a good knowledge of the mathematical techniques employed in modern physics and a good understanding of quantum mechanics in an axiomatic manner. In particular students should have a good knowledge of

- operator theory in Hilbert space, particularly selfadjoint and unitary operators, projectors and the spectral theorem for selfadjoint operators and properties of commuting selfadjoint operators,
- the basic postulates on quantum statics and dynamics, including the working of various Pictures to describe quantum evolution, and some conceptual issues,
- the use of creation and annihilation operators,
- operator theory of orbital and spin angular momenta,
- charged spin-half particle in external magnetic field,
- Klein-Gordon and the Dirac equations and the relativistic origin of spin.

Synopsis
The module is presented in several parts:
Part 1 is a review of general properties of classical and quantum systems,
Part 2 introduces Hilbert spaces starting from finite-dimensional vector spaces, and operators in Hilbert spaces, including selfadjoint operators, unitary operators, projectors, and the spectral theorem.
Part 3 sets out the basic postulates of quantum mechanics, illustrated by many examples and applications, including quantum evolution in terms Schrodinger, Heisenberg and Interaction pictures. Conceptual issues such as nonlocality, quantum entanglement, quantum paradoxes and measurement problems are also discussed.
Part 4 consists of illustrative examples which include a study of the harmonic oscillator and a general review of annihilation and creation operators and their application to harmonic oscillator.
Part 5 presents a systematic treatment of position and momentum as continuous observables.
Part 6 discusses operator theory of angular momentum, including orbital and spin angular momenta and application to the Zeeman effect and the Aharonov-Bohm effect.
Part 7 introduces relativistic quantum mechanics, including the Klein-Gordon and the Dirac Equations and the relativistic origin of spin.

Pre-requisites
PH3081 or PH3082 or (MT2506 and MT2507), PH3061 and PH3062

Anti-requisites
None

Assessment
2 Hour Examination = 100%

Recommended Books
Please view University online record:
http://resourcelists.st-andrews.ac.uk/modules/ph5002.html

General Information
Please also read the general information in the School's honours handbook.