10586 - 714 (16) Quantum Mechanics B
(Advanced Formalism and Applications) (3L, 3P)

2020

Course summary

Bra-ket notation, the axioms of quantum mechanics, basis transformations and unitary operators, position and momentum representations, Schrödinger and Heisenberg images, spin, formal theory of angular momentum, time-dependent perturbation theory, scattering theory, identical particles.

Module relevance in programme:

The first half of the module focuses on consolidating the content of the second and third year quantum mechanics modules into a unified mathematical framework. This formalism serves to elucidate the formal structure of quantum mechanics and serves as a basis for the more advanced theory modules that follow, specifically quantum many-body theory and quantum field theory. The second half of the module is dedicated to a detailed development of time-dependent perturbation theory and scattering theory. These topics find application in virtually all areas of physics and are particularly crucial to the understanding of atomic, molecular and nuclear phenomena. In this way the module aims to equip both theory- and experimentally-oriented students with the skills required to master the content of later, more specialised modules.

Outcomes of course:

After introductory courses in quantum mechanics this course equips the student with an understanding and working knowledge of the formal structure of quantum mechanics and its relation to wave mechanics. In particular the student is skilled in operator techniques which are an essential tool in any more advanced application of quantum mechanics.

Lecturer:

Dr JN Kriel
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Mentor:

The Department of Physics has appointed a staff member as mentor for each year of its physics programme to be available to students for consultation. Students should feel free to discuss general issues related to the physics programme or specific modules in the programme with the relevant mentor, in addition to usual consultations with their individual lecturers of modules.

The mentor for the Honours programme and its modules is Dr CM Steenkamp cmsteen@sun.ac.za.

Course content:

Fundamental concepts

Bra- and ket spaces, state vectors and basis states. Matrix representations and change of basis. Dynamical variables, their operators and the simultaneous measurement of different variables. Continuous bases with application to the position and momentum bases and their mutual transformations. The uncertainty principle.

Quantum dynamics
Time development of states, the time-dependent Schrödinger equation and the energy-time uncertainty relation. The Heisenberg picture, Heisenberg equation of motion and applications.

Angular momentum
The rotation operator in terms of the angular momentum operator J and the characteristic non-commuting property of the components of J. Eigenvalues and eigenvectors. The coupling of angular momenta and the calculations of Clebsch-Gordan coefficients.

Time dependent perturbation theory
Time dependent potentials, the interaction picture and time dependent perturbation theory with applications.

Scattering theory
The Lippmann-Schwinger equation, Born approximation, phase shifts and the optical theorem.

Practical (Tutorials):

1 Tutorial every week as per schedule provided at start of course

Study material:

A set of lecture notes is provided. These notes contain references to additional sources which the student is required to consult.

Learning opportunities:

3 Lectures per week

Assessment:

Methods of Assessments
Continuous Evaluation

Venue and time of assessment opportunities
See timetable

Availability of marks:
Within two weeks after the handing in of tasks or tests.

Calculation of final mark for the module:
Test 1 - 25% Test 2 - 25% Orals, tutorial tests and take-home tests – 20% Homework Problems - 30%

Note: If a student commits plagiarism in a homework assignment then none their homework will be taken into account in the calculation of the final mark. In such a case the test marks will make up the full final mark.