Imperial College London

Module Outline

Group Theory

Module Code	PHYS96019	FHEQ Level	Level 6
Pre-requisites	None	Co-requisites	None
Primary Department	Physics		
Module Leader	Professor Dimitri Vvedensky		
Additional Teaching Departments	None		
Teaching Staff	Dimitri Vvedensky + Associate		

Programmes on which the Module is delivered	Core/Elective
All UG Physics programmes (F300, F303, F309, F325, F390, F3W3)	Elective

Learning Outcomes

On completing the Group Theory course, students will have:

- understood the fundamentals of the abstract group theory
- understood the fundamentals of the representation theory of finite groups
- able to apply the tools of group theory to problems in non-relativistic quantum mechanics, including
  - prediction of degeneracies and their lifting by perturbation
  - developing selection rules
  - classification of vibrational normal modes
  - application of projection operator technique
- understood the fundamentals of Lie groups and Lie algebras
- understood the representations of SO(2) and SO(3), including the origins of the addition of angular momenta and Clebsch–Gordan coefficients

Description of Content

This is a course on the theory of groups, representations, and their applications to quantum mechanics. The main part of the course deals with finite groups, which is followed by an introduction to continuous groups . The main objective is to make students fluent in the language of representation theory and confident in its applications to non-relativistic quantum mechanics.

1. Abstract group theory for finite groups: properties of the group, subgroups, cosets, Lagrange's theorem, invariant subgroup, factor-group, conjugate classes, Abelian and non-Abelian groups, isomorphism, homomorphism, symmetric group, Cayley's theorem.
2. Representation theory for finite groups: existence of unitary representation, reducible and irreducible representations, Schur's lemmas, orthogonality relations, characters and character tables, regular representation, expansion in the basis functions of irreducible representations, projection operators, representations of direct products.
3. Quantum mechanical applications: symmetry-induced and accidental degeneracies, lifting of degeneracy by perturbation, selection rules, molecular vibrations.
4. Continuous groups, Lie groups and Lie algebras, irreducible representations of SO(2) and SO(3), Clebsch–Gordan coefficients.

Assessment		Assessment Type	Weighting
Written exam		Exam	100%
Learning & Teaching Hours	Independent Study Hours	Placement Hours	Total Hours
57	93	0	150
ECTS Credit	6	CATS Credit	12
Date of introduction	October 2020	Date of Last Revision	24 April 2020