ICTS Core Course PHY206.5

Advanced Quantum Mechanics

Semester: August – December 2023

Instructor: Sthitadhi Roy (*sthitadhi.roy@icts.res.in*)

Teaching Assistant : Mrinal Jyoti Powdel and Anikat Kankaria

Logistical Details

- **Venue**: Emmy Noether Seminar Room
- **Class timings**: Mondays and Fridays 11:00 - 12:30
- **First meeting**: August 7, 11:00
- **Attendance**:
  - Like regular classes attendance is a MUST unless exceptional circumstances. This is both for students crediting and auditing.
  - Record of attendance will be kept for students attending the classes and tutorials.
- **Tutorials**: To be arranged by the Teaching Assistant in consultation with the class. Tutorials are a part of regular classes. Attendance is COMPULSORY as in the lectures.

Course Description and Details

Course description: Hilbert and Fock spaces; second quantisation; symmetries and conservation laws; perturbation theory, correlation functions and scattering theory, basics of relativistic quantum mechanics, basics of path integrals (see below for further details of each topic)

- **Mathematical Preliminaries** (4 lectures)
  - Review of vector spaces and quamtum mechanical states and operators
  - Introduction to Hilbert spaces and Fock spaces, and representations of many-body quantum states and operators therein
  - Introduction to second quantisation
- **Symmetries and quantum numbers** (4 lectures)
  - What and why of symmetries

  - Symmetries and conservation laws
  - Examples with simple symmetries such as translation symmetry and linear momentum, rotational symmetry and angular momentum

- **Perturbation Theory** (6 lectures)
  - Time-independent perturbation theory (non-degenerate and degenerate)
  - Time-dependent perturbation theory

- **Correlation functions and Scattering** (8 lectures)
  - Introduction to Scattering Theory
  - Spin-1/2 Fermions
  - Bosons

- **Introduction to relativistic quantum mechanics** (4 lectures)
  - Klein Gordon Equation
  - Dirac Equation and spin
  - Spin-orbit and Zeeman coupling as relativistic corrections

- **Introduction to path-integrals** (2 lectures)

References:

- Principles of Quantum Mechanics by R. Shankar
- Modern Quantum Mechanics by J. J. Sakurai
- Advanced Quantum Mechanics by J. J. Sakurai
- Advanced Quantum Mechanics by F. Schawbl

Evaluation

Assignments 50% + End-Semester Examination (40%)+Impromptu class tests (10%). Details below:

- **Assignments (50%)**
  - Total of five assignments will be given upon conclusion of relevant topics in the lectures.
  - Delay in the submission of the assignment beyond the deadline would attract a penalty of 10% per day unless due to exceptional circumstances with prior knowledge of the TA and/or Instructor. No assignment will be accepted after the corresponding tutorial has been conducted by the TAs.

  - Collaborations in assignments: You are encouraged to discuss with your classmates, but not copy. Any signatures of copying will be penalised by putting a total score of zero for the relevant assignment.

- **End-Semester Examination (40%)**
  - Format of the examination to be decided later
  - s will be elaborated in the question paper, NO collaborations are allowed in the exam. Any sign of copying would lead to cancellation of the exam (a zero will be recorded) and will be reported to the graduate studies cell.

- **Impromptu class tests (10%)**
  - Short examination of 30 minutes will be announced at the beginning of the lecture.
  - Typically will be based on the most recently concluded topic.

Prerequisites

The students are expected to be familiar with the topics usually taught in first course in quantum mechanics. These include but are not limited to

- Wave-functions, uncertainty principle, superposition principle in context of quantum mechanics
- Schrödinger Equation
- Free particles in dimensions, $d = 1, 2, 3, \cdots$
- Particle in a box in dimensions $d = 1, 2, 3, \cdots$
- One dimensional quantum harmonic oscillator
