Master Degree's Programme in Physics of Complex Systems

INTRODUCTION TO QUANTUM MECHANICS (4 ECTS) (By Angelo Rosa)

COURSE DESCRIPTION:

The course will cover standard topics for an introduction to Quantum Mechanics. Starting from the definitions of states, operators and observables, and the relative operations between them, the student will be introduced to the Schrödinger equations and to the most important systems in one- and three-dimensions. The course will be concluded with an introduction to various approximate methods and the study of particles in a magnetic field.

EXPECTED LEARNING OUTCOMES:

At the end of the course, the student is expected to be able to manage concepts like Hilbert spaces, solutions of Schrödinger equation with various methods, including approximate ones.

PRE-REQUIREMENTS:

Notions and tools of basic classical physics, linear algebra, vector spaces, eigenvalue problems, Fourier transforms, differential equations are needed.

COURSE TOPICS:

Topics are divided in two groups. The first group contains very basic concepts, that the student will read from the notes, while frontal lectures will mainly focus on applications and exercises. The second group will be more in the form of "traditional" frontal lectures, with theory and exercises presented back-to-back.

GROUP 1

1.1) The Rise of Quantum Mechanics

- The Black Body Problem
- The Hypothesis of Photons and the Photoelectric Effect
- Optical Spectra of Atomic Elements
- The Quantization of Angular Momentum: the Stern-Gerlach Experiment

1.2) Mathematical Foundations: Vector Spaces

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- Operators in Quantum Mechanics
- **1.3) Hermitian Operators**
- Definitions and Results
- Eigenvectors and Eigenvalues
- 1.4) Physical Observable

Hermitian Operators and Physical Observables, Commuting and Non-commuting
Observables

- Measuring Observables and Quantum averages: A physical Interpretation
- **1.5) Representations in Quantum Mechanics**

- · Representations of States and Operators
- · Representations and Probabilities in QM
- Change of Representations
- 1.6) Eigenvectors and Eigenvalues of the Momentum; Uncertainty Principle
- 1.7) Schrödinger Equation, Conserved Quantities and Stationary States
- **1.8) Time Evolution in Quantum Mechanics**

GROUP 2

- 2.1) One-Dimensional Problems A recap
- 2.2) Algebraic methods: harmonic oscillator and angular momentum
- 2.3) Schrödinger Equation in Three Dimensions; Central Potentials
- 2.4) Approximate methods I Variational methods
- 2.5) Approximate methods II Perturbative methods
- 2.6) Approximate methods III Semi-classical (WKB) approximation
- 2.7) Motion of particles in a magnetic field

COURSE STRUCTURE:

For the topics from 1.1 to 1.8 the student should read the notes before the frontal lecture; during the lecture the student will be exposed to applications and exercises. The topics from 2.1 to 2.7 will be presented in the form of more traditional frontal lectures, exercises will always be proposed and solved.

READING MATERIALS:

Merzbacher, E.; Quantum Mechanics (J. Wiley & Sons, Inc.)

Messiah, A.; Quantum Mechanics (Dover)

Picasso, L. E.; Lectures in Quantum Mechanics (Springer)

d'Emilio, E., Picasso, L. E.; Problems in Quantum Mechanics: with Solutions (Springer) (6) Sakurai, J. J.; Modern Quantum Mechanics (Addison-Wesley)

STUDY MATERIALS:

Some lecture notes will be also available and distributed at the beginning of the course.

ASSESSMENT AND GRADING CRITERIA:

The exam is written only, the student will be asked to solve exercises. The maximum score of the exam is 30/30, as per the Italian system.