UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Fundamentals of Quantum Mechanics for Materials Scientists

2223-1-F5302Q033

Aims

The main goal of this course is to provide a basic knowledge of quantum mechanics, including modern example applications, and the formal tools needed to fully understand the subsequent advanced physics courses of the Master.

Contents

- Introduction to the quantum mechanics formalism
- Observables, Operators and their properties
- Quantum Models in 1D and 3D.
- Hydrogen atom
- Spin
- Non-interacting Many-Particle Systems
- Emission and Absorption of Light

Detailed program

- Introduction to the Quantum Mechanics: Classical vs Quantum states
- The formalism of Quantum Mechanics: Hilbert Vector Space, Superposition Principle and Probabilities
- Observables and operators: Hamiltonian Formulation, Properties of Operators, Commutators, Eigenvalues, Eigenvectors, Observables and Hermitian Operators
- Time-evolution Operator, Stationary States, Ehrenfest Theorem, Uncertainty Principle
- Examples of Operators: Position Operator, Momentum Operator, Spin Operators
- 1D Quantum Models: Free Particle, Rectangular Potential Wells

- From 1 to 3D Models: Harmonic Oscillator
- Hydrogen Atom: One-body-like problem, Eigenvalues and Eigenvectors
- Approximate Methods: Static Perturbation Theory for Non-degenerate Levels, Variational Principle
- Spin: Classical Magnetic Moment, Stern-Gerlach Experiment, Spin Magnetic Moment, Coupling of Orbital and Spin Angular Momentum
- Non-interacting Many-Particle Systems: Identical Particles, Pauli Principle and Electronic Structure of Atoms, Exchange Energy
- Emission and Absorption of Light: time-dependent Perturbation Theory, Absorption and Stimulated Emission, Spontaneous Emission, Optical Transitions in Semiconductors

Prerequisites

Basic physics concepts and (likely) some quantum ideas in a modern physics course.

Teaching form

Theory lessons by using slides and/or blackboard.

Textbook and teaching resource

Slides are made available to the students through the present e-learning platform.

Textbooks:

David A. B. Miller, Quantum Mechanics for Scientists and Engineers.

Different topics of the course are also well presented in:

David J. Griffiths, Introductory to Quantum Mechanics

L.I. Deych, Advanced Undergraduate Quantum Mechanics.

S.M. Blinder, Introduction to Quantum Mechanics in Chemistry, Materials Science, Biology

Semester

First semester (from October to January)

Assessment method

Students are evaluated through a discussion prepared by the students on a topic not treated during the course, and related to the **quantum information technology**.
Students should prepare a short presentation and discuss an application of the basic concept of quantum mechanics, discussed during the course, particularly in the field of **quantum information technology**. The dcussion should evidence the understing of the main concepts of the course and to have gained basic knowledge of quantum mechanics.

Office hours

From Monday to Friday at any working hour (an appointment should be asked for by email).

Sustainable Development Goals

INDUSTRY, INNOVATION AND INFRASTRUCTURE