



UNIVERSITÀ  
DEGLI STUDI DI MILANO-BICOCCA

## COURSE SYLLABUS

### Fundamentals of Quantum Mechanics For Materials Scientists

2122-1-F5302Q033

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#### 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 an oral exam.

## **Office hours**

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

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