UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Struttura della Materia II

2425-3-E2701Q062

Aims

The main goal of this Course is to provide to the students the formal tools needed to understand some fundamental aspects of matter, such as spin, the fine structure of the hydrogen atom, the electronic structures of multi-electron atoms, and light-matter interaction.

Contents

1. General formalism of quantum mechanics
2. Electron spin
3. Approximate methods
4. Spin-orbit interaction
5. Fine structure of the hydrogen atom
6. Zeeman effect
7. Many-particle formalism
8. He atom
9. Many-electron atoms
10. Light-matter interaction

Detailed program

Formalism of quantum mechanics: Hilbert spaces, operators associated with physical observables, indetermination theorem, constant of motion, Ehrenfest theorem.

Electron spin: Orbital magnetic moment, Ster and Gerlach experiment, spin magnetic moment, Pauli matrix, spin

quantum number and formalism extension.

Approximate methods: static perturbation theory for non-degenerate and degenerate levels, variational principle.

Spin-orbit interaction: spin-orbit interaction term, total angular momentum operator.

Fine structure of the hydrogen atom: spin-orbit correction to the electronic levels, relativistic correction.

Zeeman effect: level splitting in the presence of a magnetic field, strong and weak Zeeman effect.

Many-particle formalism: identical particles, Slater determinant, Pauli esclusion principle.

He atom: ground state by neglecting electron-electron repulsion, perturbative and variational correction, single and triplet states, Hartree and exchange integrals

Light-matter interaction: time-dependent perturbation theory, electric dipole approximation, absorption, stimulated and spontaneous emission, selection rules.

Prerequisites

Students should have already tackled the crisis of classical physics, the particle-wave dualism, the Schrodinger equation and its application to the hydrogen atoms, i.e. with all topics treated in the Course Struttura della Materia I.

Teaching form

The instructor explains and derives each topic using a tablet connected to a projector.

Teaching Methods

Didactic Lectures: 12 two-hour lectures (24 hours).
Didactic Lectures: 8 one-hour lectures (8 hours).
Interactive Teaching: 10 two-hour exercise sessions (20 hours).
Interactive Teaching: 4 one-hour exercise sessions (4 hours).
All lectures and exercise sessions will be held in person.

Textbook and teaching resource

Fully explicative slides, including derivations of the full course, are made available to the students through the present elearning platforms.

Text book followed by most of the Course:

David J. Griffiths, Introduction to Quantum Mechanics.
Quantum Mechanics, L. Del Debbio and A berera

Semester

First semester

Assessment method

The assessment consists of:

Partial written tests during the course.
Optional general written test.
Final oral exam.
Two partial written tests will be held, one around the middle of the course and one at the end. Students who fail more than one partial test or who have not taken the partial tests will be required to pass a general written test on the entire syllabus at the end of the course. In this case, the written test will be followed by an oral exam on the topics covered in the lessons.

The partial written tests (and the general one) will focus on the topics covered in the exercises and will aim to assess the student's ability to apply theoretical concepts to practical problems. Two exercises will be assigned. It is sufficient to solve one of the two exercises to pass.

The final oral exam will consist of a discussion on the topics of the course and will assess theoretical understanding and the ability to connect different concepts.

The final grade will be out of thirty, following these formulas:

Final Grade = 0.7 * PO + 0.15 * PP1 + 0.15 * PP2 or Final Grade = 0.7 * PO + 0.3 * PSg

PO indicates the grade of the oral exam out of thirty. PP1, PP2, and PSg indicate the grades of the two partial or general written tests, expressed out of thirty.

More specifically, the following evaluation will be attributed to the written test:

Excellent (33/30): two perfect exercises.
Very Good (28/30): minor imperfections in one of the two exercises.
Good (24/30): minor errors in only one of the two exercises or minor imperfections in both exercises.
Sufficient (18/30): only one of the exercises is correct.
Insufficient (15/30): both exercises (or the only one completed) show errors.

Office hours

From Monday to Friday at any working hour, provided that students fix an appointment with the teacher by email.

Sustainable Development Goals