UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Modern Physics II

2122-3-E2701Q062

Aims

The main goal of this Course is to provide students with 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

General formalism of quantum mechanics

Electron spin

Approximate methods

Spin-orbit interaction

Fine structure of the hydrogen atom

Zeeman effect

Many-particle formalism

He atom

Many-electron atoms

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, Stern 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 exclusion principle.

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

Many-electron atoms: the central potential approximation, the Hartree method, symbol terms, Hund rules, atomic orbitals progressive filling.

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 Schroedinger equation and its application to the hydrogen atoms, i.e. with all topics discussed in the Course Struttura della Materia I.

Teaching form

The instructor explains and formally derives the new concepts using a blackboard or a tablet. Formal derivations are always followed by applications and exercises. At the beginning of each lesson, the instructor briefly recalls the content of the previous lecture.

Textbook and teaching resource

Fully explicative slides, including derivations of the full course, are made available to the students through the e-learning platform.

Textbook: David J. Griffiths, Introduction to Quantum Mechanics.

Semester

First semeste

Assessment method

The assessment relies on written tests scheduled during the period of the lectures. Such tests will eventually allow access to the final oral exam. The latter consists of a discussion on the topics covered during the lectures. Students who fail in more than one test (mark insufficient) or those who have not taken all the tests will be required to pass at the end of the course a written test based on the entire program. Also in this case, the written test is followed by an oral test on all the topics presented during the lectures. In the written tests two exercises are assigned to evaluate the student's ability to apply the concepts learned in the course. The solution of one out of two exercises guarantees a mark that is sufficient. During the oral examination, the instructor evaluates the student's learning level. Questions pertain solely to the topics explicitly introduced during the lectures.

Office hours

From Monday to Friday at any working hour, provided that students ask for an appointment with the instructor by email.