UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Modern Physics II

2021-3-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, 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 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 treated in the Course Struttura della Materia I.

Teaching form

The teacher explains and formally derives each new concept by live-writing on a tablet wired to a video projector. Formal derivations are always alternated with applications and exercises. At the beginning of each lesson, the teacher briefly summarizes the contents of the previous lecture.

During the Covid-19 outbreak, lectures will be delivered online and will be primarily asynchronous but dedicated synchronous events will also be planned.

Textbook and teaching resource

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

Text book followed by most of the Course:

David J. Griffiths, Introduction to Quantum Mechanics.

Semester

First semester (from October to January).

Assessment method

Students are evaluated through a final written exam followed by an oral one. In the written exam students have to solve one exercise out of two to be admitted to the oral examination with full access to any final mark. During the oral examination the teacher evaluates the level of acquired knowledge and the ability of the student to contextualize. Questions are asked only on topics explicitly treated during the lessons.

During the Covid-19 outbreak, exams will be online using WebEx. A dedicated news will be posted on the e-learning page of the course with a public link to freely access the virtual room where the exam will take place.

Office hours

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

During the Covid-19 outbreak, discussions will take place using the WebEx personal room of the teacher.