



UNIVERSITÀ  
DEGLI STUDI DI MILANO-BICOCCA

## SYLLABUS DEL CORSO

### Fisica III

2021-2-E3001Q043

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#### Aims

Illustrations of phenomena that show the inadequacy of classical physics theories for their description, formulation of new models that introduce the students to the first concept leading to quantum physics.

#### Contents

**Atomic nature of matter** (Maxwell-Boltzmann distribution) **and of charge** ( $e/m$  by Thompson, Zeeman,  $e$  determination for Millikan).

**Non classical behaviour of e.m. radiation.** Black body and Planck hypothesis about e.m. oscillator quantization. Photoelectric effect and Einstein hypothesis about the photon. Application of Planck oscillator to the specific heat of solids: Einstein and Debye models.

**Atomic models:** Rutherford coulombian scattering, atomic spectra, Bohr model, Sommerfeld model. Elements of magnetic properties of atoms.

**E.M. waves or photons?** X rays, Compton effect.

**Particles or waves?** De Broglie relation, electron diffraction by a crystal.

#### Detailed program

Kinetic theory of gases, Equipartition of energy: success and faults.  $C_v$  solids and of diatomic gases. Maxwell distribution for the modulus of the molecular velocity. Molecular effusion, Thermal Doppler broadening, Boltzmann factor, notes on classical statistical distribution. Mean free path for gases, transport coefficients: viscosity and thermal conductivity. Brownian motion.

Elementary charge.: electrolysis (faraday),  $e/m$  estimate (Thomson) classical Zeeman effect. Estimate of the elementary charge (Milikan). Thomson Parabolas for positive ions, Isotopes.

Thermal radiation and Black body. Kirchoff law, Isotropy of thermal radiation, Law of Stefan-Boltzmann, BB thermodynamics, radiation pressure. Wien law, Rayleigh-Jeans model for BB, Planck model, harmonic oscillator energy quantum theory.

Specific heat of solids: Einstein model and Debye model.

Photoelectric effect: the theory of Einstein and the photon.

Atomic models: Thomson, scattering of alpha particles, Rutherford model for coulombian scattering. Bohr model: postulates, orbits, energy of levels, atomic series. Franck-Hertz experiment, recoil effects. Quantization rules of Wilson-Sommerfeld (particles in a box, 1D, 3D, levels degeneration). Magnetic properties of atoms, Stern and Gerlach experiment.

X rays: production, continuum spectrum, Moseley law, Bragg law for diffraction. Thomson cross section for the electron, Compton effect, pair production.

De Broglie hypothesis. Electron diffraction: Davisson and Germer experiment.

Heisenberg Uncertainty principle: typical applications and double slit experiment.

## **Prerequisites**

The contents of the maths and physics courses of the first three semesters of the Bachelor degree in Physics and Mathematics

## **Teaching form**

Lectures

In case of Covid-19 emergency, lessons will be online, partially in streaming. In anycase, weekly webconference meeting with students will be performed. Videos of the lessons will be available.

## **Textbook and teaching resource**

Selected chapters in the following texts and lecturer's notes.

### **TIPLER "Modern Physics"**

Cap.2 – The kinetic theory of matter

Cap 4 – The Nuclear atom

### **BARROW “Chimica fisica”**

Cap. 2 - teoria cinetica

### **ENGE-WEHR-RICHARDS “Introduction to Atomic Physics”**

Cap. 2 - the atomic view of electricity

Cap. 3 - the atomic view of radiation

### **DEKKER – “Solid State Physics”**

Cap. 2 – the specific heat of solids and lattice vibrations

### **SERWAY-MOSES-MOYER “Modern Physics”**

Cap.5 – matter waves

### **RICHTMYER-KENNARD-COOPER “Modern Physics”**

Cap. 7 - X-rays

### **EISBERG-RESNICK “Quantum Physics”**

Cap. 4 – Bohr’s model of the atom

### **ALONSO – FINN “III-Quantum and statistical physics”**

Cap. 10 - classical statistical mechanics

## **Semester**

II semester

## **Assessment method**

The assessment is reached through a written exam that last three hours, with open questions (4/5) in which the student is requested to expose a topic of the program with small derivations, graphs and, if needed some numerical estimates. The use of a scientific calculator is requested. Access to textbooks during the exam is strictly forbidden. The exam score is expressed in 30 points units.

The student succeeded in a positive written exam ( $\geq 18/30$ ) can perform an optional oral exam or keep the rating obtained in the written one.

Those students that have been rated 16/30 and 17/30 in the written exam access the oral exam in order to obtain a final score  $\geq 18/30$ .

In the event of Covid-19 emergency, the lecturer might change the assessment method by introducono either an

oral (online) session or a multiple-choice written exam followed by an oral one.

## **Office hours**

By appointment

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