UNIVERSITÀ DI PISA

QUANTUM AND CONDENSED MATTER PHYSICS

GIUSEPPE CARLO LA ROCCA

Anno accademico	2018/19
CdS	MATERIALS AND NANOTECHNOLOGY
Codice	259BB
CFU	9

Moduli	Settore/i	Tipo	Ore	Docente/i
QUANTUM AND CONDENSED MATTER PHYSICS	FIS/03	LEZIONI	48	GIUSEPPE CARLO LA ROCCA

Obiettivi di apprendimento

Conoscenze
The student who successfully completes the course will be familiar with the basic concepts and methods of nonrelativistic quantum mechanics which are at the base of the modern theory of atoms, molecules and condensed matter systems. He/she will also be able to peruse the literature on the quantum microscopic theory of matter that might be useful for his/her studies/research/work.

Modalità di verifica delle conoscenze
Both the conceptual and practical knowledge on quantum mechanics will be assessed, as well as its relation to the behaviour of atoms, molecules and solids.

Capacità
Logically organize the notions taught in the course, translate them in suitable mathematical models, carry out elementary quantum mechanical calculations and discuss their relevance to atomic, molecular and solid state phenomena.

Modalità di verifica delle capacità
During the final exam, the studenrt will be asked to discuss a theoretical and/or experimental issue related to the contents of the couse: non only his/her factual knowledge will be assesed, but also his/her logical and mathematical capabilities.

Comportamenti
The student will acquire a critical attitude towards our understanding of the microscopic structure of matter and will realize how the quantum behaviour might be at variance with expectations based on classical physics.

Modalità di verifica dei comportamenti
During the lectures, the students will be constantly stimulated to ask questions and raise doubts. The best students will be challanged to think about intriguing problems.

Prerequisiti (conoscenze iniziali)
A sound background in classical physics (mechanics, thermodynamics, electromagnetism), basic inorganic chemistry and mathematics (calculus and linear algebra) is required. Part of the mathematical background needed will be covered during optional recitation classes (about 10 hours).

Indicazioni metodologiche
Face to face lectures will be delivered using the traditional blackboard, occasionally also slides will be projected (especially concerning figures and/or experimental data).

Programma (contenuti dell'insegnamento)
1. Introduction to quantum mechanics
Waves and particles. Wave-particle duality and uncertainty principle. Wave function. Schroedinger equation and stationary states. Expectation

values. Examples: potential well and harmonic oscillator. Operators. Commutators. Measurement process. Transition probability and selection rules.
2. Atomic physics
First atomic models and their shortcomings. Hydrogen atom: energy spectrum, angular momentum and eigenfunctions. Electron spin. Pauli exclusion principle. Helium atom, singlet and triplet states. Many-electron atoms, periodic system of elements. Atomic spectroscopy.
3.Molecular physics
Adiabatic approximation. The ionized hydrogen molecule. The hydrogen molecule. Homonuclear and heteronuclear diatomic molecules. Polyatomic molecules. Molecular vibrations. Molecular Spectroscopy.
4. Condensed matter physics
Structure of liquids, amorphous solids and crystals. X-ray diffraction. Types of crystals: molecular, ionic, covalent and metallic. Boltzmann distribution, equipartition of energy. Quantum statistics: bosons and fermions. Phonons and specific heat of solids. Free electron model of metals: electrical conductivity and specific heat. Bloch functions and electronic bands. Optical transitions and band spectra.

Bibliografia e materiale didattico
Alonso-Finn: “Fundamental university physics, vol. 3: quantum and statistical physics", Addison Wesley
Landshoff-Metherell-Rees: "Essential quantum physics", Cambridge University Press
Kittel: "Introduction to Solid State Physics", Wiley
Notes of the lectures and sets of self-testing questions will be handed out

Indicazioni per non frequentanti
Attendance is strongly recommended, otherwise students should preliminary contact the professor to have all relevant handouts and notes.

Modalità d'esame
Final oral exam on the entire course. The students will be invited to individually contact the professor to agree upon a suitable exam date and sets of self-testing questions covering the program will be distributed them in advance.

Altri riferimenti web
https://en.sns.it/ugovserse/teaching/1076 (everything)
https://en.sns.it/ugovserse/teaching/1062 (only optional preliminary tutorial introduction)

Note
The course will be taught in English.
To contact the teacher E-mail: giuseppe.larocca@sns.it
The course will be given at Scuola Normale Superiore (SNS), the detailed schedule will be agreed upon with the students. It will comprise courses offered to the SNS studens, in particular the entire course “Introductory quantum physics” (https://en.sns.it/ugovserse/teaching/1076) and the introductory section of the course “Condensed matter physics” (https://en.sns.it/ugovserse/teaching/1062).
The course is unchanged with respect to 2017-18 and 2016-17

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