UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Theory of Condensed Matter I

2425-1-F1701Q107

Aims

To provide an introduction to the study of the electronic structure of solids beyond the independent electrons approximation. To provide an introduction to the magnetic properties of solids.

Contents

The Hartree-Fock equation and the dielectric properties of the electron gas. Second quantization. The homogeneous electron gas. Density Functional Theory and its applications to the electronic structure of solids. Magnetic properties of insulators and metals.

Detailed program

Interacting electrons

From the many-electron system to mean field theory: the Hartree and Hartree-Fock equations. Thomas-Fermi model.

Second quantization for bosons and fermions, creation and annihilation operators, field operators, one-electron and two-electron operators.

The jellium and the Hartree-Fock method for the homogeneous electron gas. Screening in the electron gas in the theories of Thomas-Fermi and Lindhard: Friedel oscillations. Properties and phase diagram of the homogeneous electron gas.

Density Functional Theory (DFT): the Hohenberg-Kohn theorem and the Kohn-Sham equation. Applications of DFT to the electronic properties of solids, Pseudopotentials. Hellmann-Feynman theorem and first principles molecular dynamics.

Magnetic properties of solids

Diamagnetism and paramagnetism in insulators. Paramagnetic and diamagnetic properties of the homogeneous electron gas. Ferromagnetism in insulators: Heisenberg Hamiltonian and the Curie-Weiss model. From Hubbard to Heisenberg Hamiltonian: direct and kinetic exchange, superexchange. Magnetic excitations in ferromagnets: spin waves. Stoner theory for itinerant ferromagnetism in metals.

Prerequisites

The courses of Quantum Mechanics and Structure of Matter of the first level degree in Physics.

Teaching form

Frontal lectures. The lectures will be given in English.

Textbook and teaching resource

M. L. Cohen and S. G. Louie, Fundamentals of Condensed Matter Physics, Cambridge University Press (Cambridge, 2016).

G. Grosso and G. Pastori Parravicini: Solid State Physics, Academic Press (San Diego, 2000).

R. Martin, Electronic Structure, Cambridge University Press(Cambridge, 2008)

Book for additional material on magnetic properties

S. Blundell, Magnetism in Condensed Matter, Oxford University Press (New Yors, 2001), e-book available at library

Advanced book on magnetic materials

D. Khomskii, Transition Metal Compounds, CambridgeUniversity Press (Cambridge, 2014)

Semester

First semester

Assessment method

Oral exam.
Discussion concerning the topics covered during the course.
The ability to present the topics covered in class in all their conceptual and formal aspects will be assessed, including the derivation of the results.
No ongoing partial tests are planned.

Office hours

After the lectures or by appointment.

Sustainable Development Goals

QUALITY EDUCATION