UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Quantum Materials

2122-1-F5302Q037

Aims

The physical description of the materials is rooted in quantum mechanics, which describes how atoms bond between each other and how electrons interact. Although these quantum effects can in many cases be approximated by a classical description at the macroscopic level, there are material systems where quantum effects remain evident over a wider range of energy and length scales. Such quantum materials include superconductors, graphene, topological insulators, Weyl semimetals. Many of them derive their properties from reduced dimensionality, in particular from confinement of electrons to two-dimensional sheets. Moreover, they tend to be materials in which electrons cannot be considered as independent particles but interact strongly and give rise to collective excitations known as quasiparticles. This course will introduce the electronic properties of quantum materials and examines how its entanglement and topology give rise to a rich variety of quantum states and phases.

Contents

Topological Effects, Integer Quantum Hall Effect, Topological Insulators, Weyl semimetals, Superconductivity

Detailed program

1. Topological effects
    - Berry phase
    - Ahronov-Bohm effect
    - Berry Curvature

    - Topological quantization of Hall conductivity
    - Topological insulators
    - Weyl semimetals
2. Superconductivity
    - Type I and II superconductors
    - Electrodynamics
    - Theory of Landau Ginzburg
    - Josephson effect and SQUIDS
    - Quantum bits
3. Microscopic theory of superconductivity
    - Hamiltonian BCS
    - Electromagnetic response

Prerequisites

electromagnetism, quantum mechanics, solid state physics

Teaching form

Lectures

Textbook and teaching resource

Textbook

Girvin S.M & Yang K. Modern Condensed Matter Physics – Cambridge University Press

Semester

II semester

Assessment method

oral examination

Office hours

at the end of the lessons or by appointment