# Solid State Physics

## Proff. Stefania Pagliara, Luigi Sangaletti

***COURSE AIMS AND INTENDED LEARNING OUTCOMES***

Students will acquire the experimental and theoretical foundations of the properties of solids relating to the translational symmetry of the crystal lattice, with particular focus on aspects relating to the electronic structure of crystals and vibrational spectra. The lectures will be supplemented with discussions of problems pertaining to condensed matter physics. The experimental aspects will be addressed primarily with reference to the quantum theory of radiation-matter interactions.

Intended learning outcomes.

At the end of the course, students will be able to:

- present the development of theories on solids, from the classical approach to quantum theories for independent electrons

- describe the crystalline structure of elementary solids and the diffractive techniques developed to experimentally determine this structure

- discuss the electronic structure of metallic and semiconductor materials, the properties of the Fermi surface in metals, and the experimental techniques for determining the electronic structure.

- discuss the vibrational structure of metallic and semiconductor materials on the basis of harmonic approximation and the relationship between vibrational spectrum and specific heat.

- discuss the transport properties of metallic and semiconductor materials on the basis of the Boltmann equation.

- relate semiconductor doping to semiconductor devices based on pn junctions.

***COURSE CONTENT***

1. From the Drude model to the Sommerfeld theory of metals. Limits of the free electron model.

2. Structural order and disorder. The crystal lattice. The reciprocal lattice. Diffraction of x-rays by crystals. Bravais lattices and crystal structures.

4. Electron levels in a periodic potential. Bloch theorem.

5. Electrons in a weak periodic potential. The tight-binding method. The Kronig-Penney model: energy levels in a periodic structure of quantum wells: computation of allowed energy bands.

6. The Fermi surface. Experimental methods for the Fermi surface mapping.

7. Band structure of metals.

8. Classification of solids. Cohesive energy.

9. Classical theory of the harmonic crystal. Quantum theory of the harmonic crystals and specific heats in solids.

10. Transport in solids. The Boltzmann approach. Electrical and thermal concuctivity in metals. Thermal conductivity in insulators.

11. Electrons in magnetic fields. Landau levels and quantum Hall effect.

12. Pure and doped semiconductor materials. Homojunctions, heterojunctions and semiconductor devices. Low-dimensional systems.

***READING LIST***

Neil W. Ashcroft - N. David Mermin, *Solid State Physics,* Saunders College, Philadelphia.

G. Grosso - G. Pastori Pallavicini, *Solid State Physics,* Academic Press, 2000.

F. Bassani - U. M. Grassano, *Fisica dello Stato Solido,* Bollati Boringhieri, Turin, 2000.

C. Kittel, *Introduction to Solid State Physics,* John Wiley, New York,1995 (It. transl. Boringhieri Turin).

***TEACHING METHOD***

Lectures. Focus Seminars.

***ASSESSMENT METHOD AND CRITERIA***

Oral examination aimed to assess the level of knowledge of the main topics of the course, the ability to present them, and the student’s mastering of these concepts to discuss problems in the field of condensed matter systems.

The assessment of the oral exam will take into account students'accuracy in the procedures illustrated, and efficacy and accuracy of their presentation; an ability to assimilate the concepts and personally rework them will be particularly valued.

***NOTES AND PREREQUISITES***

The course lays the foundations for a subsequent discussion of the theoretical and experimental aspects of radiation-matter interaction, the physics of strong electronic correlation systems, magnetism, and superconductivity. The prerequisites are knowledge of the methods for solving Schrödinger’s equation at steady states for a single particle, and knowledge of the basic elements of thermodynamics.

Further information can be found on the course folder of the Blackboard platform.