Condensed matter physics 9 ECTS

Organisation :

Effective duration: 12 weeks
Lectures: 2 hrs x 12 = 24 hrs
Tutorials: 1 hrs x 12 = 12 hrs
Lab/Projects: 4 hrs x 12 = 48 hrs
Total : 84 hrs

Examination :

Written examination, project reports

Teachers :

Lecture : Andrea GAUZZI, gauzzi@impmc.jussieu.fr (responsible)
Tutorial, lab/project :
Philippe DEPONDT, depondt@insp.jussieu.fr
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Plan of lectures (24 hrs)

CHAPTER I. ELECTRONIC STATES IN CRYSTALLINE SOLIDS.
1. Quasi-free electron approximation. The Kronig-Penney model. Linear Combination of Atomic Orbitals (LCAO). Electronic bands.
2. Interacting electrons. Relationship between scattering length and mass renormalisation. Virial coefficients. Exchange interaction in the Fermi and Bose gas. The Hartree-Fock approximation.
3. Methods for calculating band structures. Tight-binding approximation. Orthogonalised plane-wave method. Pseudopotentials.
4. Examples of band structure calculations applied to metals, semi-metals and insulators.

CHAPTER II. FERMI LIQUIDS.
5. Fermi liquids. Single-particle approximation. Limits of validity. The concept of quasi-particle.
6. Energy spectrum of electron Fermi liquids. Approximate solution. Thermodynamic properties.

CHAPTER III. SCATTERING PROCESSES.
7. Electron as wave packet. Group velocity. Kinetic equation. Electron-electron, electron-photon and electron-phonon scatterings. Umklapp processes.
8. Electrical and thermal conductivity of metals and insulators. Normal and anomalous skin effect.
9. Raman, infrared and Brillouin spectroscopies. Compton effect and photoemission spectroscopy.

CHAPTER IV. PHASE TRANSITIONS.

10. I and II order phase transitions. Legendre transformations. Ginzburg-Landau theory. The concept of order parameter. Symmetry aspects.
11. Relevant cases of II order phase transitions. Order-disorder phase transitions. Ferro- and antiferro-magnetic transitions. The Ising model. Ferroelectric transition.
12. Superconducting transition. Magnetic and electrodynamic properties of superconductors.

Tutorials (12 hrs)

Selected exercise on the lecture topic or that introduces the laboratory/project

Laboration/numerical project (48 hrs)

Numerical study of Kronig-Penney
Crystal and electronic structure of graphite-I
Crystal and electronic structure of graphite-II
Crystal and electronic structure of Mg-I
Crystal and electronic structure of Mg-II
X-ray diffraction of Cu3Au
Unit cell and Rietveld refinement of Cu3Au
Crystal structure and lattice vibrations of Si (Ab initio)
Raman on Si
IR on Si
Ising
Order-disorder in Cu_3Au