MAPR1492 Materials physics

[30h+15h exercises] 4 credits

This course is taught in the 2nd semester

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Language: French
Level: First cycle

Aims

This module presents the basics of material physic (particularly periodic solids). At the end of the module, the student masters the simple models of solids, and understand their electronic, dynamic, thermodynamic, magnetic and transport properties (transport of charge and heat).

Main themes

The covered topics include : Born-Oppenheimer and independent electron approximations, electronic band structures and its simple models, phonons and anharmonic effects, semiconductors, magnetism, some transport properties.

Content and teaching methods

Content :
1. Born-Oppenheimer approximation and independent electron approximation.
(splitting of the dynamics of nuclei and electrons, screening, exchange and correlation effects)
2. Periodic potential and band structure.
(review of crystallography and symmetry, reciprocal space, Brillouin zone, Bloch theorem, density of states, Fermi surface, metals, insulators)
3. Nearly-free electron approximation.
(Born-Von Karman method, folding of the free electron parabola in the first Brillouin zone, Bragg reflections, gap opening, sodium, magnesium, aluminum)
4. Tight-binding approximation.
(monoatomic linear chain, s-p bonding in semiconductors and carbon compounds, d bonding in transition metals, ionic compounds)
5. Nuclei dynamics.
(harmonic approximation; dynamical matrix; normal modes of vibration ; phonon band structure, monoatomic and diatomic chain, acoustic and optic modes, transverse and longitudinal modes, exemples of phonon band structures for different solids).
6. The free electron gas.
(occupation of states, Fermi vector and energy as a function of the density, electronic specific heat, thermodynamical functions, comparison with the lattice specific heat)
7. Semiconductors
(impurity levels, computation of electron and hole densities, Fermi level position).
8. Dynamics of electrons in the periodic solid.
(carrier speed, electric and magnetic field effects in metals, effective mass, current in bands : electrons and holes)
9. Transport and anharmonic effects
(diffusion processes for electrons and Boltzmann equation, metallic electric conductivity, anharmonicity and thermal expansion, diffusion process for phonons and heat conduction, electron-phonon collisions in metals; Hall effect).
10. Magnetism
(introduction and overview of magnetic properties; paramagnetism of the free electron gas ; band model of ferromagnetism)
11. Supraconductivity
(introduction : experimental characteristics and theories)
Methods :
Ex-cathedra courses, exercises, laboratory.

Other information (prerequisite, evaluation (assessment methods), course materials recommended readings, ...)

MAPR 1491 Complements of physics
MAPR 1805 Introduction to material science

Other credits in programs

FSA13BA	Troisième année de bachelier en sciences de l'ingénieur, orientation ingénieur civil	(4 credits)