MAPR2471 Transport phenomena in solids and nanostructures

[30h+30h exercises] 5 credits

This course is taught in the 1st semester

Teacher(s): Jean-Christophe Charlier, Xavier Gonze (coord.), Luc Piraux
Language: French
Level: Second cycle

Aims

Introduction to the electrical and thermal conductivity of materials by emphasizing the physical mechanism at the This lecture provides a description of the main electrical and thermal transport phenomena in materials. It also gives an introduction to the specific transport properties in nanostructures and low dimensional systems, including quantum effects. Finally, the students become acquainted with experimental set-up used for transport measurements.

Main themes

The covered topics include : electrical and thermal conductivities, thermoelectricity, experimental aspects, effects of temperature and magnetic field, spin polarized transport, electrical transport in two-dimensional and one-dimensional systems and molecular transport.

Content and teaching methods

Content :
A : Macroscopic Materials
Electrical conductivity : Theory - Comparison between metals, semiconductors and semi-metals - Scattering mechanisms and temperature dependence - Links with band structure
Thermal conductivity: Theoretical expressions for electrical and lattice contributions Scattering mechanisms and temperature dependence - Examples
Thermoelectric effects : Theoretical expressions for Seebeck et Peltier effects - Examples - thermoelectric conversion
Experimental aspects: set-up for electrical and thermal measurements
Magnetic field effects : Influence of a magnetic field on the density of states and electrical transport
B : Nanostructured materials and low-dimensional systems
Magnetic nanostructures : spin polarized currents, giant magnétorésistance in magnetic multilayers, introduction to spin electronic
2D systems : examples of 2 dimensional electron gas, density of states, influence of a magnetic field, Quantum Hall effect, weak localization
1D systems: examples of 2 dimensional electron gas, density of states, influence of a magnetic field, ballistic transport, universal quantum fluctuations, Coulomb blockade, conductance qunatization, Aharonoc-Bohm effect.
0D systems: examples of quantum dot, molecular transport
Methods :
Ex-cathedra courses, laboratories (synthesis of materials and nanostructures, various characterization, experimental set-up, electrical and thermal transport measurements), analysis of the results.

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

MAPR 1492 Physique des Matériaux
MAPR 1491 Compléments de Physique
MAPR 1805 Introduction à la Science des Matériaux

Other credits in programs

MATR22	Deuxième année du programme conduisant au grade d'ingénieur civil en science des matériaux	(5 credits)
MATR23	Troisième année du programme conduisant au grade d'ingénieur civil en science des matériaux	(5 credits)