Statistical physics and plasma physics

Lecturer
Yves LOUIS (Coordinator)

Course mnemonic
PHYS-H411

ECTS credits
5 credits

Language(s) of instruction
English

Course period
Academic year

Course content

Statistical ensembles, ideal systems at equilibrium, systems of interacting particles at equilibrium, phase transitions, brownian motion, stochastic processes.

Debye shielding, single-particle motions, main guiding centre drifts, magnetic mirrors, adiabatic invariants, magnetohydrodynamics, propagation of waves in plasmas, cutoffs and resonances, diffusion and resistivity, equilibrium and stability, kinetic theory and Landau damping, cyclotronic heating, ponderomotive force and self-focusing of laser beams in plasmas.

Objectives (and/or specific learning outcomes)

Establish a link between the microscopic dynamics of particles and thermodynamic properties of matter. Acquire progressively the basic notions about natural plasmas and thermonuclear plasmas.

- Describe a macroscopic system of classic particles by the use of distribution functions in the phase space applied to Gibbs sets.
- Use this formalism to study ideal systems at equilibrium such as perfect gas, ideal solids and ideal systems of quantic particles.
- Use this formalism to study interacting systems at equilibrium such as real gas and ferromagnetic solids.
- Develop various mathematical methods allowing to compute the temporal evolution of distribution functions in the phase space in the case of systems out of equilibrium (Liouville equation, BBGKY hierarchy, Vlassov equation, Boltzmann equation).
- Develop specific equations for markovian stochastic processes and apply these to the study of brownian motion based on Langevin equation, in order to obtain Fokker-Plank equation. Complete this description by the harmonic analysis of Langevin equation.
- Describe the motions of a single charged particle in various type of electromagnetic fields.
- Develop the equations describing a plasma as a mix of fluids (magnetohydrodynamics).
- Combine the equations of magnetohydrodynamis with Maxwell's equations in order to describe the propagation of electrostatic and electromagnetic waves in a plasma.
- Use these equations to quantify the phenomenon of diffusion into plasmas and analyse the equilibrium and stability of plasmas.
- Develop the equations of kinetic theory in order to complete the theoretical description of plasmas given by magnetohydrodynamics.
- On the basis of kinetic theory, analyse the non-collisional damping of waves in plasmas (Landau damping).

Teaching method and learning activities

Oral lecture and exercices.

Contribution to the teaching profile

Mobilize a broad spectrum of knowledge in the field of sciences and techniques.

References, bibliography and recommended reading

"Physique statistique Introduction", C. Ngô et H. Ngô, DUNOD; "Physique statistique hors d'équilibre", N. Pottier, EDP Sciences / CNRS Editions; "Introduction to plasma physics ans controlled fusion", Francis F. Chen, Plenum Press.

Other information

Contact(s)

Localisation: Campus du Solbosch, Bât. C, 4ème niveau, local C4.320 - Mail: ylouis@ulb.ac.be - Tél: 02 650 28 22.

Evaluation method(s)

Other

Evaluation method(s) (additional information)

One oral examination about theory and exercices of statistical physics is organised at the end of the first term giving the mark N1.

One oral examination about theory and exercices of plasma physics is organised at the end of the second term giving the mark N2.

Determination of the mark (including the weighting of partial marks)

The final mark is the average (N1+N2)/2.

Main language(s) of evaluation

English

Programmes

Programmes proposing this course at the Brussels School of Engineering

MA-IRPH | Master of science in Physical Engineering | finalité Professional/unit 1