2EL1920 – Advanced Quantum and Statistical Physics

Instructors: Jean-Michel Gillet
Department: DÉPARTEMENT PHYSIQUE
Language of instruction: FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 35,00
Elective Category : Fundamental Sciences
Advanced level : Yes

Description

This course is both the continuity of the first year course and its complement.
It allows us to come back to certain aspects which, due to lack of time, have been covered too superficially for an effective use and to improve the understanding of a selection of basic concepts. It will be an opportunity to discuss the statistical physics of open systems (grand-canonical ensembles) and quantum statistics (bosons and fermions). Links will be established with the basis of Hamiltonian (and Lagrangian) mechanics. The course also aims to offer an extension to the quantum physics of atoms and molecules. The last sequence will give a brief introduction to quantum intrication.

Quarter number

SG6

Prerequisites (in terms of CS courses)

Prerequisite is:
The first year course on Quantum and Statistical Physics

Syllabus

We will discuss a selection of topics among which (non-contractual):

- Basics of Lagrangian and Hamiltonian mechanics
- Complements on the quantum harmonic oscillator
- Complements on kinetic moment
- Statistical physics of open systems
- Quantum statistics
- fermions
- bosons
- Fine and hyperfine structure of the atom
- Variational theorem
- The N-electron atom

- Structure and properties of the atomic nucleus
- Aspects of Quantum Molecular Physics
- Quantum intrication and Bell inequalities

Class components (lecture, labs, etc.)

Lectures, exercises, reading and computer project
8 lectures
2 seminars (3h chacun).
10 exercices/projects

Grading

The evaluation is done by means of 2 components: -The quality of the interaction and engagement (while solving the exercises, answering oral questions during tutorials, lectures, numerical simulation project) - A written test (1h30) whose questions relate potentially to the entire program and which allows in particular to evaluate the knowledge, the mastery of the methods set out above and the associated skills. The continuous assessment and project will be 30 % of the final grade.
Competence C1, milestone 2 will be tested by means of the numerical project and an associated question during the final exam.

Course support, bibliography

The textbook is “Application-Driven Quantum and Statistical Physics” (Vol. 1, 2 & 3, World Scientific). Additional references will be given.

Resources

Teaching staff (instructor(s) names): C. Paillard, G. Schehr, T. Antoni, M. Ayouz, E. Klein, J-M Gillet
· Maximum enrollment (default 35 students): 100
· Software, number of licenses required: Python and GAMESS
· Equipment-specific classrooms (specify the department and room capacity): small amphitheater for lectures, 3 rooms for tutorials

Learning outcomes covered on the course

At the end of the course, a student will be able to :
- justify the structure of the first rows of the periodic table aswell as the bonding mechanisms.
- decide the need for a quantum approach to temperature-dependent problems.
- differentiate a fermionic behavior from that adopted by bosons. He can then justify different components involved in response functions, such as specific heat, especially at low temperatures.

- propose a method of quantum modeling for some important properties of an ideal molecular gas but will know ways to take into account certain interactions.

Description of the skills acquired at the end of the course

The skills targeted are
C1.2 (milestone 1 or 2): Study a problem as a whole, the situation as a whole. Identify, formulate and analyse a problem in its scientific, economic and human dimensions
and C1.3 (milestone 1): Solve the problem with approximation, simulation and experimentation
Competences are tested by means of the numerical project and an associated question during the final exam