1SL3000 – Quantum and Statistical Physics

Instructors: Jean-Michel Gillet
Department: DÉPARTEMENT PHYSIQUE
Language of instruction: ANGLAIS, FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 50
On-site hours (HPE): 33,00

Description

The ambition of this course is to build the foundations of 21st century physics as they were formulated at the beginning of the 20th century (except for relativity). In doing so, we aim to show how models were elaborated, starting from experimental results, firstly, by trying to use the tools of the old theory, then by reconstructing axiomatically a new theory. This is done initially on mechanics and electromagnetism leading then to quantum theory. In a second time, a better understanding of the foundations of thermodynamics lead to the elaboration of statistical physics. The focus is always on applications or the impact of the introduced concepts on the fields where the engineer (or, simply, the citizen) is active. Ultimately, the goal is to give a better acquaintance of engineering students to the conceptual contributions of physics on which many current innovations are developed. The students will master the vocabulary, will be familiar with some essential steps for an enlightened implementation and will know the limits of applicability.

Quarter number
SG3 and ST4

Prerequisites (in terms of CS courses)
Differential equations, linear algebra, vector spaces, thermodynamics, electromagnetism.

Syllabus
I. Period 1
1) Some key experiences (1h30)
(i) TD : Orders of magnitude in quantum physics (1h30)
2) From phenomenology to axiomatic formulation
a) Schrödinger equation and piecewise potentials (1h30)
(i) TD : infinite wells (1 and 2D) (1h30)
(ii) TD : tunnel effect and microscopy (1h30)

3) Postulates and mathematical artillery (1h30)
(i) TD : Flippingl of NH3 and MASER (1h30)
4) The quantum-classical fuzzy border (1h30)
(i) TD : Spreading of the wave packet (1h30)
5) Vibrations and Harmonic Oscillator (1h30)
(i) TD : Molecular vibrations (1h30)
II. Period 2
6) Perturbations (1h30)
7) Angular momentum (1h30)
(i) TD : Morse potential (perturbations) and thermal expansion (1h30)
8) Stability of the atom (1h30)
(i) TD : from H to He (1h30)
9) Statistical physics from thermodynamics to information theory (1h30)
(i) TD : Paramagnetism and Curie Law (1h30)
10) Regulated system of classical particles (1h30)
(i) TD : Sublimation of argon (1h30)
11) Physics of the atomic nucleus
FINAL EXAMINATION (1h30)

Class components (lecture, labs, etc.)
Lectures, seminar, tutorials, readings. Being (and remaining) registered in small tutorial groups is conditioned upon an active role in the group.

Grading
The global assessment is two fold:
- Two intermediate 15 min face-to-face MCQ (during the tutorial sessions). The grading of MCQ is automatic for a rapid feedback to the students.
- one final face-to-face written exam.
The program of the final exam potentially covers all subjects seen in the course. At least one question probes skill C1.
The final grade is made of the intermediate MCQ grade (30%) and exam grade (70%). In case of a justified absence to one of the intermediary examinations, the grade of this latter is replaced by the grade of the final examination.
If the conditions do not allow for continuous assessment in class, only the final grade is taken into account. In any case (face-to-face or remote teaching), the the groups with limited number of students (moderate or advanced levels) will include a participation contribution to the continuous assessment grade.

Course support, bibliography
Handout and textbook “Application-Driven Quantum and Statistical Physics” (Vol. 1 and 2, World Scientific)

Resources

Teaching staff (instructor(s) names): M. Ayouz, Z. Toffano, S. Latil, F. Bruneval, J-C Pain, J-B Charraud, P-E Masson, G. Schehr, H. Dammak, P-E. Janolin, I. Kornev, P. Cortona, T. Antoni, R. Santachiara, , R. Landfried, P. Testé, C. Paillard, B. Palpant, J-M Gillet.

· Maximum enrollment (default 35 students): 90, 50, 25

· Software, number of licenses required:

· Equipment-specific classrooms (specify the department and room capacity): Physique, 1 large amphitheater, 6 rooms of 90, 1 rooms of 50, 10 rooms of 35

Learning outcomes covered on the course

At the end of the course, on the one hand, the student are expected to know how to build and / or use an elementary quantum microscopic model. From the description of an environment and / or a simplified potential, he/she will be able to find the spectrum of energies and eigenstates. He/she will be able to predict a temporal behavior of the quantum states as well as the probabilities of results of a measurement. For this he/she will have to implement the standard methods of resolution, resort to the time-independent approximation method (or the variational theorem).

On the other hand, from a proposed quantum law (spectrum of energies and degeneracies), the student must know how to choose the adapted approach of statistical physics which will lead him/her to predict the behavior of a targeted macroscopic property. Emphasis will be placed on the deduction of equations of state and the temperature behavior of macroscopic response functions.

Description of the skills acquired at the end of the course

The competences targeted are C1.2: Use appropriate models, choose the right scale of modelling and relevant simplifying assumptions to deal with the problem and C1.3: Be critical of a solution. In particular by comparing the results of a model with those of experience.

Skill C1 is tested by means of at least one question during the final written exam.