PHYS-436 **Statistical physics IV**

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Cursus	Sem.	Type
Ing.-phys	MA2, MA4	Opt.
Physicien	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Oral
Workload	120h
Weeks	14
Hours	**4 weekly**
Courses	2 weekly
Exercises	2 weekly
Number of positions	

Summary

This course covers non-equilibrium statistical processes in the classical regime: Fluctuation dissipation relation, anomalous diffusion, stochastic (Ito) calculus, Crook's relation. The second part of this course covers modern Quantum Stochastic methods and their application in modern Quantum Optics

Content

I. Introduction to classical non-equilibrium thermodynamics
- Brownian Motion and Einstein relation
- Fokker Planck Equation
- Boltzmann Equation
- Anomalous Diffusion, Levy Flights
- Boltzmann Equation

II. Statistical Mechanics of Linear Response
- Kubo Formula
- Fluctuation Dissipation Theorem
- Markovian Processes

III. Open Quantum Systems: Quantum mechanical description of Dissipation
- The quantum Master equation and open quantum systems
- The damped quantum mechanical harmonic oscillator
- Two level system in a heat bath, de-phasing processes.
- Quantum stochastic Langevin equations
- Examples: Dephasing of Josephson junction Qubits

IV. Quantum Noise and Quantum Measurements
- Quantum Noise and basics of linear quantum measurements
- Classical versus Quantum mechanical spectral densities

IV. Special topics: stochastic quantum methods in Quantum Optics
- Applications of quantum statistical processes and simulation thereof using the "MATLAB" Quantum Optical Toolbox
- Input-output theory Gardiner and Collet
- Applications of stochastic quantum Langevin equations in Quantum Optics:Master equation, Fokker Planck equation for Optical Parametric Oscillator, Ito formalism, Phase diffusion in Lasers
- Thermodynamical noise in Physics and precision measurements

Learning Prerequisites

Recommended courses

Statistical physics I, II

Learning Outcomes

By the end of the course, the student must be able to:

- Formulate correct mathematical models of statistical processes
- Solve succesfully the quantum master equation
- Apply numerical simulation tools to non-equilibrium systems
- Explore the quantum optical numerical Toolbox (MATLAB)
- Visualize non-equilibrium processes numerically
- Elaborate modern examples from Literature of Non-Equilibrium Processes

Transversal skills

- Summarize an article or a technical report.
- Take feedback (critique) and respond in an appropriate manner.
- Use both general and domain specific IT resources and tools

Expected student activities

Students are expected to give (as a Bonus) a final presentation about a published journal paper that is related to non-equilibrium stastistical Physics in Biology, Sociology or Quantum Optics of Condensed Matter.

Assessment methods

Final presentation
Oral (or written exam)
Homeworks

Resources

Ressources en bibliothèque

- Statistical Methods in Quantum Optics 1
- Input and Output in damped quantum systems / Gardiner
- Irreversibility and Generalized Noise / Callen
- Quantum Optics Toolbox
- Statistical Physics II: Nonequilibrium Statistical Mechanics / Kubo
- Quantum Noise
- Introduction to Quantum Noise, Measurement and Amplification / Clerk
- Nonequilibrium statistical mechanics / Zwangzig

Moodle Link

- http://moodle.epfl.ch/enrol/index.php?id=13933