Summary
his course covers non-equilibrium statistical processes in the classical regime and treats important historical developments by Einstein, Boltzmann and Kubo. The second part of this course covers modern Quantum Stochastic methods and their application in modern Quantum Optics and Condensed Matter

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 Langlevin 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 successfully 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
- Make an oral presentation.
- 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 statistical 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
- Nonequilibrium statistical mechanics / Zwanzig
- Statistical Physics II: Nonequilibrium Statistical Mechanics / Kubo
- Quantum Noise
- Introduction to Quantum Noise, Measurement and Amplification / Clerk
- Quantum Optics Toolbox

Moodle Link