Field Theory of Non-Equilibrium Systems

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The course gives an introduction to various aspects of the field theory of non-equilibrium many-body systems, a young and rapidly evolving area of research. A modern functional integral formulation opens up the powerful toolbox of quantum field theory to non-equilibrium situations, such as the efficient use of collective degrees of freedom or the renormalization group. We develop the theoretical concepts needed to work in this field, and apply them to concrete and prominent physical situations.

Contents:

$$Z = \mathrm{tr}\rho = \int \mathcal{D}(\varphi^*_\pm, \varphi_\pm) e^{iS[\varphi^*_\pm, \varphi_\pm]}$$

- Classical limit: Langevin equations, Fokker-Planck equations, Martin-Siggia-Rose functional integral.
- Quantum regime: Keldysh functional integral for closed and open quantum systems.
- Near-equilibrium dynamics:
  - Rare fluctuations, activation problems.
  - What is thermal equilibrium, actually? From detailed balance to dynamical symmetries.
  - Dynamical phase transitions.
- Non-equilibrium dynamics:
  - Directed percolation, or: wetting transition and chemical reactions.
  - Surface dynamics, KPZ equation, or: fire spreading, bacterial growth.
  - Driven quantum matter, exciton-polaritons systems.
  - Turbulence (if time permits).
- Disordered fermion systems, many-body localization.

Requirements:

Quantum and statistical mechanics including second quantization; knowledge of functional integrals is helpful but not mandatory.

Literature:

A. Kamenev, Field Theory of Non-Equilibrium Systems; U. C. Tauber, Field Theory Approaches to Non-Equilibrium Dynamics; A. Altland and B. Simons, Condensed Matter Field Theory; J. Zinn-Justin, Quantum Field Theory and Critical Phenomena

Dates:

Mo(5) BZW/A120/P and Fr(4) (odd weeks) BZW/A120/P