Condensed Matter Theory II – SuSe'24
Quantum Many-Body Theory

This course focuses on the concepts and physical pictures behind collective phenomena in interacting many-body systems.

Quantum many-body systems often behave fundamentally different from their elementary building blocks: symmetries are spontaneously broken and new phases appear; new kinds of collective degrees of freedom emerge; particles fractionalize. In this course, we work out concepts of quantum many-body theory and use them to understand phenomena like superconductivity and strong electron correlations.

The course will consist of lectures and exercises, where we combine analytically solvable problems with computational exercises.

Topics

- Interaction effects in quantum many-body systems: Electron-electron and electron-boson correlations, Magnetism & superconductivity
- Spontaneous symmetry breaking and collective phenomena
- Green functions and diagrammatic many-body theory
- Path integrals in quantum many-body physics

Time & Place

- Lectures
    - Mondays 8:30-10:00 (SemRm 1076)
    - Thursdays 10:00-12:00 (SemRm 1076)
- Exercises
    - Mondays 10:00-12:00 (SemRm 1076)

Literature

- **Bruus, Flensberg: Many-Body Quantum Theory in Condensed Matter Physics: An Introduction**
- **Altland, Simons: Condensed Matter Field Theory**
- **Doniach, Sondheimer: Green's function for solid state physicists, Imperial College Press**
- **Coleman: Introduction to Many-Body Physics**
- Mahan: Many-Particle Physics
- Fetter, Walecka: Quantum Theory of Many-Particle Systems
- Lifschitz and Pitajewski: Statistical Physics, Part 2. (Vol. 9 of Landau and Lifschitz "Course of Theoretical Physics")
- Abrikosow, Gorkov and I. E. Dzyaloshinski: Methods of Quantum Field Theory in Statistical Physics (Prentice-Hall)
- Negele, Orland: Quantum Many Particle Systems

Exam

- Oral exam (45 mins.). Possible dates: August 20th and 21st or September 17th and 18th 2024

Conent (Preliminary)

Entreé:

- Second quantization
- Interaction effects in solids and electronic correlations: Mott-Hubbard physics, magnetism, superconductivity

Premier plat principal:

- Many-body Green functions: Definition, equations of motion, self-energy and Dyson equation
- Matsubara Green functions & Wick's theorem
- Feynman diagrams: Introduction, linked cluster theorem & block diagrams, examples: Hartree-Fock, GW, DMFT

Cours intermédiaire:

- Superconductivity: BCS and Gorkov theory

Deuxième plat principal:

- Coherent states: Bosons, Fermions, Grassmann numbers
- Coherent state path integrals
- Broken symmetry and collective phenomena

Dessert:

- Dynamical Mean Field Theory and Dual Fermions