Module: Elective Advanced Lectures: Theoretical Physics

Module No.: physics70c

Course: Quantum Field Theory for Condensed Matter Physics (T)

Course No.: physics759a

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	3+2	7	WT

Requirements for Participation:
Quantum Mechanics (physik421)
Thermodynamics and Statistical Physics (physik521)

Preparation:
Elementary condensed matter physics (physik411 or similar)

Form of Testing and Examination:
Requirements for the examination (written or oral): successful work with the exercises

Length of Course:
1 semester

Aims of the Course:
Knowledge of quantum field theory of interacting many-body systems at finite temperature
Knowledge of quantum field theory for non-equilibrium systems
Ability to construct and evaluate perturbation theory using Feynman diagrams
Basic understanding of problems of open quantum systems

Contents of the Course:
Fock space and occupation-number representation for bosons and fermions (if not yet familiar)
Elementary linear response theory
Quantum field theory at finite temperature: functional integral fomulation
Green's functions: analytical properties and their relation to observable quantities
Perturbation theory in thermodynamic equilibrium: Feynman diagrams, Matsubara technique
Kondo effect and renormalization group
Quantum field theory away from thermodynamic equilibrium: Schwinger-Keldysh functional integral
Perturbation theory away from equilibrium: Keldysh technique
Open and driven-dissipative quantum systems: Lindblad formalism

Recommended Literature:
A. Kamenev, Field Theory of Non-Equilibrium Systems, 2nd edition, Cambridge University Press (2023).
G. Stefanucci, R. van Leeuwen, Nonequilibrium Many-Body Theory of Quantum Systems, A Modern Introduction, Cambridge University Press (2013).
H.-P. Breuer, F. Petruccione, The Theory of Open Quantum Systems, Oxford University Press (2002, reprinted 2010).
P. Coleman, Introduction to Many-Body Physics, Cambridge University Press (2015, reprinted 2017).