

**Module: Elective Advanced Lectures:  
Theoretical Physics**

Module No.: physics70c

**Course:**  universität**bonn**

**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 formulation  
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).