# Theoretische Festkörperphysik/ Theoretical Condensed Matter Physics

**Instructor:** H. Kroha

**Lectures:** Tue 13:15 - 14:00, Thu 09:15 - 11:00 at HS I

**Exercises:** Fri 12:15 - 14:00, AVZ 22 (with T. Langenbruch), first exercise 25.04.2008

**Certificates:** Ungraded certificates will be assigned for attaining 50% of all possible homework points. For a graded certificate an oral exam at the end of the term is necessary.

**Prerequisites:** Quantum Mecanics I and II (second quantization)

**Contents:**

1. Quantum field theory at finite temperatures
   - Green's functions, correlation functions
   - Analytical properties: Matsubara technique
   - Relation to observable quantities (linear response theory)
   - Feynman diagrams and Wick's theorem
2. Landau Fermi liquid theory
   - Concept of continuity
   - Quasiparticle concept
   - Physical consequences: Fermi liquid relations
3. Basics of collective excitations
   - Phonons
   - Plasmons
4. Superconductivity
   - Concept of spontaneous symmetry breaking (Goldstone theorem, Higgs mechanism)
   - BCS theory
   - Mesoscopic superconductivity: penetration depth, superconductor-normal metal contacts: Andreev reflection
   - superconducting contacts: Josephson effects

5. Magnetism and strong correlations
    - Quantum mechanical origin of magnetism
    - Magnetic defects in metals: Kondo effect
    - Concept of renormalization group
    - Magnetic lattice systems:
    - Types of magnetic coupling
        - Hund's rule: FM
        - exchange, superexchange, AFM
        - Dipole: FM
        - RKKY: FM, AFM
    - Models: Heisenberg, Hubbard, t-J
6. Metal-insulator transition in strongly correlated systems
    - Hubbard model
    - Dynamical mean field theory (DMFT)

**Important general concepts:**

- Continuity: Quasiparticles
- Collective phenomena of many particles
- Spontaneous symmetry breaking: Discontinuity
- Renormalization: Strong correlations out of weak interactions

**Literature:**

- W. Nolting: Grundkurs Theoretische Physik 7: Viel-Teilchen-Theorie
- A. A. Abrikosov: Fundamentals of the Theory of Metals
- G. Mahan: Many Particle Physics
- A. Altland, B. Simons: Condensed Matter Field Theory
- M. Tinkham: Introduction to Superconductivity
- J. R. Schrieffer: Theory of Superconducivity
- A. Auerbach: Magnetism
- P. Fazekas: Lecture Notes on Electron Correlations and Magnetism
- F. Gebhard: The Mott Metal-Insulator transition