Level: PhD

Course title: Methods of quantum field theory in condensed matter physics

Status: elective

ECTS: 30

Requirements: none

Learning objectives

Providing the basic knowledge in Quantum Field Theory. Introduction to the formalism of Green's functions at T=0 and at finite temperatures. The application of these methods to some particular physical problems in condensed matter physics.

Learning outcomes

After taking the course, the students should have developed:

General abilities: basic knowledge in this field, following the literature, analysis of various solutions and the choice of the most adequate solution, application in practice and other subjects, creativity.

Subject-specific abilities:

- knowledge of the basic methods of Quantum field theory used in the condensed matter physics;
- knowledge of the principles of diagrammatic techniques at T=0 and finite temperatures;
- application of the diagrammatic technique to some particular problems in condensed matter physics.

Syllabus

Theoretical instruction

Introduction (and repetition) into many particle systems, solving methods: the model of independent particles (effective potentials, selfconsistency, quasiparticles), elementary excitations. Interaction energy quanta: photons, phonons. Second quantization: bosons, fermions, interaction. Coherent states. Representations (Schroedinger, Heisenberg, interaction representation). Adiabatic hypothesis (ground state theorem in the field theory - Gell-Mann and Low). Quantum theory methods at T=0. Definition of Green's function - propagators. Vick's theorem. Basic principles of diagrammatic technique - Feynman diagrams. Vacuum fluctuations, connected and disconnected diagrams. Ground state energy. Dyson's equation, quasiparticle properties. Examples of calculation of Feynman's diagrams for particular processes. Equation of motion for Green's functions and solution methods (Hartree, Hartree-Fock). Boson Green's functions. Fermion – boson interaction. Physical systems at finite temperatures. Diagrammatic technique at finite temperatures. Temperature Green's functions. General properties. Perturbation theory. Diagrammatic technique in coordinate and momentum space – examples. Time dependent Green's functions at finite temperatures. Application to physical systems. Phonons and electrons, superfluidity, superconductivity.

Practical instruction

Weekly teaching load				Other:
Lectures: 5	Exercises:	Other forms of teaching: Seminars	Student research: 15	