

## QUANTUM MECHANICS

Course Workload		Assessment form (examination/ graded test/ ungraded test)
ECTS	Hours	
6	216	Exam

The aim of the course is the introduction to the basic concepts and theoretical methods used in the problems of modern quantum mechanics and condensed matter physics. The course is divided in two parts. In the first part, we will thoroughly study the theoretical methods of solving single-particle problems in quantum mechanics: tight-binding approximation for finding the spectrum of periodic systems such as crystals, different methods in time-dependent perturbation theory to study optical properties of quantum systems. Moreover, students will get acquainted with the concept of topology in quantum mechanics. The second part is dedicated to the basic methods of studying many-body interactions in quantum mechanics. Using the basic problems as examples, we will discuss the simplest yet effective methods of the mean field approximation, diagrammatic technique and path integrals.

### Course structure:

#### 1. SINGLE PARTICLE QM METHODS

- 1.1. Tight binding approximation. Crystall energy spectra.
- 1.2. Time-periodic perturbation. Floquet theory.
- 1.3. Topology concept in QM. Quantum Hall effects (conventional, anomalous, spin etc...).  
Topological invariants.
- 1.4. Density matrix. Pure and mixed states.
- 1.5. Time evolution pictures. Schrodinger, Heisenberg and interaction pictures. Series expansion of time evolution operator in interaction picture.
- 1.6. Linear response theory. Kubo formula. Electric and magnetic permeabilities of quantum systems.

#### 2. INTRODUCTION TO MANY-BODY PROBLEMS IN QM

- 2.1. Second quantization. Occupation number formalism. Many body wavefunction and operator representations.
- 2.2. Mean field theory. Phase transitions.
- 2.3. Basics of diagramm technique. Partial summation. HartreeFock approximation for interacting electrons and its relation to mean field. Random phase approximation.
- 2.4. Basics of path integral approaches. Harmonic oscillator on the language of path integrals. Stratonovich transformation. Anharmonic oscillator.