Topological theory in condensed matter

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ECTS credits: 3

Language of instruction: English

Examination: oral exam during tutorials

Description:

The main goal of this course is to provide an introduction to the subject of topological phenomena in condensed-matter. After an introduction to the mathematical tools, we will focus on electronic models and discuss how topology plays a major role in shaping their physical properties. We will then move to the quantum Hall effect and discuss its spectacular phenomenology, deeply rooted into topological notions, from robust edge states to fractionalised excitations, such as Majorana fermions.

Plan of the course:

PART I: Topological theory of free fermions

- Introduction: Berry phase, Dirac monopole, Aharanov-Bohm effect, Foucault pendulum

- Fermionic models I: SSH model, graphene

- Fermionic models II: Haldane model (Chern insulator), Weyl semimetals, topological insulators

- Adiabatic pumps à la Thouless

- Integer quantum Hall effect

PART II: Topological order and anyons

- Topological order and anyons: the toric code

- Majorana fermions: Kitaev chain and p-wave superfluids

- Fractional quantum Hall effect, Laughlin wavefunction and Laughlin pumping

- Anyons, the Moore-Read wavefunction and Majorana modes