Electrodynamics in Quantum Materials

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ECTS credits: 3

Language of instruction: English

Examination: Oral exam (50%) and projects (50%).

Description:

The main goal of this course is to provide an advanced view of the optical response of quantum materials. We will start from the notions acquired in the mandatory condensed matter theory course of the first semester and develop the modelling of the electronic excitation spectrum in particular for a framework adapted to materials with strongly correlated electrons. We will then provide a unified method to determine the optical conductivity and Raman responses. We will apply these concepts to concrete examples from present frontier research like high-Tc superconductors and graphene.

The main topics we will cover in this course are:

1. Linear-response theory - Kubo formulae - fluctuation-dissipation theorem
2. Causality and Kramers-Kronig relations
3. Interaction of light and crystalline matter
4. Optical conductivity and Raman spectroscopy: what is measured. Selection and sum rules.
5. Raman in an electron gas: single particle and collective modes. Effect of magnetic field.
6. Drude and extended-Drude model, Fermi liquid, effective mass and scattering rates
7. Optical conductivity and Raman in correlated materials: single-band vs multi-band effects. Examples in cuprates and iron-based superconductors and related compounds.
8. Peculiarities of Graphene: Universal Optical conductivity and Raman fingerprints of electron-phonon coupling.
9. Optical and Raman spectroscopy of broken symmetry phases: superconductivity, density waves and magnets.