CHARGE TRANSPORT, SPINTRONICS, AND TOPOLOGY OF SOLIDS

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First part:

Basics of band structure and transport phenomena in solids.

Two-dimensional structures and integer quantum Hall effect. Quantum-based standards. Novel single-layer two-dimensional materials.

Quantum wires. Conductivity and conductance. Landauer theory of quantum transport.

Relativistic effects for electrons in solids. Spin-orbit coupling, spin relaxation, spin transport.

Quantum dots. Zero-dimensional quantum systems. Spin-based solid-state qubits.

Electric dipole spins resonance. Spin qubit manipulation by electric field.

Literature:

Yoseph Imry *Introduction to Mesoscopic Physics* (Mesoscopic Physics and Nanotechnology, 2)

Igor Žutić, Jaroslav Fabian, and S. Das Sarma *Spintronics: Fundamentals and applications* Rev. Mod. Phys. **76**, 323 (2004)

Modality of the exam: continuous evaluation/homework

Slides will be provided.

Second Part:

Review of electronic structure theory: We will review the main features of band theory that we will apply for topological characterization.

Adiabatic perturbation theory.

Introduction to topology: Berry and Zak phase and the Chern theorem.

Chiral anomaly and magnetoelectric response

Literature:

D. Vanderbilt, Berry Phases in Electronic Structure Theory: Electric Polarization, Orbital Magnetization and Topological Insulators, Cambridge University Press, 2018.

S. H. Simon, The Oxford Solid State Basics, Oxford University Press