

# SEMICONDUCTOR PHYSICS, TRANSPORT AND SPINTRONICS

[Evgeny Sherman, Maia Garcia Vergniory]

## I. CHARGE TRANSPORT, SPINTRONICS

**Basics of Band Structure and Transport Phenomena in Solids.**

**Two-Dimensional Structures and Application of the 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.

### Bibliography

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

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

N.W. Ashcroft and D. Mermin, *Solid State Physics*, Saunders College, 1976.

Slides will be provided.

## II. TOPOLOGY OF SOLIDS

**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.

### Bibliography

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

Assessment by **continuous evaluation/homework**.