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Selected chapters from statistical physics and solid-state physics

The course will take place at the Institute of Electrical Engineering of SAS in room 101 in the period October 11 - October 26, 2018, each working day at time 8,30 - 12,00

Lecturer: M. Moško

The course is suitable for the PhD students in fields of physical engineering, solid state physics, microelectronics, etc. Besides the PhD students of the IEE, we invite to participate also the PhD students from other institutes of SAS, from the Comenius University, and from the Slovak Technical University. Cordially invited are also other researchers who are interested in the topic.

Information and contact: martin.mosko@savba.sk

Outline of the course content:

Statistical physics: illustration for system of spins and system of particles in box: microstate, macrostate, macrostate degeneracy, statistical postulate, two systems in thermal contact, thermal equilibrium and spontaneous deviations from equilibrium. Thermal contact between macroscopic systems, entropy, absolute temperature, direction of the energy flow, second law of thermodynamics. System in thermal contact with reservoir, canonical distribution, Curie paramagnetism, ferromagnetism, mean energy and mean pressure of the ideal gas, equation of state for ideal gas. Measurements of absolute temperature, specific heat, and entropy. Statistical physics of classical systems, classical canonical distribution, equipartition theorem, specific heat of gases and solids. Two systems in thermal and diffusion contact, conditions for thermal equilibrium and diffusion equilibrium, chemical potential, direction of the particle flow, fluctuations. System in thermal and diffusion contact with reservoir, grand-canonical distribution. Quantum ideal gases, Fermi-Dirac and Bose-Einstein distribution, Boltzmann distribution as a classical limit. Barometric formula, chemical reactions, plasma ionization. Statistics of conduction electrons in metal, Fermi energy, specific heat of degenerate electron gas, Pauli paramagnetism. Statistics of electrons and holes in intrinsic and doped semiconductors. Metal – semiconductor junction, p-n junction.

Electron transport in metals and semiconductors of macroscopic size: Resistance of macroscopic conducting sample, classical Lorentz-Drude theory, microscopic theory based on the Boltzmann transport equation in the relaxation time approzimation.

Electron transport through the tunnel junction: I-V characteristic of the metal-insulator-metal tunel junction, tunneling and thermionic emission. Coulomb blockade and single-electron tunneling in a small junction. Coulomb blockade of small double junction – Coulomb staircase, single-electron transistor.

Electron transport in mesoscopic conductors: What are the mesoscopic conductors? Conductance of ballistic conductor, fundamental conductance quantization. Resistance of mesoscopic conductor with disorder – mean resistance, giant resistance fluctuations, typical resistance.

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