MODERN PROBLEMS IN SOLID-STATE PHYSICS

Vladimir A. Kashurnikov, professor

Lecture schedule

Lecture 1. Ordinary Hall effect

Ordinary Hall effect. Applications. Cases of strong and weak field. The concept of magnetic length. The two-dimensional electron gas.

Lecture 2. Integer quantum Hall effect

Integer quantum Hall effect. Level quantization in a magnetic field (Landau sublevels).

Lecture 3. Fractional quantum Hall effect

A system of levels in the first Landau band. The concept of Laughlin liquid as a new state of two-dimensional electron gas. Excitations with fractional charge.

Lecture 4. Wigner crystallization

Theoretical and experimental studies of fractional Hall effect. Wigner crystal – Laughlin liquid phase transitions.

Lecture 5. Low-temperature superconductors

Basic experimental data and theoretical concepts.

Lecture 6. Main classes of HTSCs

Main classes of HTSCs. Features and differences from low-temperature compounds.

Lecture 7. Structure of HTSCs

Influence of pressure, radiation, impurities, external fields on HTSCs. Crystal structure.

Lecture 8. Features of electronic structure

Features of the electronic structure. Experiments. Symmetry of the superconducting order parameter, s-and d-pairing.

Lecture 9. Non-phonon mechanisms of pairing of charge carriers in HTSCs

Non-phonon mechanisms of pairing of charge carriers in HTSCs. Schrieffer's "Spin bags" and Anderson's RVB model. Multiband Emery model.

Lecture 10. Theoretical and numerical research of the HTS models

Exact diagonalization and Monte Carlo methods. Experimental observations of the Fermi surface via photoemission spectroscopy.

Lecture 11. Superfluidity of the ^{4}He isotope

Experimental data. Landau theory of superfluid Bose-liquid. Excitations. Hydrodynamics.

Lecture 12. ^{3}He isotope

The Pomeranchuk effect. Three superfluid phases. Theoretical concepts. P-pairing.

Lecture 13. Bose condensation in a gas phase

Spin-polarized hydrogen. Experiments in alkaline metals. Ultra-low cooling. Observation of Bose condensate. Three-partial recombination and the "1/6" law.

Lecture 14. Flow of liquid helium

Mott insulator – superfluid liquid phase transitions. Low-dimensional superfluidity. Problem of existence of phase transitions. Criteria.

Lecture 15. Criteria of phase transitions

Features of a one-dimensional case. The concept of renormalization group. Theoretical research of critical points within the bosonic Hubbard model.