Aleksander Wittlin, Superconductivity

Begin of the course: March 15, 2024; end: June 24 2024

The course is prepared for students of the International PhD Studies at the Institute of Physics of the Polish Academy of Science.

After completing the course, the participants should understand fundamental concepts, theories, experimental techniques

and the state of the art of research in the field of superconductivity. They should be able to undertake studies of superconductivity and of

superconducting materials.

1. Introduction and historical overview part I: fundamental phenomena, early models.

2. Introduction part II: Superconducting elements,phase diagrams, phenomenological models.

3. Electrodynamics of superconductors part I: Model by Londons, the critical current, Meissner-Ochsenfeld effect

4. Electrodynamics of superconductors part II, some mathematical preliminaries,high frequency phenomena, the sum rule.

5. Superconductors in magnetic field, superconductors of the I and the II type,flux quantization, vortex matter etc.

6. Ginzburg-Landau theory.

7. Elements of the BCS theory, order parameter, physical interpretation of the Ginzburg-Landau $\psi(x)$ function.

8. Experimental confirmations of the BCS theory, superconducting gap.

9. Josephson effect, SQUID magnetometers, quantum detectors, quantum gates etc.

10.Superconductivity in low-dimensional structures. The Kosterlitz-Thouless transition, introduction to topological superconductors.

11.Experimental techniques of studies of the superconductivity, part I, general techniques

12.Experimental techniques of studies of the superconductivity, part II, spectroscopy and other advanced techniques

13.High Tc superconductivity, the discovery, present landscape of research and of applications.

14.Critics of the BCS theory and modern state of the art of the theory of the high Tc superconductivity.

15.Current research, modern and exotic superconducting materials, results and challenges.

Literature

(*textbooks, **general):

**AA. Abrikosov, Introduction to the Theory of Normal Metals, Academic Press

*S. Blundell, Superconductivity : A Very Short Introduction, Oxford University Press

*M. Cyrot, D. Pavuna, Introduction to Superconductivity and High-Tc Materials

**RP.Feynman, Statistical Mechanics, W. A. Benjamin

**E. Fradkin, Field theories of condensed matter physics, Cambridge University Press

**P-G de Gennes, Superconductivity of Metals and Alloys / P.G. de Gennes, W.A. Benjamin

**B Ketterson & SN Song, Superconductivity, Cambridge University Press

*CP Poole, HA Farach RJ Creswick.Superconductivity Academic Press

*JR Schrieffer, Theory of Superconductivity, W.A. Benjamin

*M. Tinkham, Introduction to Superconductivity: Second Edition

(textbooks, general):

S. Blundell, Superconductivity : A Very Short Introduction, Oxford University Press

M. Cyrot, D. Pavuna, Introduction to Superconductivity and High-Tc Materials

E. Fradkin, Field theories of condensed matter physics, Cambridge University Press

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(articles, review articles, etc.)

A list will be given at lectures