UNIVERSITY OF GOTHENBURG

FACULTY OF SCIENCE

FIM670, Superconductivity and low-temperature physics, 7,5 higher education credits

Supraledning och lågtemperaturfysik, 7.5 högskolepoäng

Second Cycle

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1. Confirmation

The course syllabus was confirmed by Department of Physics on 2012-02-16 to be valid from 2012-01-02.

Field of education: Science 100 %
Department: Physics

2. Position in the educational system

The course is an elective course within the Masters Programme of Physics of Materials and Biological Systems. It can also be given as a freestanding advanced course at the University of Gothenburg.

Main field of studies	*Specialization*
Physics	A1N, Second cycle, has only first-cycle course/s as entry requirements

3. Entry requirements

To be eligible for the course, the student needs knowledge in mathematics and physics equivalent to a Bachelor degree. The student should also have completed a basic course in quantum mechanics and a basic course in solid state physics/electronics.

Applicants must prove knowledge of English: TOEFL test result of at least 600 points (computerized 250 points, on Internet 100 points) or IELTS test result of at least 6.0, including at least 6.5 for the Writing. This requirement does not apply to students with a Bachelor degree from an English speaking university, or to students having passed English level B at Swedish/Nordic Upper Secondary School.

4. Course content

The course may be considered as an application of courses in quantum physics, solid state physics, electrodynamics and thermodynamics.

The course has three parts:

SUPERCONDUCTIVITY

- •Basic properties of superconductors, thermodynamics, superconductors in magnetic fields
- •The London equations, electromagnetic properties, penetration depth
- •Ginzburg-Landau theory, coherence length, type I and type II superconductors
- •BCS theory, second quantization, Cooper-pairing, energy gap
- •Tunneling, Josephson effects and SIS tunneling
- •High Tc superconductors, structure, d-wave symmetry, phase diagram
- •Overview of applications, squids, microwave devices, power applications

SUPERFLUIDITY

- •Properties of liquid helium-4, the phase diagram, superfluidity
- •Superfluid phenomena, rollin film, fountain effect, second sound
- •Exitations and vortecies in superfluids
- •Properties of liquid helium-3, the phase diagram, superfluidity
- •Symmetry properties of superfluid helium-3

CRYOGENICS

- •Themal and electrical properties for different materials at low temperature
- •Cooling methods above 1K, Joule-Tomphson, Gifford-McMahon, evaporation cooling
- •Liquefication of helium
- •Cooling methods below 1K, dilution refrigeration, adiabatic demagnetisation, Pomerantchuck cooling

5. Learning outcomes

After completion of the course the student should be able to:

- •Explain the basic properties of both high Tc and low Tc superconductors.
- •Apply Londons equations to superconductors to explain their electromagnetic properties.
- •Describe thermodynamic properties of superconductors with the help of Ginzburg-Landau theory describe different lengthscales such as the penetration depth and the coherence length, and explain the differences between type I and type II superconductors.
- •Account for the basic ideas of the BCS theory, like Cooper-pairing, energy gap and the density of states for exitations.
- •Describe the phase diagrams for both helium-3 and helium-4.
- •Describe how Bose-Einstein condensation comes about.
- •Describe superfluid phenomena such as, rollin film, the fountain effect and second sound.
- •Describe different cooling methods which are used both above and below 1 kelvin.
- •Explain physical properties of different materials at low temperature.

6. Literature

See separate literature list.

7. Assessment

The course embraces lectures (about 30 hours), two laborations (Josephson effect, and superfluid helium) and home exercises. The laborations are compulsory.

The course ends with a written exam.

8. Grading scale

The grading scale comprises Fail (U), Pass (G), Pass with Distinction (VG).

To obtain ECTS grades, the person responsible for the course should be notified within one week of the beginning of the course.

9. Course evaluation

The results of the evaluation will be communicated to the students and will function as a guide for the development of the course.

10. Additional information

Language of instruction: English.

The course is given jointly with Chalmers University of Technology. The Chalmers code for the course is FMI036.