

# SK2905 Superconductivity and other quantum liquids, 7.5 credits

## Autumn 2021

### Introduction

The main part of this course will cover fundamental theoretical models and applications of superconductivity. Towards the end of the course, it will also cover a module on other quantum liquids (like superfluid He) and quantum gases (like Bose-Einstein condensates).

The first three modules on superconductivity in this course is also part of the PhD course FSK2759 Superconductivity and its applications.

### Intended learning outcomes

After finished course, the student should be able to:

- apply basic theory and concepts of superconductivity (1)
- analyze and evaluate superconducting applications (2)
- apply basic concepts for other quantum liquids (3)

### Course content

Physical properties of superconductors, London theory, vortices in type-II superconductors, vortex dynamics, Bean's model, Josephson junctions, quantum interference, SQUID, Ginzburg-Landau theory, BCS theory, applications of superconductivity, introduction to other types of quantum fluids (superfluid helium and Bose-Einstein condensates)

### Examination

The examination in the course consists officially of two parts – a written exam (TEN1) and hand-in assignments (INL1). A minimum grade of E is required on each part to obtain a final degree in the course.

#### Written exam, 4.5 credits (TEN1)

The written exam is this academic year replaced with an oral exam at the end of the course. To qualify for the oral exam, you must have passed a continuous examination during the course, which consists of a combination of quizzes, individual hand-in problems and group hand-in problems. This part examines mainly learning outcome 1 but also part of learning outcome 3.

#### 1. Quizzes in Canvas

The course is divided into 4 modules (three modules on superconductivity and one module on other quantum liquids and gases). After each module, there will be a quiz in Canvas on the fundamental knowledge in the module.

To be eligible for the oral exam, at least 80% correct answers on each quiz is required.

#### 2. Individual hand-in problems

These problems are all on grade E level and they should be solved individually and handed in digitally to Canvas.

To be eligible for the oral exam, at least 6 out of 7 problems have to be solved.

#### 3. Group hand-in problems

After each module, there are a number of problems which should be handed in as a group assignment based on concurrent engineering principles. This means that first, each of you should make an individual attempt to solve the problem and then the study group should meet

and make a self-assessment of the suggested solutions. The self-assessed solution of each problem is then handed in to Canvas together with an assessment from the other group members, specifying if each individual group member had made a serious attempt to solve a problem or not before the meeting. The number of correctly solved problems and the number of serious attempts will affect the highest possible grade that a student can obtain during the oral exam.

To be eligible for grade E on the oral exam, a serious attempt on  $\geq 8$  problems is required.

To be eligible for grade D on the oral exam, a serious attempt on  $\geq 8$  problems and correct solutions to at least 10 group problems are required.

To be eligible for grade C on the oral exam, a serious attempt on  $\geq 10$  problems and correct solutions to at least 12 group problems are required.

To be eligible for grade B on the oral exam, a serious attempt on  $\geq 12$  problems and correct solutions to at least 14 group problems are required.

To be eligible for grade A on the oral exam, a serious attempt on  $\geq 14$  problems and correct solutions to at least 15 group problems are required.

**The total number of problems is 17. If a single student makes a considerably larger contribution to solving the group problems than other students in the group, the examiner can decide to test that student for a one step higher grade than specified in this table.**

### Oral exam

At the end of the course, there will be an individual oral examination and at this exam, you cannot ask for a higher grade than you have been qualified to be tested for. You register for the oral exam in Canvas. The time slots are 30 minutes, but the examination is in most cases expected to take about 15 minutes.

When you arrive to the oral exam, you will be asked to first state for which grade you want to be examined for. To pass the grade level you have chosen, you must be able to:

- i) Make one theoretical proof at your grade level. The proof is randomly chosen from the list of proofs specified for your grade level.
- ii) Explain and reflect about four randomly chosen problems that you have handed in during the course. This includes both the individual and the group hand-in problems. The problems can either be at your grade level or at a lower grade level. You must bring a printout of your handed-in solutions to this examination, since that printout will be the starting point for the discussions.

Students asking for grade B are allowed to beforehand specify 3 grade A questions, which will be excluded from the examination.

Students asking for grade D are allowed to beforehand specify 3 grade C questions, which will be excluded from the examination.

### *Grading criteria on the oral exam TEN1*

**Pass all 5 questions on the oral exam:** You get the grade you asked for.

**Pass 4 out of 5 questions on the oral exam:** You get one step lower grade than you asked for.

**Miss 2 questions (or more) on the oral exam:** You have failed the exam.

Each student has the right for one oral re-examination in the course. The date can earliest be on January 31 and latest be on April 8, 2022. The actual date and time for an oral re-exam is decided on an individual basis between the examiner and the student.

### Hand-in assignments, 3.0 credits (INL1)

There are two hand-in assignments in the course – the first one is a group hand-in work that examines learning outcome (2) and the second one is an individual hand-in work that examines learning outcome (3).

#### Part A – group hand-in work to evaluate a superconducting application

You will make a group evaluation of a suggested superconducting applications, which should result in a written report (2-3 pages) where the group argue whether or not it is reasonable for a company or an organization to engage in developing or using the application. The evaluation must include two parts:

- A correct technical evaluation about how superconductors can be used for the suggested application including both advantages and disadvantages.
- A correct societal analysis of the use of the suggested application, considering the following parts: competing technologies, environmental, health, safety and economical aspects. Details are not required, but important factors should be found and the argumentation must be correct.

#### Part B – individual hand-in work to describe one detailed aspect of another quantum liquids

You will individually search for and find material about one specific aspect of a non-superconductor quantum liquid or quantum gas. This work should be reported in a short written review (2-3 pages) where you explain the phenomena in a pedagogic way.

#### *Grading criteria on INL1*

Each report is assessed on a 10 point scale, where the assessment starts from 10 points and deductions of points are made for each error according to the following scheme:

- Incorrect or misleading arguments: - 5p
- Missing vital information: - 3p
- Missing or misleading references: -3p
- Unstructured report: - 2p
- Missing important information: - 2p
- Unstructured argumentation: - 2 p
- Missing conclusions: - 2p
- Incorrect references or missing vital references: -2p
- Missing useful information: - 1p
- Repeated syntax, spelling or layout errors: - 1p
- Repeated misses in presentation of tables, figures or data: - 1p
- Repeated mistakes in reference list: -1p
- Minor syntax, spelling or layout errors: - 0.5p
- Misses in presentation of tables, figures or data: - 0.5p
- Minor mistake in reference list: -0.5p

The grading is based on the total number of points on the two reports.

Grade A: Minimum 19 points

Grade B: 18-18.5 points

Grade C: 16-17.5 points

Grade D: 15-15.5 points

Grade E: 14-14.5 points

Grade FX: 13-13.5 points

Grade F: Less than 13 points

### Final grading

The final grading in the course is given according to the following table:

TEN1 grade	INL1 grade	Final grade		TEN1 grade	INL1 grade	Final grade		TEN1 grade	INL1 grade	Final grade
A	A,B	A		B	D,E	C		D	B,C	C
A	C,D	B		C	A,B	B		D	D,E	D
A	E	C		C	C,D	C		E	A	C
B	A	A		C	E	D		E	B,C	D
B	B,C	B		D	A	B		E	D,E	E

### Textbook and course material

M. Andersson, "Introduction to applied superconductivity", compendia, KTH (can be downloaded in parts from Canvas).

Other material made available through Canvas.

### Teacher

Examiner and course responsible teacher: Magnus Andersson, [magnusan@kth.se](mailto:magnusan@kth.se)

### Course management

All relevant information about this year's course can be found in the KTH Learning Management System (Canvas).

For administrative issues, please contact the course expedition at Albanova: [kursexp@physics.kth.se](mailto:kursexp@physics.kth.se)