Universidad Zaragoza

Academic Year/course: 2022/23

60031 - Low temperature physics and quantum technologies

Syllabus Information

Academic Year: 2022/23
Subject: 60031 - Low temperature physics and quantum technologies
Faculty / School: 100 - Facultad de Ciencias
Degree: 538 - Master's in Physics and Physical Technologies
589 - Master's in Physics and Physical Technologies
ECTS: 5.0
Year: 1
Semester: Second semester
Subject Type: Optional
Module:

1. General information

1.1. Aims of the course

The last two decades have witnessed a renewed interest on phenomena related to the quantum nature of matter that occur almost exclusively in the region of low temperatures. These phenomena also form the conceptual basis for the development of new technologies implying promising applications in many different areas. The course describes the phenomena and experimental techniques associated with the low temperature region, emphasizing the emergence of quantum phenomena, their influence on the properties of materials and their possible applications.

These aims are in agreement with the following Sustainable Development Goals (SDG) from United Nations (https://www.un.org/sustainabledevelopment/) :

- Goal 3 (Good HEalth and well-being).
- Goal 4 (Quality education).
- Goal 9 (Industry, innovation and infrastructure).

2. Learning goals

3. Assessment (1st and 2nd call)

3.1. Assessment tasks (description of tasks, marking system and assessment criteria)

1. A continuous evaluation is carried out throughout the entire course. It takes into account the personal work of the students, reflected in the responses they give to questionnaires devoted to each of the topics covered in the subject. This evaluation amounts to 75% of the final grade.
2. While the laboratory classes are held, a regular assessment of the practical skills acquired by the students is made which takes also into account the students? attitude during these classes. This section amounts to 10% of the final grade. The remaining 15% will reflect the analysis and description of the experimental results in written reports.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The methodology followed in this course is oriented towards achievement of the learning objectives. It favors the acquisition of theoretical and experimental knowledge in the field of low-temperature physics and quantum technologies. To achieve these objectives, activities that promote an active and continued involvement of students in the different course topics have been programmed.

The course consists of three learning activities: lectures on the contents of the course (4 ECTS); class discussion and problem solving (0.4 ECTS); laboratory work and reporting on such work (0.6 ECTS). These activities help the students learn the course contents and give them competences in handling low temperature physical techniques and in problem-solving.

4.2. Learning tasks

The course includes the following learning tasks:

- Lectures. The syllabus is detailed in Section 5.3.
- Low temperatures laboratory. It includes lectures on highly practical aspects such as cooling techniques, thermometry, thermal contact and insulation, etc. In addition, there will be three practice sessions on
    1. From room temperature to mK.
    2. Use of a SQUID
    3. Experiments on quantum circuits
- Student autonomous work to solve questionnaires about the course contents and to discuss them with the teacher and with other students during the evaluation sessions.

The teaching and assessment activities will be carried out in person unless, due to the health situation, the provisions issued by the competent authorities and by the University of Zaragoza arrange to carry them out on-line.

4.3. Syllabus

The course will address the following topics:

Topic I. Introduction

- Early evolution of low-temperature physics and its methods

Topic II. Superconductivity

- General concepts and theoretical models, Josephson effect and circuits based on superconducting Josephson junctions, applications of superconductivity

Topic III. Quantum gases and quantum liquids

- Laser cooling techniques, cold atoms and trapped ions, Bose-Einstein condensates in dilute gases, superfluidity

Topic IV. Quantum Technologies

- Introduction, ions, atoms and spins as realizations of qubits, superconducting quantum circuits, light-matter interaction in a chip, decoherence and dissipation, computing and quantum information, quantum simulation

4.4. Course planning and calendar

Further information concerning the timetable, classroom, assessment dates and other details regarding this course, will be provided on the first day of class or please refer to the Faculty of Science http://ciencias.unizar.es/

4.5. Bibliography and recommended resources

http://biblos.unizar.es/br/br_citas.php?codigo=60031&year=2019