Universidad Zaragoza

Academic Year/course: 2024/25

60031 - Low temperature physics and quantum technologies

Syllabus Information

Academic year: 2024/25
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

The subject Low Temperature Physics and Quantum Technologies is suitable for any student interested in learning about fascinating physical phenomena, such as superconductivity, superfluidity and Bose-Einstein condensation, the properties of cryogenic liquids and materials at low temperatures, and quantum information concepts. The objective is to help students to become familiar with theoretical concepts and experimental techniques in this modern area of research. It is especially recommended for students with a previous background in quantum physics, statistical physics and solid-state physics. Students are expected to attend lectures during the entire term and it is recommended that they take the first semester subject Quantum Theory of Condensed Matter.

2. Learning results

- To describe the fundamentals of physical phenomena and properties of materials characteristic of the low temperature region.
- To describe the physical fundamentals of quantum technologies.
- To solve specific problems related to these phenomena.
- To design and conduct experiments to measure the physical properties (electrical and magnetic) of materials at low and very low temperatures, interpret and present the results.

3. Syllabus

Theory:

- Early evolution of low-temperature physics
- Gases and quantum liquids (laser cooling techniques, trapped cold atoms and ions, Bose-Einstein condensates in dilute gases, superfluidity).
- Superconductivity (general notions and theoretical models, Josephson effect and superconducting circuits based on Josephson junctions, applications of superconductivity).
- Quantum technologies (introduction, ions, atoms and spins as qubit realizations, superconducting quantum circuits, light-matter interaction on a chip, decoherence and dissipation, quantum computing and information, quantum simulation).

Low temperature physics laboratory:

- Properties of matter at low temperatures
- Contact and thermal insulation
- Refrigeration techniques up to temperatures of the order of mK
- Thermometry
- Operation of a SQUID sensor
- Measurement of a quantum circuit.

4. Academic activities

To achieve the results, three learning activities have been programmed: theoretical classes on the contents of the subject (4 ECTS); discussion and problem-solving classes (0.4 ECTS); explanation and work in the laboratory and preparation of reports on this work (0.6 ECTS).

5. Assessment system

The continuous assessment of the student throughout the term will take into account the degree of personal work of the student,

reflected in the resolution of problem questionnaires on the different topics related to the subject. The assessment will take into account the quality of the solutions and will account for 75% of the final grade.

During the practical classes there will be a continuous assessment of the student's work and acquisition of skills in laboratory techniques. This section will account for 10% of the final grade. The remaining 15% will reflect the analysis of the experimental results through the preparation of written reports.

The assessment by means of a single global test will consist of the solving of a questionnaire consisting of two parts:

- Seven questions related to the concepts of the subject (3 hours). This part will be assessed with a grade from 0 to 10, and will represent 75% of the final grade.
- Practical exercise in which the student must describe the elements and the experimental setup necessary to measure a given physical property at low temperature. This part will be assessed with a grade from 0 to 10, and will represent 25% of the final grade.

6. Sustainable Development Goals

3 - Good Health & Well-Being
7 - Affordable and Clean Energy
9 - Industry, Innovation and Infrastructure