Universidad Zaragoza

Academic Year/course: 2024/25

60042 - Quantum theory of condensed matter

Syllabus Information

Academic year: 2024/25
Subject: 60042 - Quantum theory of condensed matter
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: First semester
Subject type: Optional
Module:

1. General information

The subject describes the behaviour of condensed matter from the point of view of quantum mechanics, focusing on the formulation of quantum field theory for many-body systems. It is recommended for students with a previous background in quantum physics and statistical physics. This subject is related to low temperature physics and quantum technologies (second semester).

The subject quantum theory of condensed matter can be recommended to any student interested in the behaviour of matter, especially when matter is composed of strongly interacting particles. The subject discusses the physics of electrons in metals, superconductivity and superfluidity, low-dimensionality systems such as graphene and carbon nanotubes, and other strongly correlated systems.

2. Learning results

- To analyse and compare different quantum models of matter.
- To describe the vibrational properties of molecules and solids.
- To estimate electronic properties of molecules and solids.
- To calculate electronic structures of molecules

3. Syllabus

The topics to be covered in the subject are:

1. Introduction: problems in the treatment of many-body physics. From particles to fields. Quasiparticles.
2. The second quantification. Fock's space.
3. Systems of interacting fermions: metals. Fermi gas, Fermi liquid, shielding and the
random phase approximation. Wigner crystal.
4. Boson systems. Bose-Einstein condensation: ideal gas of bosons and bosons with weak interaction.
Microscopic theories of superconductivity and superfluidity.
5. Low dimensional systems. Graphene. One-dimensional interacting systems: Luttinger liquid.
6. Linear response theory: correlation functions.

4. Academic activities

The subject is based on a series of lectures on the topics listed in the syllabus and also on the personal work of the students (mainly in the expansion of their knowledge through the study of the selected texts and the solving of the proposed exercises). As far as possible, these classes may be complemented by seminars given by renowned researchers in the field.

The program offers the students help to achieve the expected results and comprises the following activities:

activities:

-Lectures on the main topics of the subject.

-Problem solving related to the contents of the subject.

-Knowledge and use of computer tools in the field of the subject.

5. Assessment system

The student must demonstrate that they has achieved the expected learning results by means of the following assessment activities:

1) The assessment will be based (up to a maximum of 75%) on the solving of a series of proposed problems (theoretical and/or computational) related to the subject and/or the exposition of topics related to the subject proposed by the faculty. The remaining percentage of the grade will be based on the result of the completion of a theoretical-practical test.

2) Passing the subject by means of a single global test.

The subject has been designed primarily for students attending classes. However, there will also be an assessment test for students who are unable to attend classes or who fail their first assessment.

The test will consist of a questionnaire with theory and exercises on the topics covered during the term.

6. Sustainable Development Goals

4 - Quality Education
9 - Industry, Innovation and Infrastructure