Universidad Zaragoza

Academic Year/course: 2022/23

60035 - Statistical physics of critical phenomena and complex systems

Syllabus Information

Academic Year: 2022/23
Subject: 60035 - Statistical physics of critical phenomena and complex systems
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 spectacular success of microscopic physics should not conceal from students the importance of macroscopic physics, a field that remains very much alive. In this regard, Statistical Physics constitutes an essential part of our understanding of Nature, thus a fundamental subject in the background of physics education. It bridges the gap between the microscopic description of matter and fields and their macroscopic behavior. Phase changes of matter, namely transitions between dramatically different robust regimes of equilibrium macroscopic states, are accurate examples of general system crisis. Its importance relies not as much on the fact that its description and concomitant understanding focused on an unprecedented mathematical and theoretical physics research effort (decades long), as on the generality and insightfulness of the far-reaching results achieved.

This is an advanced course on Statistical Physics, with a particular focus on Phase Transitions and Critical Phenomena, as well as on Interdisciplinary Physics of Complex Systems. Although the content is largely theoretical, the course is designed so as to attract both, experimenters and theoreticians. It is highly recommended that students have a reasonably good previous background in Quantum Physics, Thermodynamics and Statistical Physics.

These aims are in agreement with the following Sustainable Development Goals (SDG) form United Nations (https://www.un.org/sustainabledevelopment/) : Goal 4 Quality education.

2. Learning goals

3. Assessment (1st and 2nd call)

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

Continuous assessment of student learning by solving problems, questions and other activities proposed by the teaching staff of the subject. This activity will account for 50% of the final grade.

Realization of a theoretical-practical test throughout the course 20%.

Continuous evaluation of the acquisition of skills in developments analytical and computational techniques through the elaboration of a work of course 30%.

Passing the subject through a single global test.

Although the course is designed for students who can attend the lectures in person, there will be an exam on theoretical questions and exercises for students unable to attend, which can also be taken by those who do not pass the previous evaluation activities.

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 development of research competences. A wide range of teaching and learning tasks are implemented, such as lectures, study, oral presentations, discussions, exercises, and projects.

4.2. Learning tasks

The course includes the following learning tasks:

- Lectures on the main topics of the course (3 ECTS)
- Practice sessions where students solve, individually or in groups, exercises and problem sets (1.2 ECTS)
- Study, oral presentation and class discussion, of selected research articles (0.8 ECTS).

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:

1. Introduction to phase transitions. Basic concepts
2. Review of Thermodynamics and Statistical Mechanics.
3. Phase diagrams and phase transitions
4. Thermodynamics of Phase Transitions
5. Mean Field Theories
6. Critical phenomena
7. Landau-Ginzburg theory
8. Statistical Models for Phase Transitions
9. Scaling and Universality: renormalization group
10. Emerging topics in phase transitions of Condensed Matter Physics: magnetocaloric materials, multiferroics, liquid crystals, topological phase transitions, quantum phase transitions, ?
11. Interdisciplinary Complex Systems: phase transitions in network theory, epidemics, synchronization, population dynamics, models of social interaction, evolutionary dynamics of games.

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=60035&year=2019