60035 - Statistical physics of critical phenomena and complex systems

Información del Plan Docente

Academic Year	2016/17
Academic center	100 - Facultad de Ciencias
Degree	538 - Master's in Physics and Physical Technologies
ECTS	5.0
Course	1
Period	Second semester
Subject Type	Optional
Module	---

1.Basic info

1.1.Recommendations to take this course

1.2.Activities and key dates for the course

2.Initiation

2.1.Learning outcomes that define the subject

2.2.Introduction

3.Context and competences

3.1.Goals

3.2.Context and meaning of the subject in the degree

3.3.Competences

3.4.Importance of learning outcomes

4.Evaluation

5.Activities and resources

5.1.General methodological presentation

Mainly aimed at training future researchers, students will attend lecture classes and study and present in public (with group discussion) selected research articles in order to acquire the necessary knowledge of the contents of the subject (3 ECTS). They will also solve exercises (both personally and in group) related to the contents of the subject (1.2 ECTS). They will carry out a thematic work throughout the course (0.8 ECTS).

5.2.Learning activities

- Lectures on the main topics of the course

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- Interactive troubleshooting sessions.
- Personal work (and / or group) of the students in the resolution of exercises.
- Study, oral presentation, and group discussion of selected research articles.

5.3.Program

1. Introduction. Some examples and phenomenology. Basic concepts: Order parameter, critical exponents, fluctuations, scaling and universality.
2. Review of Statistical Physics and Thermodynamics with an emphasis on fluctuations and correlation functions. Spontaneous symmetry breaking. Metastability.
3. Models: Percolation, Ising, XY, Heisenberg, Potts, Gaussian, Spherical. Transfer matrix. Exact solutions. Numerical methods.
4. Mean field theory: Ising, percolation, non-ideal gas. Variational derivation. Correlation functions. Critical exponents. Landau theory. Saddle-point approximation to the Landau-Ginzburg model.
5. The Landau-Ginzburg model. Spontaneous continuous symmetry breaking and Goldstaone modes. Spontaneous discrete symmetry breaking and domain walls. Scattering experiments and fluctuations. Correlation functions and susceptibilities. Lower critical dimension. Fluctuations corrections to saddle-point approximation. Upper critical dimensions and Ginzburg criterion.
6. Percolation: 1d, Bethe lattice, 2d, scaling hypothesis, scaling relations, geometric properties of clusters, critical exponents. Real space renormalization.
7. Scaling hypothesis. Widom formulation. Correlation length and hyperscaling hypothesis. Critical correlation functions and self-similarity.
8. Renormalization. Conceptual presentation (Kadanoff). Formalization (Wilson). Direct solution and renormalization approach to the Gaussian model. Epsilon (4-d) expansions. RG schemes in lattices (decimation, Migdal-Kadanoff, Niemeijer and Van Leeuwen cumulant expansions).
9. Dynamical models in critical phenomena.. Criticality in stationary non-equilibrium states: self-organized criticality and its applications to Natural Sciences.
10. Interdisciplinary Complex Systems. Phase transitions in Network theory, Breaking of KAM tori, epidemies, synchronization, population dynamics, models of social interactions, evolutionary game theory.

5.4.Planning and scheduling

The final schedule has to be done. It was announced well in advance.

5.5.Bibliography and recomended resources