Subject identification

Subject	11292 - Cooperative and Critical Phenomena
Credits	1.5 de presencials (37.5 hours) 4.5 de no presencials (112.5 hours) 6 de totals (150 hours).
Group	Group 1, 1S (Campus Extens)
Teaching period	First semester
Teaching language	English

Professors

Lecturers	Horari d'atenció als alumnes					
	Starting time	**Finishing time**	**Day**	**Start date**	**Finish date**	**Office**
Emilio Hernandez Garcia ehg899@uib.es	10:00	11:00	Tuesday	01/10/2015	31/07/2016	IFISC-214 (confirmar por email)
Maximino San Miguel Ruibal msr260@uib.es	You need to book a date with the professor in order to attend a tutorial.					
Tomás Miguel Sintes Olives tomas.sintes@uib.es	12:30	13:30	Monday	14/09/2015	25/07/2016	207 (Edifici Instituts Universitaris Recerca)

Contextualisation

The aim of this subject is to train potential researchers in the study of phase transitions, critical phenomena, kineticlattice models andnonequilibrium growth processesby using the tools and methodologies of statistical physics and nonlinear dynamics.

Chapters 1,3 and 4: Prof. Emilio Hernández-García is a Dr. inPhysics. His main research lines focus in the study of complex systems with a wide theoretical background in statistical mechanics and dynamical systems. He is a well recognized scientist due to his contributions to stochastic processes, the study of non-equilibrium phase transitions,pattern formation and in complex networks. Presently, he is the deputy director of the IFISC.

Chapters 2 and 5: Prof. M. San Miguel is a Dr. in Physics and an international well recognized scientist due to his large number of contributions in different fields, particularly in the context of phase transitions and critical phenomena. Presently, he is the director of the IFISC.

Chapters 6-10: Prof. T. Sintes is a Dr. en Physics with a broad experience in the study of growth processes out of equilibrium, aggregation and gelation in colloidal and polymer systems, the behavior of polyelectrolites and magnetic filaments.

Requirements

Recommendable

It is highly recommended that students have taken statistical physics courses during their undergraduate studies.

Skills

Specific

* To understand the critical and cooperative phenomena from the perspective of cross-disciplinary physics and complex systems (E4).
* To understand the meaning of concepts like scaling laws, and to apply the techniques of the renormalization group (E5).
* To know the main concepts of non equilibrium statistical physics, including reticular models and growth (E7).
* To understand the main concepts and techniques of complex networks (E15).
* To understand the basic concepts of the classic and quantic information theory: Shanon entropy, complexity, colectivities, quantum entanglement (E18).

Generic

* To acquire the capacity to develop a complete research plan covering from the bibliographic research and strategy to the conclusions (TG2).
* To write and describe rigoroulsy the research process and present the conclusions to an expert audience (TG3).
* To acquire high power computation skills and advanced numerical methods capabilities in applications to problems in the contex of complex systems (TG6).

Basic

* You may consult the basic competencies students will have to achieve by the end of the Master's degree at the following address: http://estudis.uib.cat/master/comp_basiques/

Content

Theme content

Chapter 1. Introduction to phase transitions and critical phenomena

Chapter 2. Lattice models and universality classes

Chapter 3. The mean field approach. The Landau theory. The hamiltonian of Ginzburg-Landau

Chapter 4. Scale Invariance and the renormalization group

Chapter 5. Kinetic Ising models

Chapter 6. Numerical study of the Ising model in 2d

Chapter 7. Non equilibrium growth models.

Chapter 8. Percolation theory

Chapter 9. Surface growth and the KPZ equation

Chapter 10. Emergence of collective behaviour. Flocking, swarming and herd behaviour.

Teaching methodology

In-class work activities

Modality	Name	Typ. Grp.	Description	Hours
Theory classes	Theoretical Lectures	Large group (G)	The students will acquire the knowledge and methodologies to understand the basic concepts in the study of cooperative and critical phenomena.	37.5

At the beginning of the semester a schedule of the subject will be made available to students through the UIBdigital platform. The schedule shall at least include the dates when the continuing assessment tests will be conducted and the hand-in dates for the assignments. In addition, the lecturer shall inform students as to whether the subject work plan will be carried out through the schedule or through another way included in the Campus Extens platform.

Distance education work activities

Modality	Name	Description	Hours
Group or individual self-study	Autonomous work	The students will apply the concepts and techniques learned during the lectures to solve a collection of specific theoretical problems proposed by the professor. This task will enforce the understanding of this subject.	45
Group or individual self-study	Autonomous work	The students will apply the concepts and techniques learned during the lectures to solve numerically a specific problem related to phase transition and critical phenomena (i.e. the 2d Ising model). The students will present the results obtained in a rigorous way and will be evaluated.	28
Group or individual self-study	Autonomous work	The students will practice the concepts and techniques learned during the lectures to numerically solve a specific problem related to growth processes out of equilibrium. Additional bibliography, such as, scientific journals, will be provided in order to enhance the student hability to follow the scientific language.The students will present the results obtained in a rigorous way and will be evaluated.	39.5

Specific risks and protective measures

The learning activities of this course do not entail specific health or safety risks for the students and therefore no special protective measures are needed.

Student learning assessment

Autonomous work

Modality	Group or individual self-study
Technique	Papers and projects **(non-retrievable)**
Description	The students will apply the concepts and techniques learned during the lectures to solve a collection of specific theoretical problems proposed by the professor. This task will enforce the understanding of this subject.
Assessment criteria	The students must solve acollection of specific problems related to the content of this subject and will be evaluated accordingly.

Final grade percentage: 40%

Autonomous work

Modality	Group or individual self-study
Technique	Papers and projects **(non-retrievable)**
Description	The students will apply the concepts and techniques learned during the lectures to solve numerically a specific problem related to phase transition and critical phenomena (i.e. the 2d Ising model). The students will present the results obtained in a rigorous way and will be evaluated.
Assessment criteria	Public presentation of the results of a selected project on phase transitions and critical phenomena (i.e. the 2d Ising model).

Final grade percentage: 25%

Autonomous work

Modality	Group or individual self-study
Technique	Papers and projects **(non-retrievable)**
Description	The students will practice the concepts and techniques learned during the lectures to numerically solve a specific problem related to growth processes out of equilibrium. Additional bibliography, such as, scientific journals, will be provided in order to enhance the student hability to follow the scientific language.The students will present the results obtained in a rigorous way and will be evaluated.
Assessment criteria	Public presentation of the results of a selected project in out of equilibrium growth processes.

Final grade percentage: 35%

Resources, bibliography and additional documentation

Basic bibliography

1. J. M. Yeomans, "Statistical Mechanics of Phase Transitions". Oxford Sci. Pub (2002).
2. P. M. Chaikin and T. C. Lubensky, "Principles of Condensed Matter Physics". Cambridge Univ. Press (2000)
3. E. Stanley, "Introduction to Phase Transitions and Critical Phenomena". Oxford Sci. Pub (1987)
4. P. Meakin, " Fractals, scaling and growth far from equilibrium". Cambridge University Press, (1998).

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