Subject identification

Subject	11016 - Quantum transport and quantum noise
Credits	1.2 in-class (30 hours) 1.8 distance (45 hours) 3 totals (75 hours).
Group	Group 1, 2S
Teaching period	2nd semester
Teaching language	English

Lecturers

Lecturers	**Timetable for student attention**					
	Starting time	**Finishing time**	**Day**	**Start date**	**Finish date**	**Office**
David Sánchez Martín david.sanchez@uib.es	There are no defined sessions					

Degrees where the subject is taught

Degree	**Character**	**Academic year**	**Studies**
Master's Degree in Physics of Complex Systems	Optional		Postgraduate degree

Contextualisation

Quantum transport is nowadays an indispensable ingredient of nanoscience, aiming at controlling and manipulating matter at small scales. It has been recently become possible to fabricate structures with typical dimensions smaller than the mean free path. This amounts to a few nanometers in metallic nanograins up to a few microns in semiconductor heterostructures and even further a few millimeters in carbon nanotubes. In this regime, the Drude-Boltzmann picture is clearly an incorrect approach to discuss transport properties, which can be described only within a fully quantum-mechanical framework.

Very often, the behavior of electrons restricted to move in low dimensional conductors lead to a strong enhancement of correlations. These can be induced by Coulomb interactions or by collective phenomena such as superconductivity or magnetism, which give rise to the formation of complex quantum states accessible at low temperatures to present experimental techniques.

Finally, the enormous interest in nanosystems arise, in part, from their new functionalities and capabilities. Only a correct description of the fundamental dynamics and fluctuations of current-carrying charges can provide a complete insight into nontrivial effects likely to take place in future quantum devices.

Requirements

Essential requirements

It is not necessary to be familiar with nanoscience prior to this course. However, it is recommended to have taken introductory courses to Quantum Physics and Statistical Mechanics.

Skills

Specific

1. E16 (to be able to identify characteristic properties of quantum systems including nonlinear effects) and E17 (to be able to identify and model dissipation and decoherence effects in physical systems coupled to environments).

Generic

1. TG1 (to be able to describe, both mathematically and physically, complex systems in different situations), TG2 (to acquire the capacity to develop a complete research plan covering from the bibliographic research and strategy to the conclusions) and TG3 (to write and describe rigoroulsy the research process and present the conclusions to an expert audience).

Content

The goal of this course is twofold. On the one hand, we will overview paradigmatic systems in experimental nanoelectronics. On the other hand, we will develop theoretical methods than can be useful for students not necessarily interested in nanoscience research.

Theme content

Tema 1. The scattering approach
Scattering matrix. Counting statistics. Interference effects.

Tema 2. Nonequilibrium Green functions
Coherence effects. Electron-electron interaction.

Tema 3. Master equation approach to mesoscopic transport
Relaxation and decoherence.

Tema 4. Quantum noise
Current-current fluctuations. Quantum detectors.

Teaching methodology

In-class work activities

Modality	Name	Typ.Gr.	Description
Theory classes	Lectures	Large group (G)	Discussion of the theoretical contents in lectures. Special emphasis will be put on the illustration of the theoretical formalisms with the aid of practical examples.
Assessment	Assignments	Large group (G)	The problem sets are an essential part of the course. Working through these problems is crucial to understanding the material deeply.
Assessment	Talk and essay writing	Large group (G)	Presentation of a written statement on a topic relevant to the course. A discussion will follow after the talk.

Distance education work activities

Modality	Name	Description
Individual self-study	Study of theory and problems	Study of the classroom activities using the recommended bibliography and the lecture notes. Elaboration of a discussion paper on a related topic and its corresponding presentation.

Riscs especifics i mesures de protecció

Les activitats d'aprenentatge d'aquesta assignatura no comporten riscs específics per a la seguretat i salut de l'alumnat i, per tant, no cal adoptar mesures de protecció especials.

Workload estimate

Modality	Name	Hours	ECTS	%
In-class work activities		**30**	**1.2**	**40**
Theory classes	Lectures	20	0.8	26.67
Assessment	Assignments	8	0.32	10.67
Assessment	Talk and essay writing	2	0.08	2.67
Distance education work activities		**45**	**1.8**	**60**
Individual self-study	Study of theory and problems	45	1.8	60
	Total	**75**	**3**	**100**

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.

Student learning assessment

Assignments

Modality	Assessment
Technique	Papers and projects **(Non-recoverable)**
Description	The problem sets are an essential part of the course. Working through these problems is crucial to understanding the material deeply.
Assessment criteria	Correctness of the solutions and clear discussions.

Percentage of final qualification: 50% following path A

Talk and essay writing

Modality	Assessment
Technique	Papers and projects **(Non-recoverable)**
Description	Presentation of a written statement on a topic relevant to the course. A discussion will follow after the talk.
Assessment criteria	Brevity, clarity and quality of the presentation.

Percentage of final qualification: 50% following path A

Resources, bibliography and additional documentation

Basic bibliography

Here follows a list of recommended books. We will mostly follow references 1 and 2.
1. S. Datta, "Electronic Transport in Mesoscopic Systems", CUP, Cambridge, 2003.
2. Yu. V. Nazarov and Ya. M. Blanter, "Quantum Transport", CUP, Cambridge, 2009.
3. D. K. Ferry and S. M. Goodnick, "Transport in Nanostructures", CUP, Cambridge, 1999.
4. Th. Ihn, "Semiconductor Nanostructures", OUP, Oxford, 2010.

Complementary bibliography

Other resources