Subject identification

Subject	11016 - Quantum Transport and Quantum Noise
Credits	1.2 de presencials (30 hours) 1.8 de no presencials (45 hours) 3 de totals (75 hours).
Group	Group 1, 2S
Teaching period	2nd semester
Teaching language	English

Professors

Lecturers	Horari d'atenció als alumnes					
	Starting time	**Finishing time**	**Day**	**Start date**	**Finish date**	**Office**
María Rosa López Gonzalo rosa.lopez-gonzalo@uib.es	09:30h	10:30h	Monday	01/09/2014	30/06/2015	208

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

* 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

* 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).

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

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. Grp.	Description	Hours
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.	20
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.	8
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.	2

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
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.	45

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

Assignments

Modality	Assessment
Technique	Papers and projects **(non-retrievable)**
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.

Final grade percentage: 50%

Talk and essay writing

Modality	Assessment
Technique	Papers and projects **(non-retrievable)**
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.

Final grade percentage: 50%

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.