# . – Advanced Solid State Physics

## Professor Claudio Giannetti

***COURSE AIMS AND INTENDED LEARNING OUTCOMES***

The course aims to provide students with an advanced understanding of the electronic, magnetic and optical transport properties of solids. The topics, listed in the *Course Content* section, will constitute an advanced study of the basics introduced by the *Solid State Physics* course. In particular, the skills acquired during the *Advanced Solid State* course, will allow the student to quantitatively understand the working principles of semiconductor devices, classical and quantum transport processes, emerging quantum properties in technologically relevant materials and devices, electron and magnetic dynamics, impact of electron many-body interactions on the macroscopic properties of solids. Current research topics in solid state physics will be possibly addressed.

At the end of the course, students will be able to:

1. Understand the working principles of technologically relevant classical and quantum devices, quantitatively model coherent and incoherent transport phenomena, capture the quantum-mechanics nature of the macroscopic properties of paradigmatic materials;
2. Use a correct technical language and present the course topics to both a technical and popular audience;
3. Undertake advance research programs (eg. master thesis and PhD) in the field of condensed matter physics, both theoretical and experimental.

***COURSE CONTENT***

The course contents should be intended as indicative and not as a strict list of topics: some topics could be changed on the basis of the students’ feedback during the first part of the course.

The course will cover the following topics:

* Theory of quantum and classical transport.
* Quantum transport phenomena (eg. Bloch’s oscillations, quantized conductance) and approximations necessary to retrieve classical transport equations.
* Boltzmann’s equations and application to electrical and optical conductivity, diffusion, thermal transport and external force actions.
* Superlattices and Kronig-Penney model.
* Main properties of semiconductors. Optical excitons and charge bound states.
* Homo- and hetero-junctions.
* Transport phenomena across junctions and transistors.
* Electronic bandstructure beyond the independent-electron approximation. Electron correlation effects. Formalism for many-body systems (eg. Green’s function, self-energy) and application to the interacting electron gas.

***READING LIST***

Neil W. Ashcroft - N. David Mermin, *Solid State Physics,* Saunders College, Philadelphia.

G. Grosso - G. Pastori Pallavicini, *Solid State Physics,* Academic Press, 2000.

John H. Davies, *The physics of low-dimensional semiconductors,* Cambridge University Press.

C. Kittel, *Introduction to Solid State Physics,* John Wiley, New York, 1995 (Trad. it. Boringhieri Torino).

G.D. Mahan, *Many particle Physics*, Springer New York, 2000.

S.L. ALTMANN, *Band Theory of Solids: An Introduction from the Point of View of Symmetry*, Oxford University Press 1994.

Additional reading materials will be provided before lectures and will be posted on Blackboard.

***TEACHING METHOD***

The teaching method is mainly based on frontal lectures. The interactions among students and professor will be fostered by case-studies discussions and assignments (eg. presentations of specific topics) carried out under the professor's guidance. Expert testimonials on specific subjects will be possibly invited during the course.

***ASSESSMENT METHOD AND CRITERIA***

The final assessment will be based on an oral exam. During the colloquium, the student will be assessed on the basis of the following criteria:

1. capacity to summarise and present the body of subjects studied (overview and capacity to summarise); 80% weight on the final score.
2. problem solving (analytical understanding and independence in application of the concepts learned); 20% weight on the final score

More specifically, under positive evaluation of the capacity to present the course subjects (point A) the student will gain marks up to 24/30. In order to get full marks (30/30), the student must demonstrate capacity of elaborating on the course subjects and applying them in an original and personal fashion. The full marks cum laude will be reserved to outstanding cases, in which the student demonstrates a knowledge of the course subjects as deep as what is needed to originally address issues not strictly related to the course contents.

***NOTES AND PREREQUISITES***

 In order to proficiently attend the course, basics of quantum mechanics, condensed matter physics, electrodynamics and solid state physics are required.

 Covid 19

In case the current Covid-19 health emergency does not allow frontal teaching, remote teaching will be carried out following procedures that will be promptly notified to students.

Prof. Claudio Giannetti meets students any time, by appointment (*claudio.giannetti@unicatt.it*).