UNIVERSITÀ DI PISA

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

"Envelope-function method for the study of charge transport in graphene and graphene-related materials"

Prof. Paolo Marconcini

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Short Abstract: After a general introduction on the use of the envelope-function method in the study of semiconductors, the course will focus on the application to graphene and graphene-related materials. Due to its particular lattice structure, in monolayer graphene the envelope-function equation takes the form of the Dirac-Weyl equation (i.e., the same relation that describes the behavior of relativistic massless quantum particles, which explains why in graphene several exotic relativistic effects, such as Klein tunneling, appear at non relativistic speeds). The course will describe the derivation of the Dirac envelope-function equation in graphene and related materials, the numerical methods that can be adopted for its solution, and the way in which this description can be applied for the study of transport of graphene-based devices. Particular care will be devoted to the discretization and ill-conditioning numerical problems which may emerge using this modelization and to the methods which can be used to overcome them.

Course Contents in brief:

- General introduction to the envelope-function method in semiconductors.
- Derivation of the Dirac envelope function equation in graphene and graphene-related materials.
- Numerical solution of the Dirac equation and related discretization problems.
- Application to the study of charge transport in graphene-based devices, in the presence of a generic potential profile and of an orthogonal magnetic field.

Total # of hours of lecture: 12 hours

References:

[1] P. Marconcini, M. Macucci, "The k.p method and its application to graphene, carbon nanotubes and graphene nanoribbons: the Dirac equation", La Rivista del Nuovo Cimento 34, Issue N. 8-9, p. 489 (2011), DOI: 10.1393/ncr/i2011-10068-1.

[2] D. Logoteta, P. Marconcini, C. Bonati, M. Fagotti, M. Macucci, "High-performance solution of the transport problem in a graphene armchair structure with a generic potential", Phys. Rev. E 89, 063309 (2014), DOI: 10.1103/PhysRevE.89.063309.

CV of the Teacher

Paolo Marconcini received the Master's (summa cum laude) Degree in Electronic Engineering and the Ph.D. Degree in Information Engineering from the University of Pisa, Pisa, Italy, in 2002 and 2006, respectively. He was a Visiting Researcher with the Technical University of Munich, Germany, in 2005. In 2006, he had a research contract with the Italian National Research Council.

Since 2006, he has been first a Post-Doctoral Researcher and then a Tenure Track Researcher with the University of Pisa, where he is now an Associate Professor. He received the Italian National Scientific Qualification for Full Professor in Electronics in 2021. He has been involved in 15 national and international research projects. He has authored over 100 papers in international journals and proceedings. His current research interests include the study of nanoelectronic devices (mainly based on semiconductor heterostructures, nanowires, carbon nanotubes, graphene, and 2D materials), with particular focus on the effect of quantum phenomena on transport and noise properties. He has developed several numerical simulators for the analysis of electronic devices and of material properties. He is also involved also in the research and design of innovative electronic systems for various applications, mainly in the transport field.

Room and Schedule

Room: *Aula Riunioni del Dipartimento di Ingegneria dell'Informazione, Via G. Caruso 16, Pisa – Ground Floor*

Schedule:

- 18/07/2022: h. 14.00-18.00
- 19/07/2022: h. 14.00-18.00
- 20/07/2022: h. 14.00-18.00