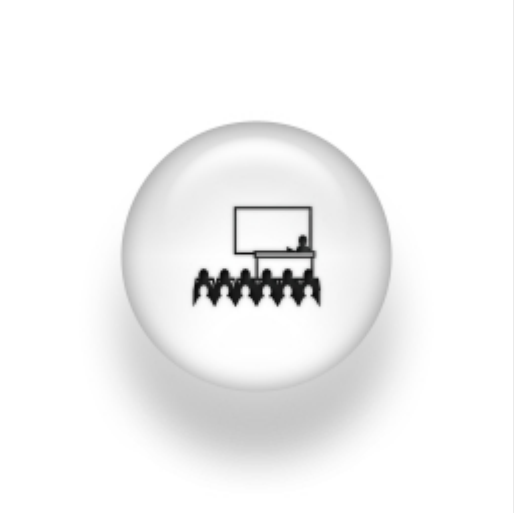
Fano interference and infrared phonon activity in bilayer graphene

Thursday, 23th February 2012. 12:00-13:00

Emmanuele Cappelluti



CNR, Roma & Instituto de Ciencia de Materiales de Madrid, CSIC

ABSTRACT:
The detection and analysis of the spectral properties of optical phonon in single-layer and multilayer graphene provides a powerful tool not only for a careful characterization of the systems but also for investigating the role of the underlying electron-phonon interaction.
Recent experiments in gated bilayer graphene revealed a clear phonon resonance at 1590 cm-1 with several interesting features, as for instance a giant enhancement of the phonon intensity as a function of teh gate voltage as well as a pronounced Fano lineshape asymmetry.
In this talk I will discuss how these features can be analyzed and predicted on a microscopic quantitative level using a charge-phonon theory applied to the specific case of graphene systems.
We show in particular how the phonon intensity and the Fano asymmetry are strictly related, stemming out from the quantum interference between the electronic and phononic degrees of freedom.
Within this context we are also able to elucidate the relative role of the Eu and Eg phonon modes in regards to the infrared activity and the Fano asymmetry of the observed phonon peaks.
We present thus a complete phase diagram for the strength of the phonon modes and their Fano properties as functions of the chemical potential and of the gated-induced electronic gap, showing that a switching mechanism between the dominance of the Eu or Eg mode can be controlled by the external gate voltage.
Our work permits thus reconciling within a unique theoretical approach the phonon-peak features observed by different experimental groups, and it provides an analytical tool for predicting and controlling on a quantitative level the spectral properties of the phonon resonances in the infrared spectra of graphenes.

Electronic transport in defective low dimensional carbon materials: nanotubes and graphene

Wednesday, 8th February 2012. 12:00-13:00

Cristina Gomez-Navarro

Departamento de Física de la Materia Condensada, Universidad Autónoma de Madrid

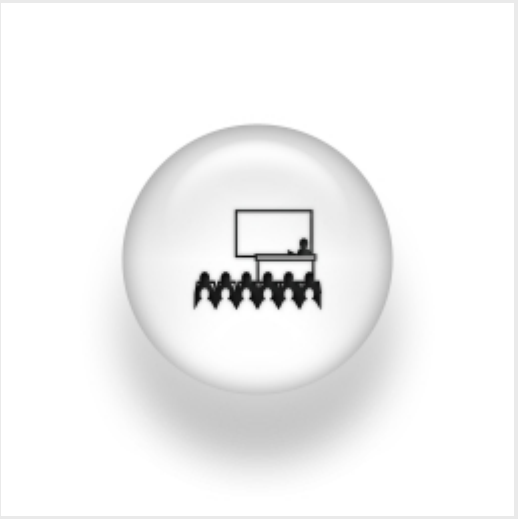
ABSTRACT:
Electronic transport properties of carbon nanotubes and graphene are of interest due to their potential use in future electronic devices but also from a fundamental point of view. These materials, due to their low dimensionality and peculiar band structure, present a broad spectrum of electronic transport regimes.
In this talk I will first talk about our experimental work on carbon nanotubes focusing on the effect of different scattering mechanism: atomic scale defects [1] and high energy phonons [2], I will finish trying to give an overview of the phase diagram of electronic transport in carbon nanotubes.
Then I will focus on our work on chemically derived graphene. These graphene layers are obtained by a mass production technique based in the oxidation and subsequent reduction of graphite [3]. I will describe our experiments with the aim of characterizing this material from a structural [4], electronic [3,5] and mechanical [6] point of view. I will also discuss a route for enhancement of its conductivity [7].
[1] Gomez-Navarro, C. et al., Tuning the conductance of single-walled carbon nanotubes by ion irradiation in the Anderson localization regime. Nat Mater
4 (7), 534 (2005).
[2] Sundqvist, P. et al., Voltage and length-dependent phase diagram of the electronic transport in carbon nanotubes. Nano Letters 7 (9), 2568 (2007).
[3] Gomez-Navarro, C. et al., Electronic Transport Properties of Individual Chemically Reduced Graphene Oxide Sheets. Nano Letters 7 (11), 3499 (2007).
[4] Gomez-Navarro, C. et al., Atomic Structure of Reduced Graphene Oxide.
Nano Letters 10 (4), 1144 (2010).
[5] Kaiser, A. et al., Electrical Conduction Mechanism in Chemically Derived Graphene Monolayers. Nano Letters 9 (5), 1787 (2009).
[6] Gomez-Navarro, C., Burghard, M., and Kern, K., Elastic properties of chemically derived single graphene sheets. Nano Letters 8 (7), 2045 (2008).
[7] Lopez, V. et al., Chemical Vapor Deposition Repair of Graphene Oxide: A Route to

Highly Conductive Graphene Monolayers. Advanced Materials 21 (46), 4683 (2009).

On the optical properties of graphenes

Wednesday, 1st February 2012. 12:00-13:00

Tobias Stauber



Departamento de Física de la Materia Condensada, Universidad Autónoma de Madrid

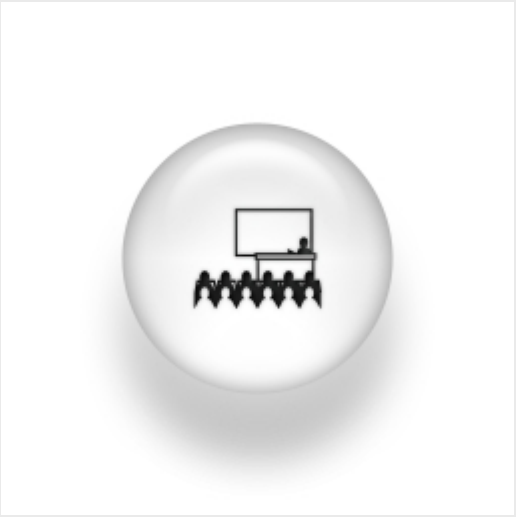
ABSTRACT:
One of the hallmarks of the optical properties of (suspended) graphene is that a simply-observable quantity as the optical transparency is defined solely by the fine structure constant [1]. In the first part of this talk, I will give the theoretical explanation to this experiment, i.e., show that even in the visible-optics regime the corrections to the Dirac cone approximation are small (a few percent) and the effect of next-nearest neighbor hopping is negligible [2]. I will also discuss the infrared conductivity of graphene on a substrate where electron-phonon and impurity scattering become important [3].
In the second part, I will look at the optical properties of double layer graphene with respect to their plasmonic excitations, near-field amplification and extraordinary (perfect) transmission [4]. Also graphene's fluorescence quenching including transverse decay channels and full retardation will be discussed [5]. Finally, the current-current correlation function of the full hexagonal tight-binding model will be derived [6] and I will show that lattice effects lead to a paramagnetic response for graphene with intrinsic doping at low temperatures [7].

[1] R. R. Nair, P. Blake, A. N. Grigorenko, K. S. Novoselov, T.J. Booth, T. Stauber, N. M. R. Peres, and A. K. Geim, Science 320, 1308 (2008).
[2] T. Stauber, N. M. R. Peres, and A. K. Geim, Phys. Rev. B 78, 085432 (2008).
[3] T. Stauber, N. M. R. Peres, and A. H. Castro Neto, Phys. Rev. B 78, 085418 (2008).
[4] T. Stauber and G. Gómez-Santos, Phys. Rev. B 85, (2012).
[5] G. Gómez-Santos and T. Stauber, Phys. Rev. B 84, 165438 (2011).
[6] T. Stauber and G. Gómez-Santos, Phys. Rev. B 82, 155412 (2010).

[7] G. Gómez-Santos and T. Stauber, Phys. Rev. Lett. 106, 045504 (2011).

The Tau-3 lattice, graphene's big brother: transport and spectral properties

Tuesday, 31st May 2011. 12:00-13.00



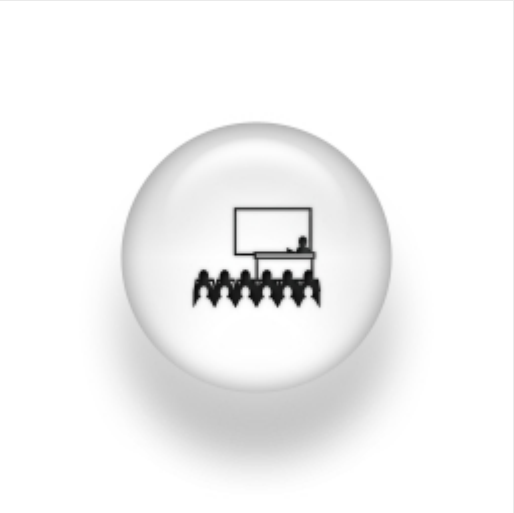
Prof. Daniel Urban
Freiburg University

ABSTRACT:
Albeit the Tau-3-lattice exhibits a reciprocal lattice similar to graphene with two inequivalent Dirac-points at six corners of the hexagonal first Brillouin zone, where relativistic electron-hole symmetric bands touch, Tau-3 differs and considerably generalizes graphene. Peculiarities of Tau-3 are the occurance of an additional dispersionless energy band at energy E = 0 and an enlarged pseudo-spin S = 1 instead of S = 1/2 as for graphene. This leads to an enhanced “super” Klein tunneling through rectangular electrostatic barriers, compared to the case of graphene. Moreover, at the particular energy of half the barrier height we find even complete transparency, T = 1, irrespective of barrier thickness and of incidence angle. We also investigate rectangular magnetic barriers and in this case identify regimes of zero barrier transparency, qualitatively similar to the case of graphene. Furthermore, we investigate the Tau-3 lattice (and other related 2-dimensional lattices) with respect to them becoming a topological insulator when spin/orbit interactions are present. Topological insulators are band insulators with large spin-orbit interactions that exhibit the quantum spin-Hall (QSH) effect. Physical phenomena driven by topological properties, have the appealing feature to be robust with respect to external perturbations. We investigate the transition between QSH and normal insulating phases under topological deformations of a two-dimensional lattice, namely transformations between the honeycomb and the Tau-3 lattice and propose a method for verifying our predictions with fermionic cold atoms in optical lattices.
Bercioux, Urban, Grabert, Häusler, Phys. Rev. A 80, 063603 (2009)

Bercioux, Goldman and Urban, Phys. Rev. A 83, 023609 (2011)
Goldman, Urban, Bercioux, arXiv:1101.4500 (PRA, in press)

Spin transport in graphene

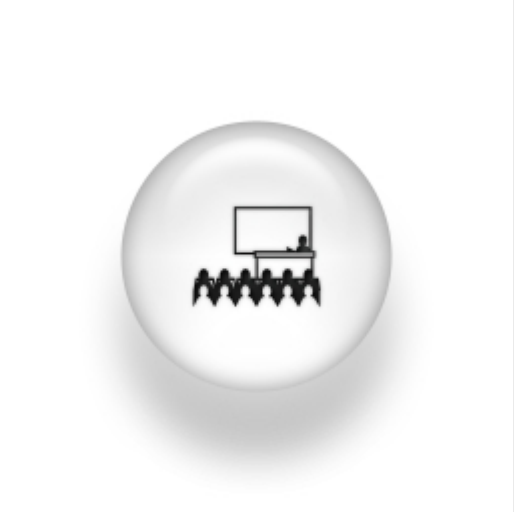
Wednesday, 4 May 2011. 12:00-13.00



Prof. Juanjo Palacios
Departamento de Fisica de la Materia Condensada, UAM
ABSTRACT:
In this talk I will review our recent work on two topics related to spin transport in graphene:
1) First, I will discuss some fundamental (some would say academic) issues related to the conductance quantization expected for 2D topological insulators in the context of graphene nanoribbons. In particular, I will explore the extent to which disorder and (the lack of) inversion symmetry play a role in this manifestation of the topological nature of grahene with strong spin-orbit coupling.
2) Second, I will discuss our proposal to unveil magnetism in hydrogenated graphene. The reasons why magnetic phenomena in graphene remain elusive are still unclear, but are definitely rooted in two issues: 1) the formation of individual magnetic moments, which is plagued with technical and fundamental difficulties, and 2) the underlying antiferromagnetic correlations inherent to graphene, which do not favor the observation of a collective behavior. I will present a critical analysis of the first issue and propose a way to unveil the antiferromagnetic correlations based on spin-dependent features in the conductivity of bulk graphene, chemically modified by hydrogen adatoms.

Coupling between topological insulators: Band topology and quantum spin Hall effect in bilayer graphene

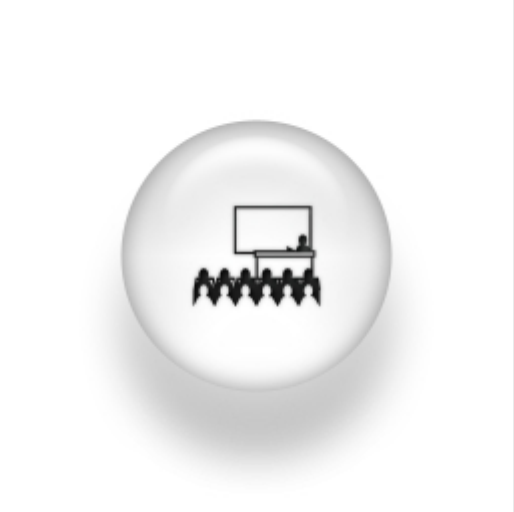
Wednesday, 15 Dicember 2010, 12:00-13.00



Prof. Luis Brey
Instituto de Ciencia de Materiales de Madrid, CSIC
ABSTRACT:
In this seminar, first, I will review the electronic structure of CdTe and I will describe the conditions under which this material is a topological insulator.
Using band theory, I will introduce the concept of topological insulator and I will discuss the surface states of these materials.
Considering spin-orbit coupling graphene is a topological insulators. In the second part of the talk I will present the electronic properties of a graphene bilayer in presence of spin orbit coupling, and using this model system I will comment on the properties of two coupled topological insulators. Finally, I will analyze a bilayer graphene where the spin orbit coupling only exists in one of the layers.

Quantum pumping in graphene

Wednesday, 26 May 2010, 12:00-13.00



Prof. Elsa Prada
ICMM, CSIC
ABSTRACT:
We show that graphene-based quantum pumps can tap into evanescent modes, which penetrate deeply into the device as a consequence of Klein tunneling. The evanescent modes dominate pumping at the Dirac point, and give rise to a universal response under weak driving for short and wide pumps, in close analogy to their role in the minimal conductivity in ballistic transport. In contrast, evanescent modes contribute negligibly to normal pumps. Our findings add an incentive for the exploration of graphene-based nanoelectronic devices.