Tuning the transport properties of graphene through AC fields

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More than a century ago, the use of alternating currents (ac) sparked a revolution that changed our modern world. Today, the use of ac fields has reached the nanoscale. Here, the interplay between the quantum coherence of the electrons, inelastic effects and dynamical symmetry breaking offers fascinating opportunities for basic research and applications. The interest on time-dependent excitations by electromagnetic fields or gate voltages has been steadily growing [1] and many captivating phenomena such as photon-assisted tunneling, coherent destruction of tunneling [2] and quantum charge pumping [3] have been unveiled.

Graphene and carbon nanotubes offer an outstanding ground for these studies [4,5,6]. Here we give a brief overview of our recent research on driven electronic transport in these materials with a twofold focus: the effects of radiation on electronic transport properties in graphene [6], notably the emergence of *dynamical band gaps*, and how defects in carbon-based devices could help to generate a dc current in the presence of ac fields [7]. More specifically, we will try to shed light on questions such as: Is it possible to use ac fields to control the electric response (current and noise)? Could we achieve tunable band gaps in graphene through illumination with a laser of suitable wavelength and polarization (see Fig. 1 and its caption)? What is the role of defects in quantum pumping through carbon-based devices?

A brief overview of other facets of the wealth of phenomena that could be awaiting us, such as the possibility of using the laser fields to generate the so called Floquet Topological Insulators [8,9,10], will also be presented.

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Figures

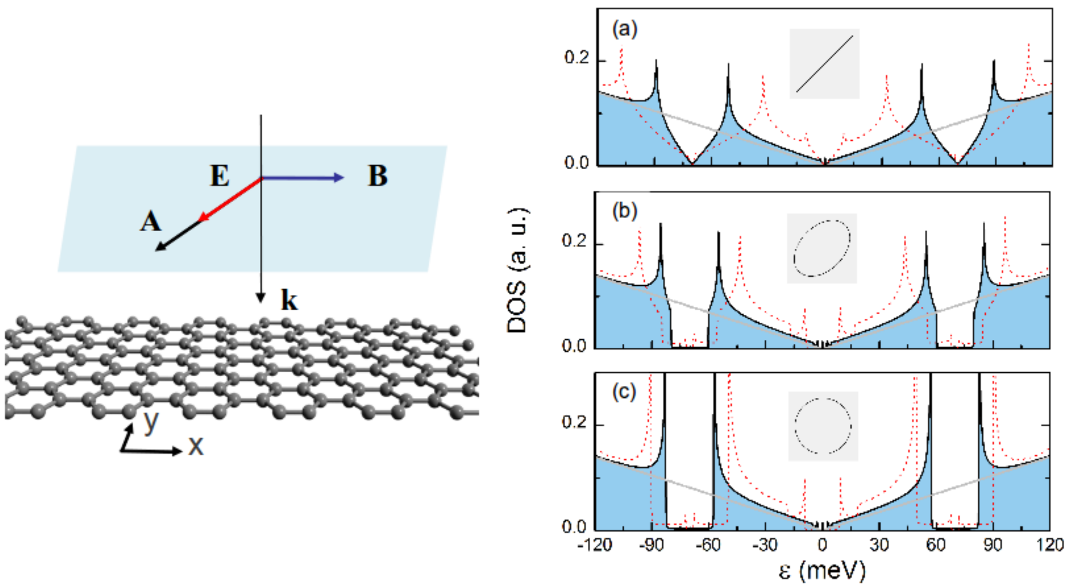

Figure 1: (Left) Scheme of the proposed setup where a laser field is applied perpendicular to a graphene monolayer. (Right) Effective density of states (DOS) as a function of the incident electron energy for three different laser polarizations: linear (a), elliptic (b) and circular (c). The DOS for unirradiated graphene (gray line) suffers dramatic modifications when the laser beam with $\hbar\Omega=140$ meV is turned on (the solid black and red dotted curves are for intensities of 32 mW/mm^2 and 130 mW/μm^2 respectively). As a result of the interaction between the electrons and the radiation, ***dynamical gaps*** *open at $\pm\,\hbar\Omega/2$ and even at the Dirac point for circularly polarized light. These results are taken from Ref. [6], where we showed the first atomistic simulations of the electrical response (dc conductance) of a large graphene ribbon. Our results hint that a transport experiment carried out while illuminating with a laser in the mid-infrared could unveil these phenomena.*

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