Ballistic nano-detectors based upon the Ratchet effect on patterned graphene

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In the present talk, we describe a theoretic analysis, propaedeutic to the optimization of the photogalvanic current induced by a high frequency radiation in monolayer graphene [1-3], patterned with asymmetric nano-defects. Specifically, the latter are given by clusters of atomic vacancies of triangular shape. We propose a completely ballistic picture of the Ratchet effect, where the main contribution to the collective and cumulative charge displacement is due to ballistic scattering. Numerical simulations are performed in the framework of the Scattering Matrix (SM) approach, described elsewhere [4], which is conceptually analogous to the non-linear Green's function formalism (NEGF). The main difference is that it provides a convenient description of the graphene lattice in terms of propagating and evanescent modes. Triangular holes are analysed as paired defects in monolayer graphene, as depicted in figure 1(a). The shape of the holes affects the charge scattering and changes the charge distribution induced by an external applied voltage. The latter is given by a plane-wave impinging on the plane of graphene in the normal direction: the electric field E is assumed as polarized along the y-axis, in order to promote charge displacement in the this direction. The resulting voltage can varied continuously in the interval from $-\Delta V$ to ΔV, with $\Delta V = |E_y| \cdot L$ and the resulting charge distribution can mediated in this interval, in order to reproduce an average charge distribution over a period $2\pi/\omega$ of the electromagnetic excitation [5]:

$$Q = \overline{\int_{\mu_c}^{\mu_c+v} \sum_{i=1:N} \left|\psi_i\right|^2} \qquad (1)$$

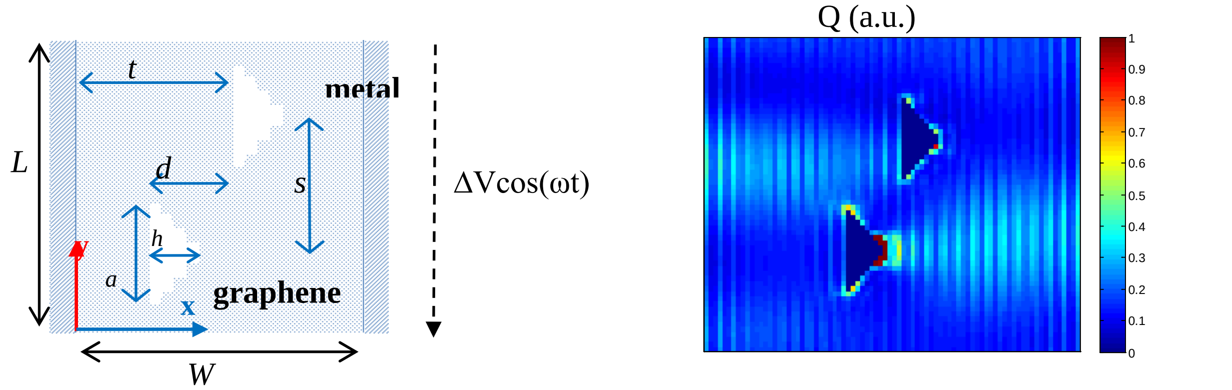

Figure 1. a) Triangular vacancy defect in paired configuration. (b) Top view of surface charge density Q. Here, μ_c=0.22 eV, with d=3 nm, a=7 nm, h=2 nm, s=9 nm, t=13 nm.

In the present framework, the lateral metal contacts are replaced by Dirichlet conditions for the electron wavefunctions. More rigorously, absorbing boundaries, mediated by the metal-graphene discontinuity, could be assumed, but this is largely beyond the purpose of the present work. Figure 1(b) shows an example of simulated distribution $|\psi|^2$ - namely charge per unit area and per unit energy, after Landauer normalization, at energy μ_c.

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