Quantum transport in carbon-based nanostructures perturbed by time-dependent potentials.

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Novel quantum transport phenomena rise when nanoscale materials are perturbed by external time-dependent fields [1-2]. Comparing with stationary fields, a time-varying one can effectively modulates the quantum phase of the electronic wave functions, bringing new possibilities of technological applications [3]. However, most experimental and theoretical studies on carbon-based nanomaterials have been made for dc transport properties and more extensive studies are still lacking to take advantage to this useful technique for novel nanodevices applications.

In this work we study transport properties of carbon nanotubes and graphene nanoribbons under time-dependent perturbations, external magnetic fields and electrostatic gates. In particular we investigate nanostructures which can confine electronic states realizing a carbon-based double quantum-dot (CDQD). These structures are fabricated by forming tunnel barriers within the nanotube by means of topological defects or obtained by bending or kinking mechanically the tube using an AFM [4]. CDQD are also obtained by patterning a single-layer graphene by electron-beam lithography [5]. In a CDQD the conductance as a function of the gate voltage presents resonances which will be modified due to the time-varying potential [6]. We will study the feasibility that the conductance of carbon-based CDQDs devices can be controlled by tuning the frequency and radiation field intensity (AC parameters) and by applying gate or source-drain voltages.

The combination of both external magnetic fields and time-dependent potentials provides alternative schemes to modulate the Fabry-Perot conductance oscillations [7]. We will study the conductance of driven three-terminal carbon-based systems in the Fabry-Perot interference regime in the presence of a magnetic field and external time-dependent fields applied on the gate plate or as a bias voltage.

We solve the problem using standard non-equilibrium Green's function (NGF) techniques. The conductance is calculated by the Landauer-type formula in terms of the transmission function which is obtained from the retarded and advanced Green's function of the carbon-based system in the presence of the field, and its coupling to the leads.

References:

[1] G. Platero and R. Aguado, Phys. Rep. **395** (2004) 1
[2] P. A. Orellana, and M. Pacheco, Phys. Rev. B **75** (2007) 115427
[3] B. L. Altshuler, and L. I. Glazman, Science **283** (1999)1864; C. Kocabas, H-sik Kim, T. Sanks, J. A. Rogers, A. A. Pesetski, J. E. Baumgardner, S. V. Krishnaswamy, and H. Zhang, PNAS **105** (2008)1405
[4] P. Jarillo-Herrero et al. Phys. Rev. Lett. **94** (2005)156802; S. Sapmaz et al. Nano Lett. **6** (2006)1350 ; M. J. Biercuk et al. Nano lett. **4** (2005)2499.
[5] C. Stampfer, E. Schurtenberger, F. Molitor, J. GÜttinger, T. Ihn, and K. Ensslin, Nano Lett. **8** (2008) 2378.
[6] L. E. F. Foa Torres, and G. Cuniberti, App. Phys. Lett. **94** (2009) 222103
[7] B. Raquet, R. Avriller, B. Lassagne, S. Nanot, W. Escoffier, J-M Broto, and S. Roche, Phys. Rev. Lett. **101** (2008) 046803.