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Pumping in graphene: ribbons: transport in adiabatic and non-adiabatic regimes.

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The interest in the development of devices at the nano-scale has intensified the search for mechanisms that provide control of transport properties while reducing effects of heat dissipation and contact resistance. Charge pumping, in which dc currents are generated in open-quantum systems by applying time-dependent potentials, may achieve these goals. Since the theoretical proposal by Thouless [1], the application of a periodic perturbation to pump dc charge or spin current was achieved in various experimental settings. Most of these works focused on the adiabatic regime (low driving), in configurations with two or more periodically changing parameters that yield dc currents proportional to the driving frequency.
New insights into pumping have appeared from studies of models of two-dimensional graphene systems. The solution of a two-parameter pumping model in the adiabatic regime, based on the Dirac Hamiltonian, showed an enhanced pumped current (as compared with semiconductor materials), which was attributed to the unusual persistence of evanescent modes in the presence of Dirac points [2]. Green's function methods were used to analyze the effects of resonant tunneling in a similar configuration, showing the persistence of anomalous behavior in this regime [3].
Among the extraordinary properties of graphene, there are those arising from confinement effects with significant consequences for the conductance of finite samples.
With the purpose to understand the effect of boundaries and geometry in realistic experimental settings, we have analyzed the properties of non-equilibrium zero-bias currents through graphene nanoribbons using a tight-binding Hamiltonian and the Keldysh non-equilibrium formalism.
Using a numerical implementation with two local single-harmonic time-dependent potentials, we provide detailed analysis of transport through armchair and zigzag ribbons, attached to metallic leads (modeled by semi-infinite square lattice contacts, as a function of chemical potential of the leads and pumping parameters. The model fully describes adiabatic and non-adiabatic regimes and the crossover between both for finite size ribbons. Furthermore, it provides a detailed account of the contribution of evanescent modes to the current, which it is shown to strongly depend on the aspect ratio of the ribbon.
Most importantly, the analysis of different boundaries and contact geometries reveals the fundamental role played by space inversion symmetry in the value of the pumped current that can vanish for appropriate setups [4].

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