Finite frequency measurements and characteristic time scales in graphene devices.

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Most numerical calculations that are performed with Recursive Green's Function (RGF) or similar techniques are concerned with DC transport. The AC case has been developed withing the Scattering formalism for some time [1-2], but has received little attention from the numerical community so far. To our knowledge, there have been not so many groups trying to do simulations for these types of questions [2-4]. A crucial point of physics at finite-frequency is that electron-electron interactions must be included, at least at the mean field level, in order to account for basic physical facts such as current conservation.

Finite-frequency physics makes it possible to consider a very large class of situations and questions. For instance, one could discuss the problematic of quantum pumping (making use of quantum interferences to pump a current in a device that would not work classically), quantum rectification or spin pumping (the spin analogue of quantum pumping which was observed in the line-width of ferro-magnetic resonances). Other examples include non-linear effects in the current-tension characteristic of a device (“Landauer dipoles”), AC conductance and quantum capacitances.

We perform numerical simulations of quantum transport in graphene based devices at finite (GHz - THz) frequencies. Our simulations are based on the Non Equilibrium Green Function (NEGF) approach that we extend in order to relate finite frequency quantities to Green function elements that can be calculated using standard recursive techniques. Our simulations show that characteristic time scales of the device (such as the transverse Thouless time from which the electronic speed can be extracted) can be obtained from the frequency dependance of the ac conductance. We also discuss the interplay between finite frequency and magnetic fields.

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