Conductivity of chiral particles: Boltzmann-like analytical approach and finite-size Kubo formula simulation

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The sublattice degree of freedom of chiral carriers in graphene can be characterized by means of the pseudospin which is an additional quantum number formally similar to the real spin in spin-orbit coupled systems [1]. In chirally stacked N-layer graphene, the pseudospin makes N full rotations when the momentum winds around the Fermi surface resulting in the winding number $N_c = N$ [1]. There are quite a few speculations on the possibly important role of the pseudospin-coherent contribution in the electrical dc conductivity of graphene at low carrier concentrations [2, 3, 4, 5]. There is however no agreement whether this contribution really matters and can be extracted from the total conductivity. The main goal of the present work is to compare the exact numerical (finite-size Kubo) and approximated analytical (Boltzmann-like) pseudospin-coherent conductivities for an arbitrary N_c and in that way to figure out the correct approximation needed to derive the most reasonable analytical expression.

To investigate the relation between the winding number N_c and the conductivity of chiral carriers with the dispersion $E_k = \gamma k^{N_d}$ we start from the Hamiltonian

$$H_0 = \gamma k^{N_d} \begin{pmatrix} 0 & \exp(-iN_c\theta) \\ \exp(iN_c\theta) & 0 \end{pmatrix}, \qquad (1)$$

where k is the absolute value of the particle wave vector, $\theta = \arctan(k_y/k_x)$, and γ is a constant determined by the band parameters. In the special case of $N_d = N_c$ the Hamiltonian describes the low energy behaviour of carriers in chirally stacked multilayer graphene [1], but the general choice of $N_c \neq N_d$ makes it possible to distinguish the true pseudospin coherent conductivity contribution from the effects related to the change of the density of states. Using this Hamiltonian we compare the pseudospin-coherent Boltzmann-like conductivity in terms of the Fermi wave vector k_F and mean free path l with the corresponding finite-size Kubo conductivity computed in the spirit of [6] by means of the exact diagonalization of the total Hamiltonian $H = H_0 + V$ with V being point-like impurity potential which can be related to the mean free path l.

In the poster to be shown we discuss proper treatments of the collision integral in the Boltzmann equation for chiral particles as well as connections between our theoretical findings and the real electron transport in graphene.

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