Quantum transport of massless Dirac fermions in graphene nanoribbons

Branislav K. Nikolić* and Liviu P. Zârbo*

**Department of Physics and Astronomy, University of Delaware, Newark, DE 19716-2570, USA*

Abstract. The recent experimental discovery of a two-dimensional (2D) allotrope of carbon—termed *graphene*—has ushered unforeseen avenues to explore transport and interactions of low-dimensional electron system, build quantum-coherent carbon-based nanoelectronic devices, and probe high energy physics of "charged neutrinos" in table-top experiments. Graphene represents one-atom-thick layer of carbon atoms tightly packed into a honeycomb crystal lattice whose symmetries impose linear energy-momentum dispersion of the low-energy quasiparticles. Moreover, its bipartite structure introduces an internal pseudospin degree of freedom which connects electrons and holes through chirality (projection of pseudospin on the direction of motion) of opposite signs, so that the effective mass equation turns into the Weyl equation for massless Dirac fermions (such as neutrinos).

We employ the formalism of bond currents, expressed in terms of the nonequilibrium Landauer-Keldysh Green functions, to image the charge flow between two sites of the honeycomb lattice of graphene ribbons of few nanometers width. In sharp contrast to nonrelativistic electrons, current density profiles of quantum transport at energies close to the Dirac point in clean zigzag graphene nanoribbons (ZGNR) differs markedly from the profiles of charge density peaked at the edges due to zero-energy localized edge states. For transport through the lowest propagating mode induced by these edge states, edge vacancies do not affect current density peaked in the center of ZGNR. The long-range potential of a single impurity acts to reduce local current around it while concurrently increasing the current density along the zigzag edge, so that ZGNR conductance of quantum transport through this 'chiral' (lowest) conducting channel can remain perfect $G = 2e^2/h$. We also discuss the effect of antiferromagnetic spin ordering along the edges of ZGNR on spin-polarized quantum transport.

REFERENCES

1. L. P. Zârbo and B. K. Nikolić, arXiv:0704.2419 (2007).