Unconventional quantum transport in graphene-based compounds and flat-band supermetallic phases

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Over the past decade, we can witness a growing interest for the physics in flat-band systems. Because of destructive quantum interferences, in FB systems, the electron group velocity is exactly zero, thus the kinetic energy is quenched. The presence of flat bands in the electronic dispersion gives rise to a plethora of exotic physical phenomena, such as topological states, unconventional superconductivity, Wigner crystals, and ferromagnetism. The quantum transport in several graphene-based compounds that have both a flat band and a tunable gap is investigated. Despite the localized nature of the FB states and the vanishing group velocity, a super-metallic (SM) "Drudeless" phase at the FB energy is revealed. In contrast to conventional electronic transport, well described semi classically, the FB transport is purely of quantum nature. The SM phase is found robust against the strength of the inelastic scattering and controlled only by the (off-diagonal) inter-band matrix elements of the velocity operator between the FB and the dispersive band states. The SM phase appears to be insensitive to the gap amplitude and to the nature of the lattice (disordered or nano-patterned) as well. The universal nature of the unconventional quantum transport in flat bands is addressed by considering the case of electrons in the 2D disordered Lieb lattice.

References

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[2] G. Bouzerar and D. Mayou, Phys. Rev. B, 103, 075415 (2021).
[3] G. Bouzerar et al., submitted.

Figures

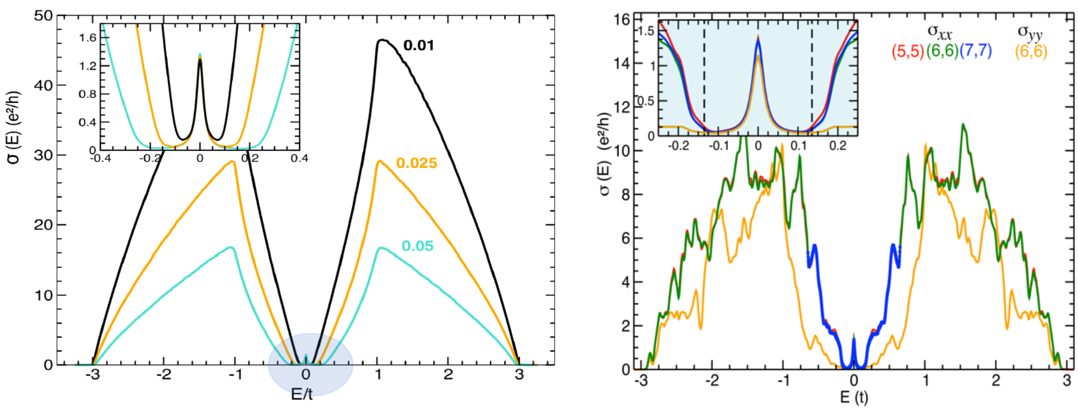

Figure 1: (left) Conductivity as a function of the Fermi energy in fully compensated graphene for various concentration of C vacancies (x = 0.01,0.025 and 0.05). (right) Effects of the fractalization of the lattice on the electronic conductivity. The insets magnify the neutrality point region.