Interacting electrons and spin-splitting in graphene and graphene nanoribbons in the quantum Hall regime

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In the present work we study the effect of electron-electron (e-e) interaction and spin on electronic and transport properties of gated graphene and graphene nanoribbons (GNRs) in a perpendicular magnetic field. The model is based on the tight-binding Hamiltonian where the effect of electron-electron interaction is taken into account self-consistently using the Hartree and Hubbard approximations.

We calculate the conductance of GNR in a vicinity of the charge neutrality point (CNP) in the lowest Landau level (LLL) making use of the recursive Green's function technique within the Landauer formalism, and discuss the possibility of edge state localization due to the presence of different types of disorder (impurities, warping, edge disorder). We demonstrate that e-e interaction leads to the pinning of Fermi level to the LLL and subsequent formation of compressible strips in the middle of the nanoribbon. The states which populate the compressible strips are not spatially localized and manifested through the increase of the conductance in the case of an ideal GNRs. Due to their spatial distribution these additional states are very sensitive to different types of disorder and do not significantly contribute to the conductance of real samples. In contrast the edges states are found to be very robust to the disorders. Our calculations show that the edge states can not be easily suppressed and survive even in the case of strong spin-flip scattering [1].

Finally, we investigate spin-splitting in graphene calculating the effective g-factor. Recent experiments demonstrate that e-e interaction can lead to the increase of spin-splitting in a high magnetic fields [2]. We perform self-consistent Thomas-Fermi calculations where the spin effects are included within the Hubbard approximation and show that the effective g-factor in graphene sheets oscillates from its normal value g=2 up to g=3.5 depending on the value of magnetic field and concentration of charged impurities in the substrate. If the concentration of impurities is high enough, the oscillations of the g-factor are stabilized and reach the value g=2.3.

References

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