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Disorder-induced localised gating in graphene

Thomas Aktor, Antti-Pekka Jauho and Stephen R. Power

Introduction
Gating of individual atoms in graphene would allow extremely precise control of current flow. In practice, however, this is very difficult to achieve. In this work we investigate whether doping or spatially restricted gating can be used to achieve similar control. Two systems are considered:

- Sublattice asymmetric doping within a region in a pristine graphene sheet [1,2].
- Sublattice symmetric gated region in a pristine graphene sheet [4].

Methods
We use:

- A 1NN tight binding model.
- The Patched Green’s Functions (PGF) method [3].
- The PGF is explained in the right column.
- A simple onsite energy shift for dopants

Sublattice symmetric potential

The onsite potential is shifted in both sublattices, with an average change (keeping the shift times concentration constant) of: \( e_A = e_B = 0.1|\psi| \), for a varying concentration of atoms \( c = 1.0, 0.5, 0.2 \) within a circular region of radius 20nm. The positive energies are the most interesting.

Sublattice asymmetric potential

The onsite potential is shifted in one of the sublattices, with an average change (keeping the shift times concentration constant) of: \( e_A = 0.2|\psi| \), \( e_B = 0 \), for a varying concentration of A-atoms \( c_A = 1.0, 0.5, 0.2 \) within a circular region of radius 20nm.

Conclusion
- The key features of the DOS for the asymmetrically doped dot are largely independent of \( c_A \).
- The key features of the DOS for the uniformly gated dot are very dependent on the concentration. The peaks associated with the vortex behavior get completely smeared out.

DOS of states (shaded region is the pristine version)

Green’s Function of Graphene
- The 1NN tight binding model graphene pristine Hamiltonian:
  \[ H^{(0)} = \begin{pmatrix} 0 & -t f(k) \\ -t^* f(k) & 0 \end{pmatrix} \]
- The Green’s Function
  \[ G^{(0)}(\epsilon, r_i, r_j) = \frac{1}{\Delta} \int d^2 k \frac{\sum_{\alpha=\pm} N_{\alpha}^{(0)}(k) \epsilon^{(\alpha)}_{\alpha}(k)}{\epsilon - E^{(\alpha)}_{\alpha}(k)} \]
- Depending on the sublattice
- One of the k integrals can be done analytically [4], leaving one to be calculated numerically

Green’s Functions of graphene
- \( \Sigma^{(0)} \) for a varying concentration of \( c = 0, 0.5 \) and \( c = 0.2 \)

Conclusions
- The key features of the DOS for the asymmetrically doped dot are largely independent of \( c_A \).
- The key features of the DOS for the uniformly gated dot are very dependent on the concentration. The peaks associated with the vortex behavior get completely smeared out.

References