Scanning gate microscopy in graphene nanoribbons and quantum point contacts

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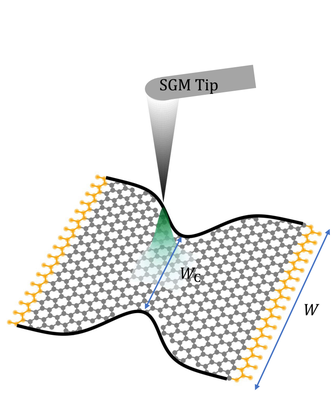
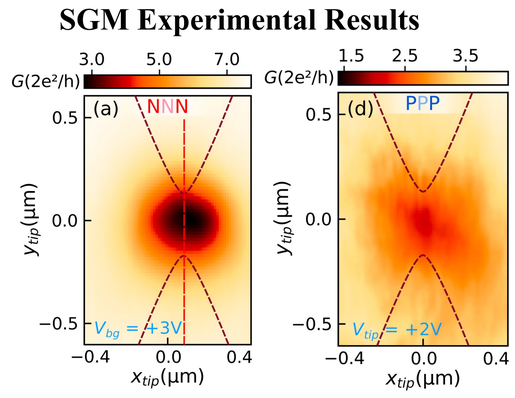
SGM setup





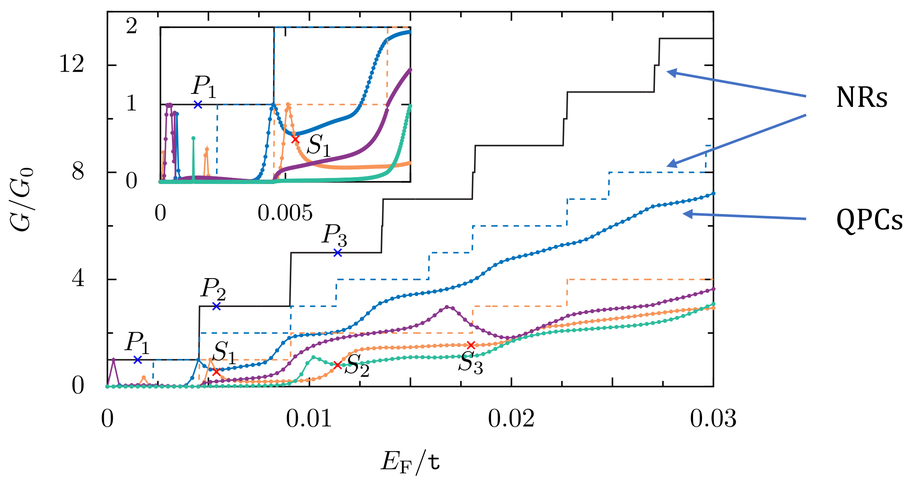
B. Brun, et al, Phys. Rev. B, 2019

Electrostatic potential induced by SGM tip:

$$U_{\mathrm{T}}(\mathbf{r}) = \frac{u_{\mathrm{T}}}{1 + (\mathbf{r} - r_{\mathrm{T}})^2/d^2}.$$

SGM: Scanning gate microscopy
NRs: Nanoribbons
QPCs: Quantum point contacts

Conductance in graphene



$$G = G_0 \mathrm{Tr}\left[t^\dagger t\right],$$
$$G_0 = 2e^2/h.$$

SGM in graphene NRs

Conductance correction

$$\delta T_{\mathrm{NR}} = -4\pi^2 G_0 \mathrm{Tr}\left[\mathcal{U}^{12}\mathcal{U}^{21}\right],$$

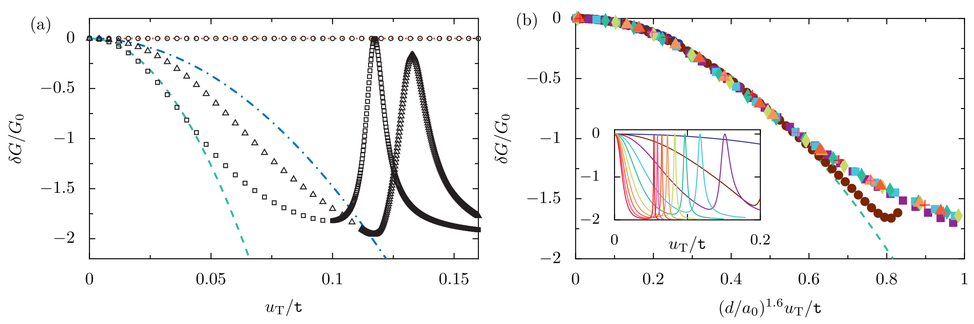
where the matrix elements

$$\mathcal{U}^{\bar{l},\bar{l}'}_{c,c'}(\bar{\varepsilon},\bar{\varepsilon}') = \sum_{m''=0}^{M+1} \int \mathrm{d}y'' \Psi^{\dagger}_{\bar{l},\bar{\varepsilon},c}(m'',y'')\; U_{\mathrm{T}}(m'',y'')\; \Psi_{\bar{l}',\bar{\varepsilon}',c'}(m'',y'').$$

For a given SGM tip,

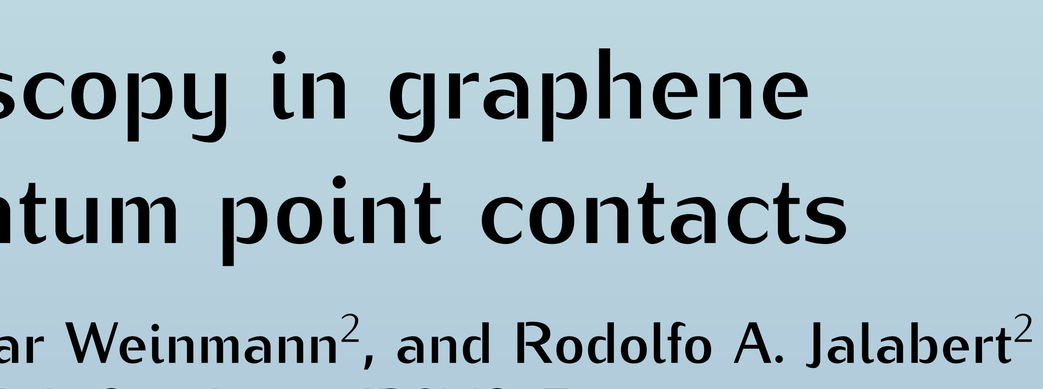
$$\frac{\delta G_{\mathrm{NR}}}{G_0} = -\left(\frac{2u_{\mathrm{T}}d^2}{\hbar v_F W}\right)^2 \sum_a \left(\frac{q_a}{k_a}\right)^2 K_0^2(2k_a d),$$

K_0: the zeroth-order modified Bessel function of second kind.



SGM in graphene NRs

Conductance correction resonance and SGM scan map

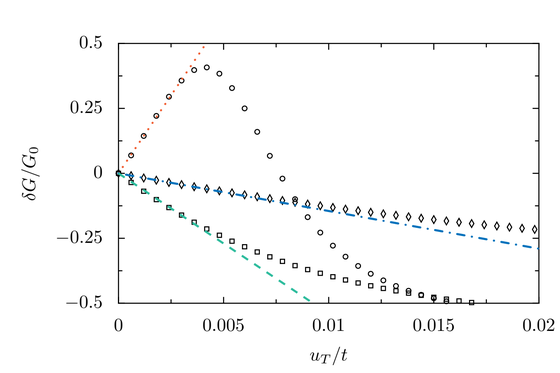


$a_0 = 0.246$ nm: graphene lattice constant

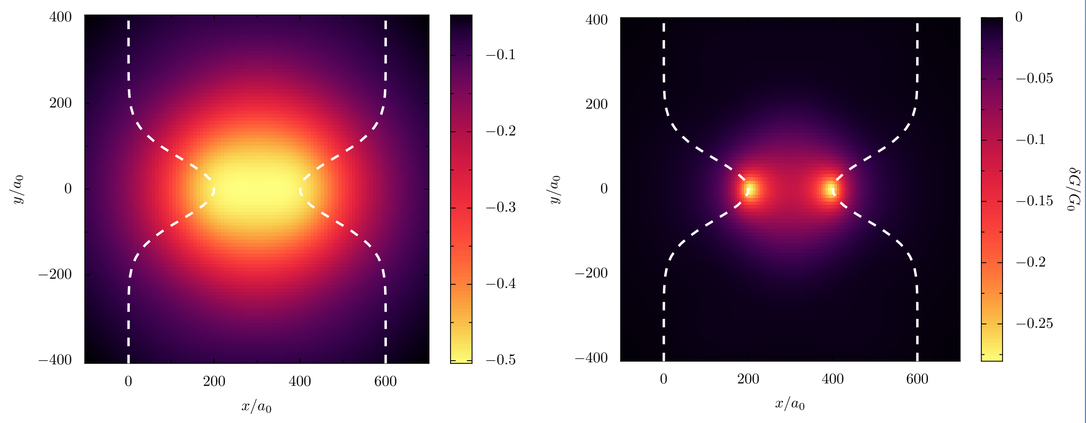
SGM in graphene QPCs

Conductance correction

$$\frac{\delta G_{\mathrm{QPC}}}{G_0} = 4\pi \mathrm{Im}\left\{\mathrm{Tr}\left[t^{\dagger} r' \mathcal{U}^{2,1}\right]\right\}.$$



SGM scan maps with different tip widths



$d = 100\, a_0$ $\qquad$ $d = 20\, a_0$

SUMMARY

- SGM tip induced conductance corrections in graphene NRs and QPCs have been studied
- Conductance correction resonance in graphene NRs have been observed
- Different SGM scan maps in QPCs with different tip widths have been shown

ACKNOWLEDGMENTS

We thank Eros Mariani for useful discussions. This work was supported by NSFC under Grant No. 12047501. X.C. acknowledges the financial support from the China Scholarship Council and the Programme Doctoral International of the University of Strasbourg.

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