Towards a graphene-based quantum interference device

J. Munárriz, A. V. Malyshev and F. Domínguez-Adame

Quantum Nanosystems Group
Departamento de Física de Materiales
Universidad Complutense de Madrid, Spain

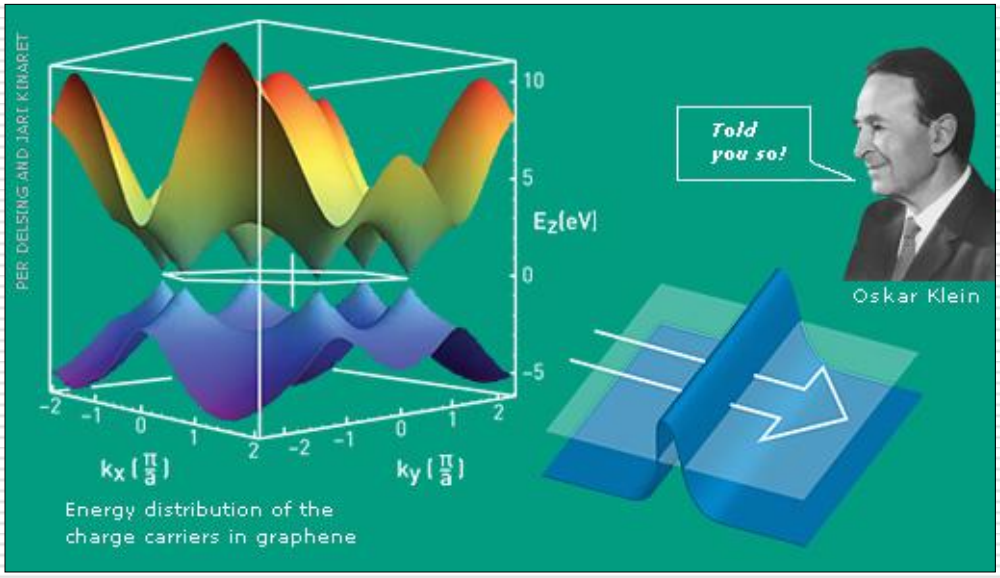
L'Aquila, May 2011

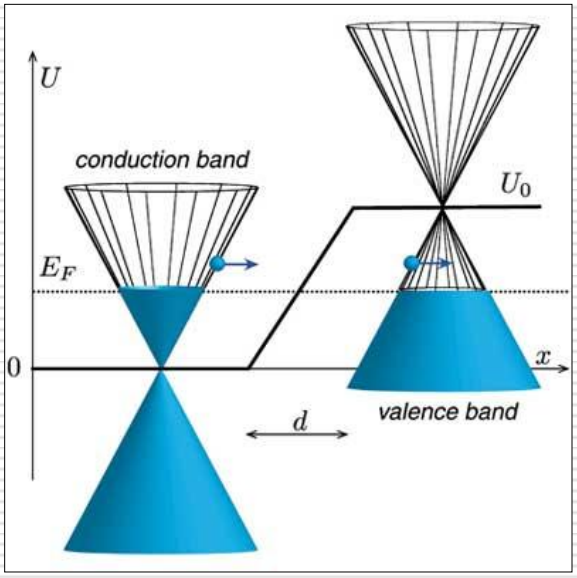
Outline

- Current control in graphene-based devices.
- Quantum rings threaded by a magnetic flux.
- Electric control of the current.
- Transmission and *I*-*V* characteristics.

Current control in graphene-based devices

Klein tunneling (predicted in 1929)

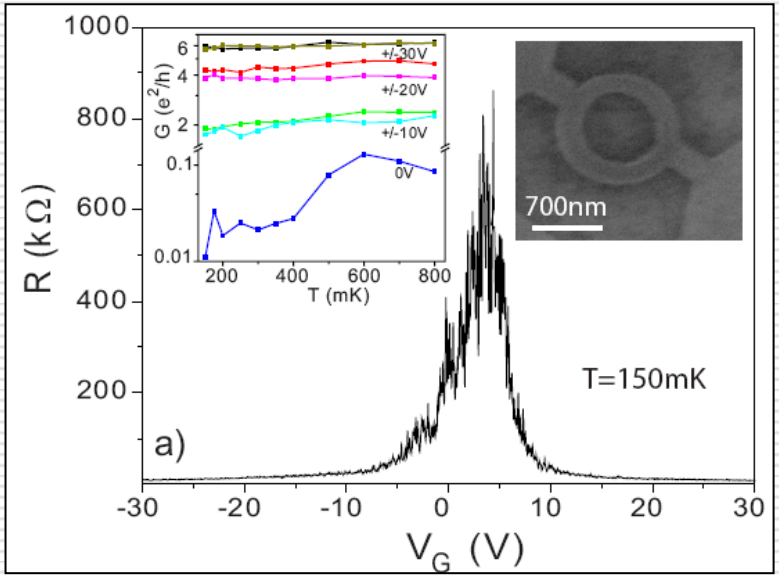


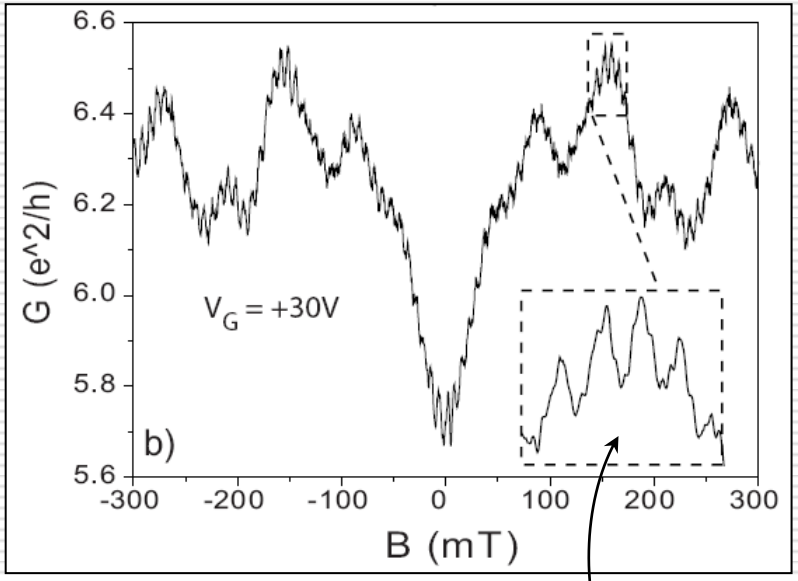


Klein tunneling in graphene

- Theory → Kastnelson *et al*., Nat. Phys. **2**, 620 (2006).
- Experiment → Stander *et al*., Phys. Rev. Lett. **102**, 026807 (2009).

Quantum rings threaded by a magnetic flux

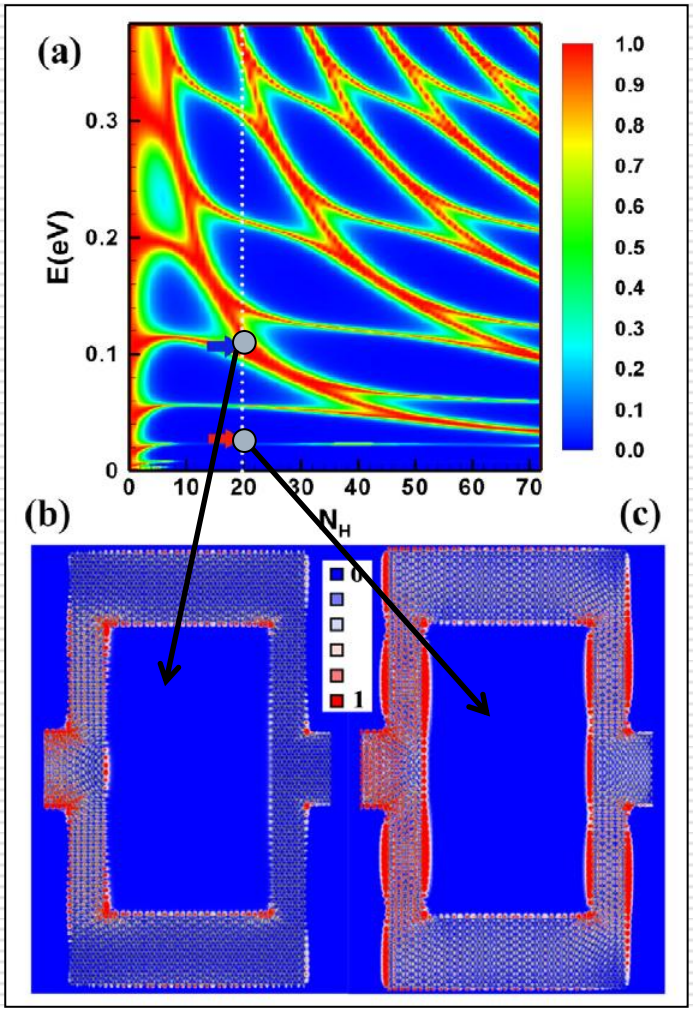


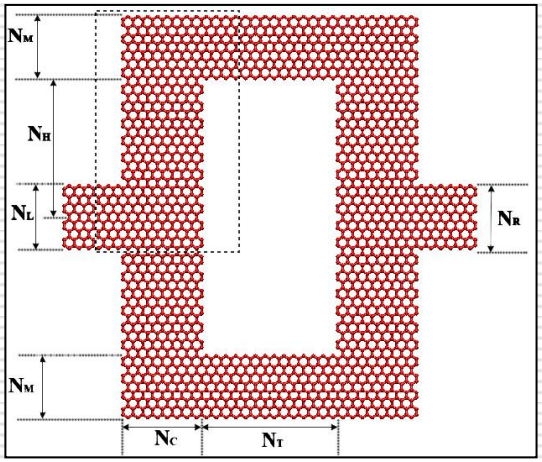


7 mT

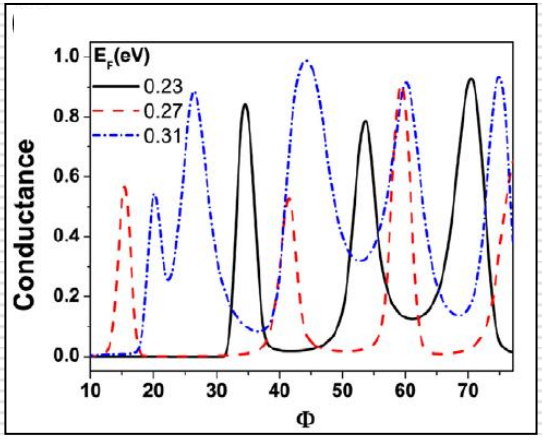
Russo *et al*., Phys. Rev. B **77**, 085413 (2008).

Current control in graphene-based devices



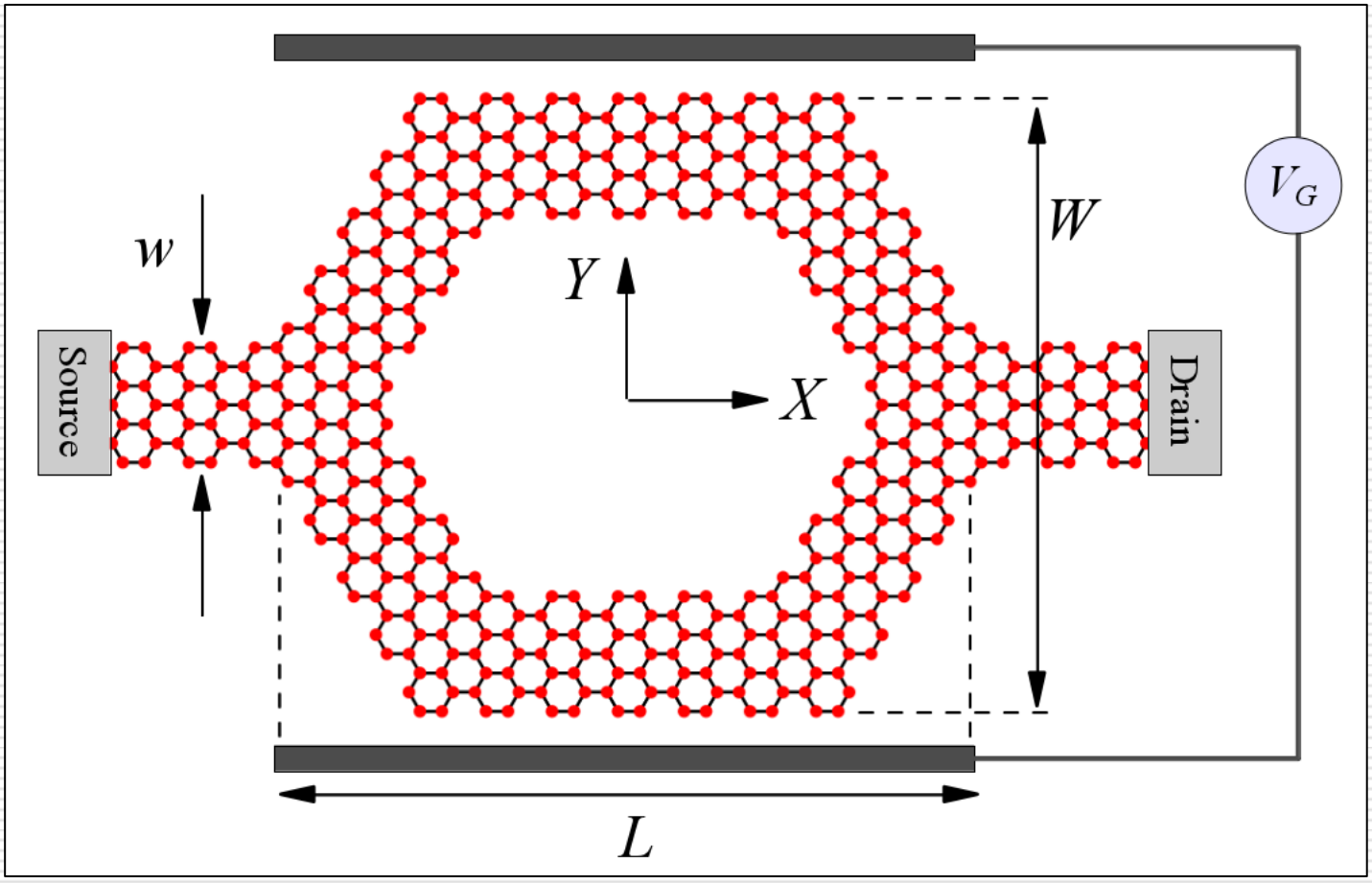


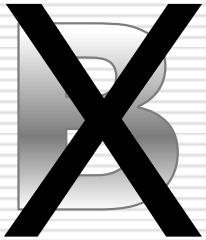
Tight-binding approach



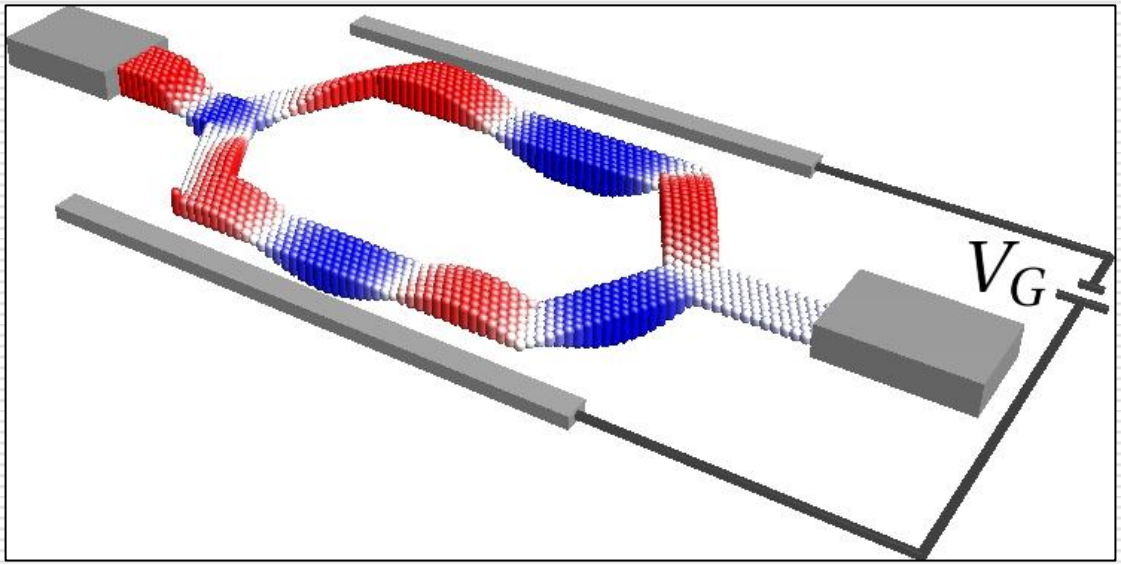
Wu *et al*., Nanotechnology **21**, 185201 (2010).

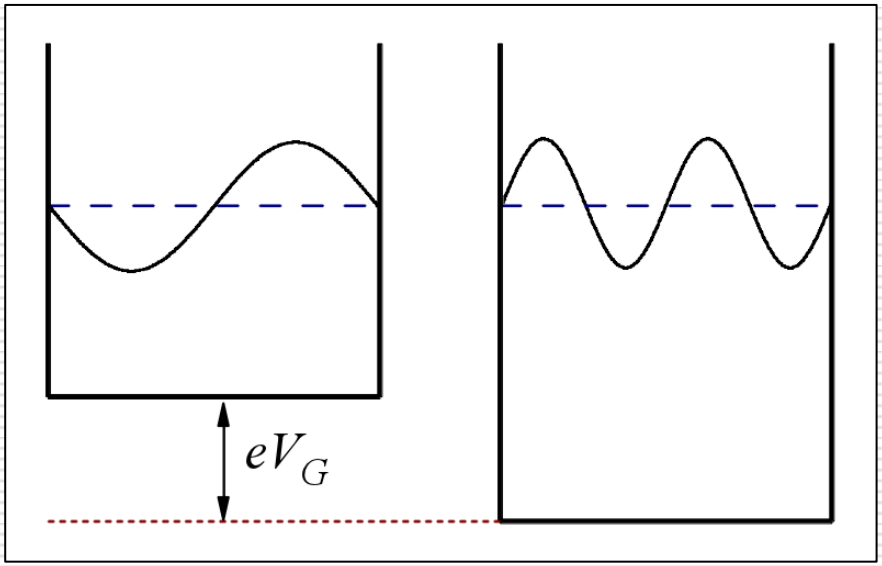
Electric control of the current





Electric control of the current

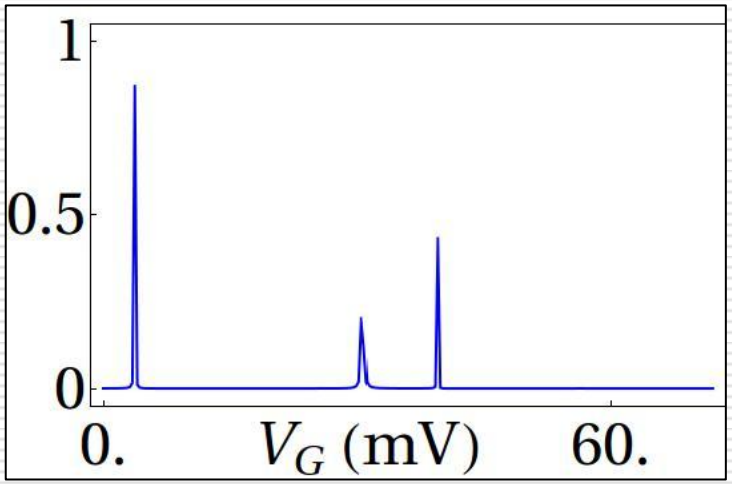


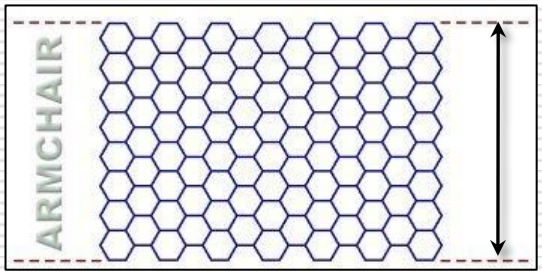


$$H = \sum_i \varepsilon_i c_i c_i^\dagger + \sum_{\langle \hat{\imath}, j \rangle} t_{ij} c_i c_j^\dagger$$

Not uniform !

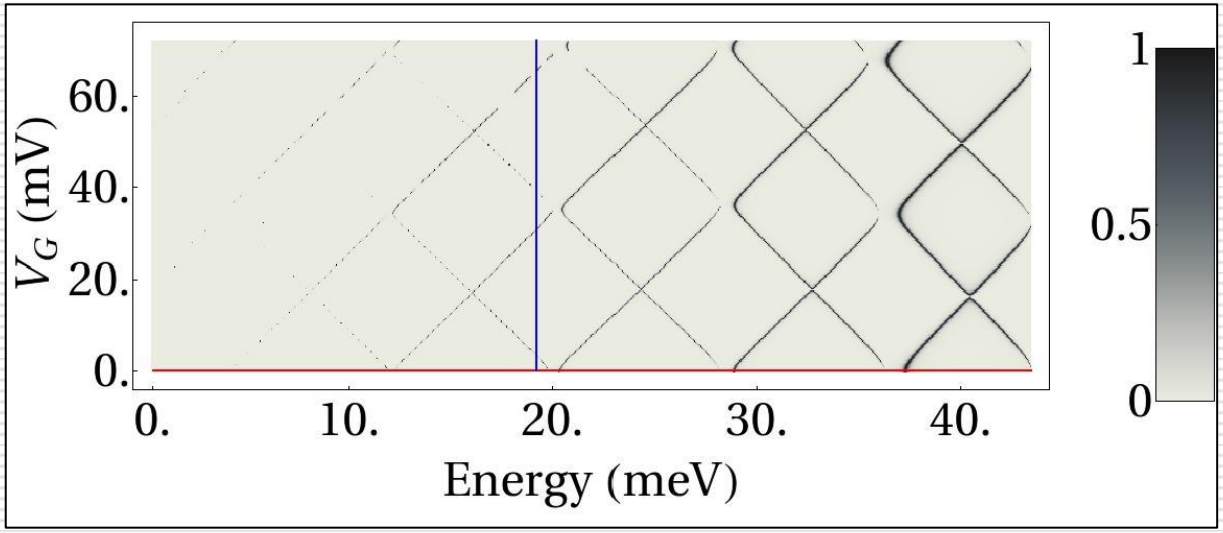
Transmission and I-V characteristics



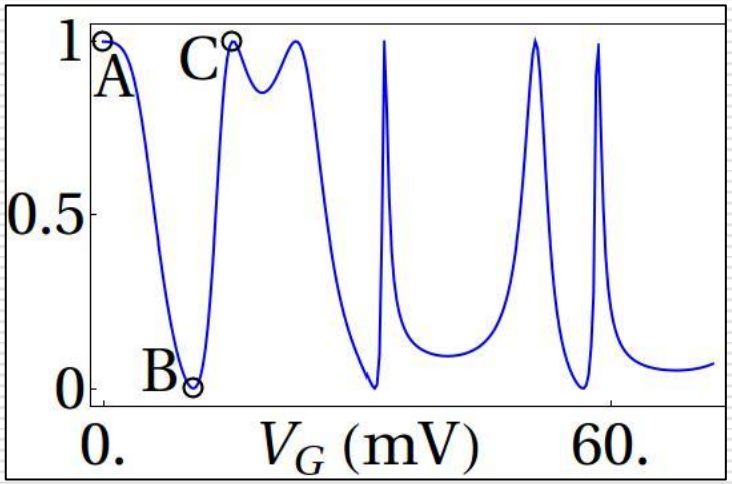


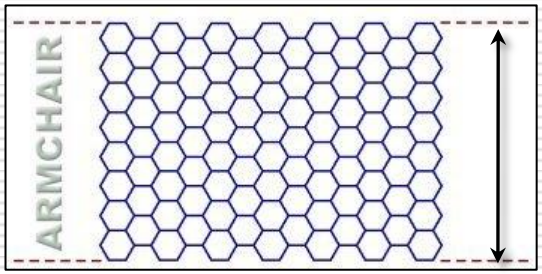
$N = 62$

$N = 3n - 1$ Linear dispersion



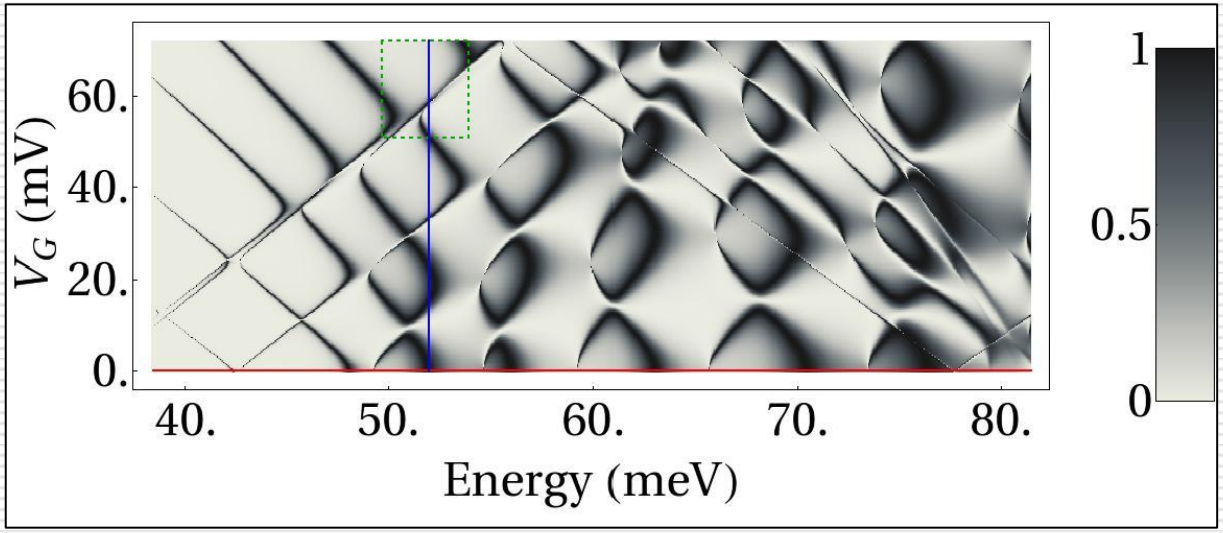
Transmission and I-V characteristics





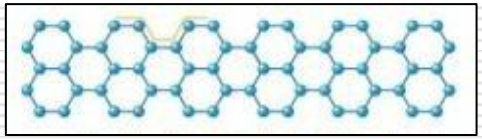
$N = 63$

$N \neq 3n-1$ Quadratic dispersion

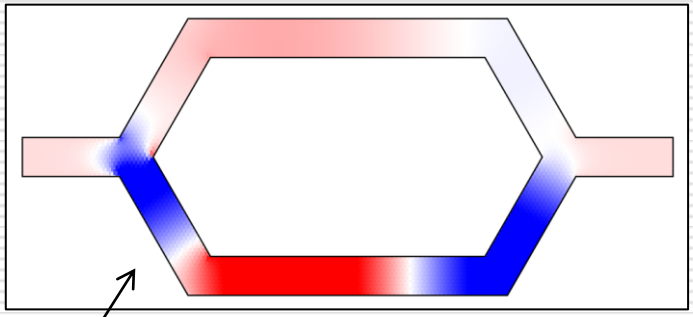


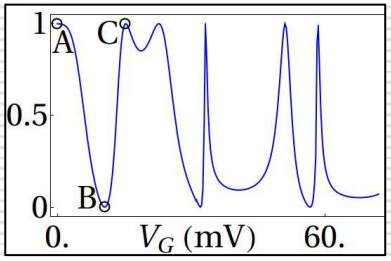
Transmission and I-V characteristics

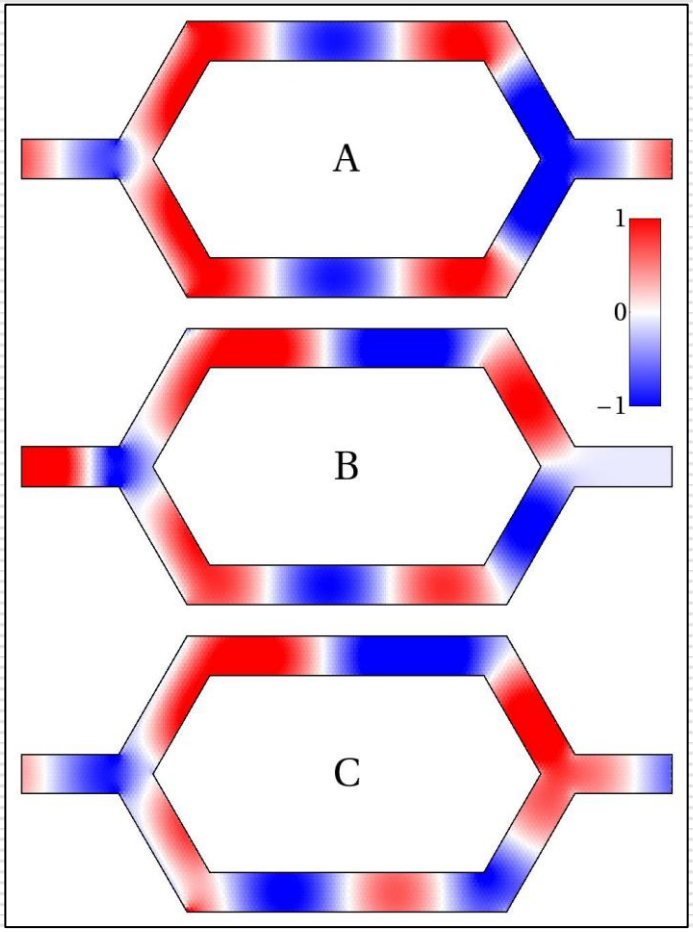
$N = 62$



$N = 63$

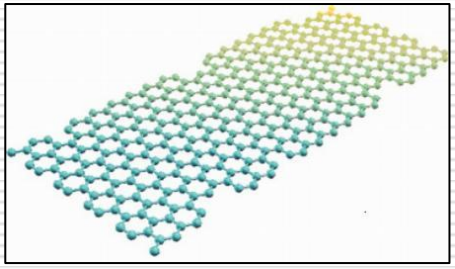


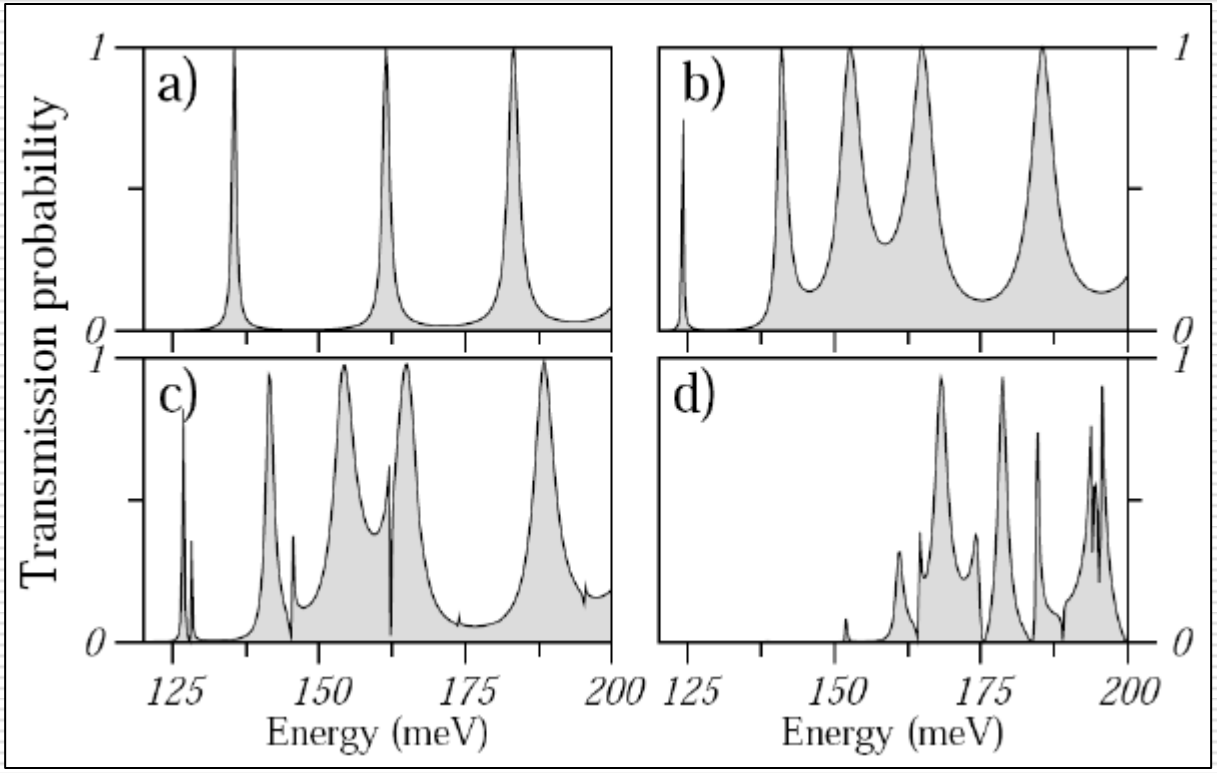




Transmission and I-V characteristics

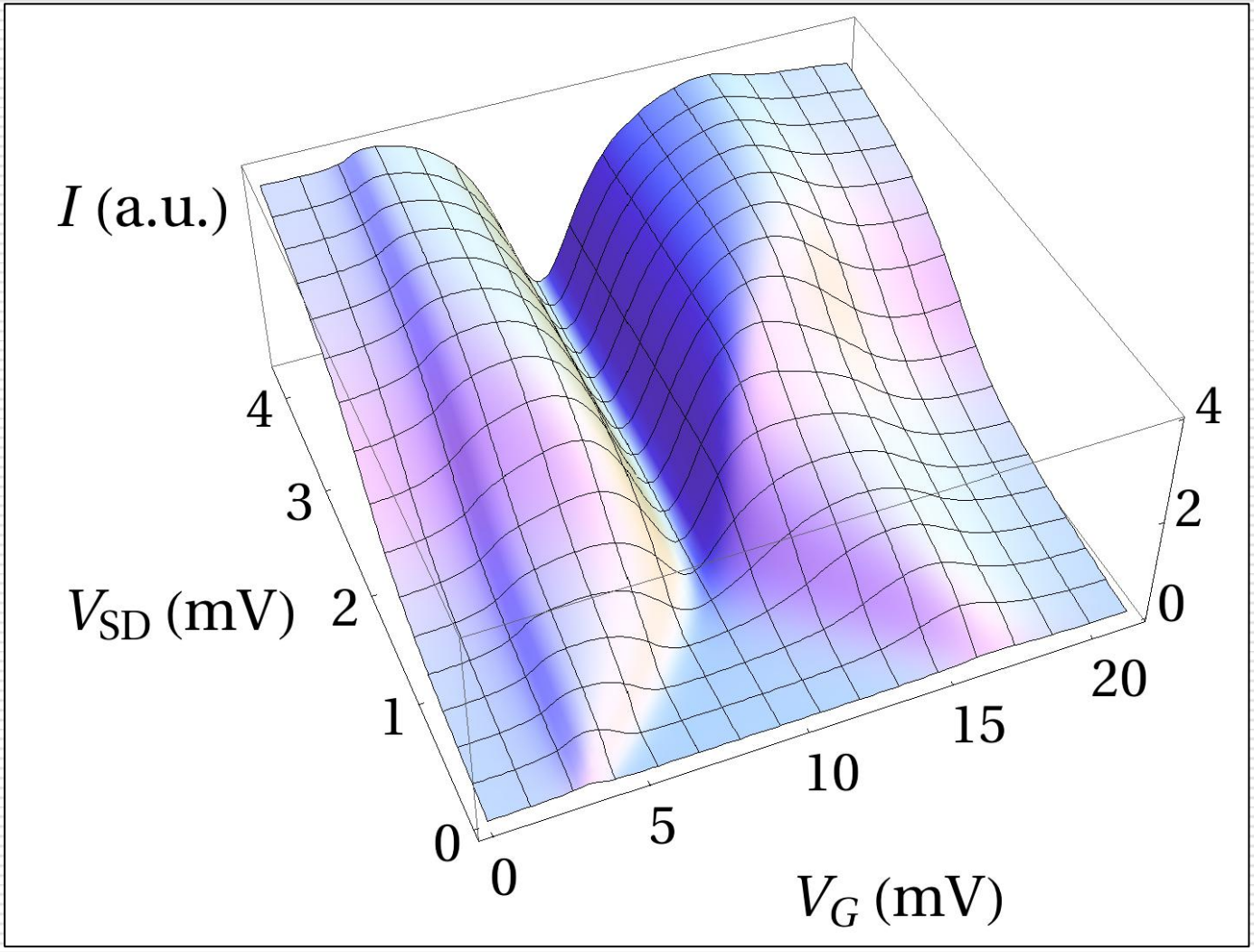
Edge disorder



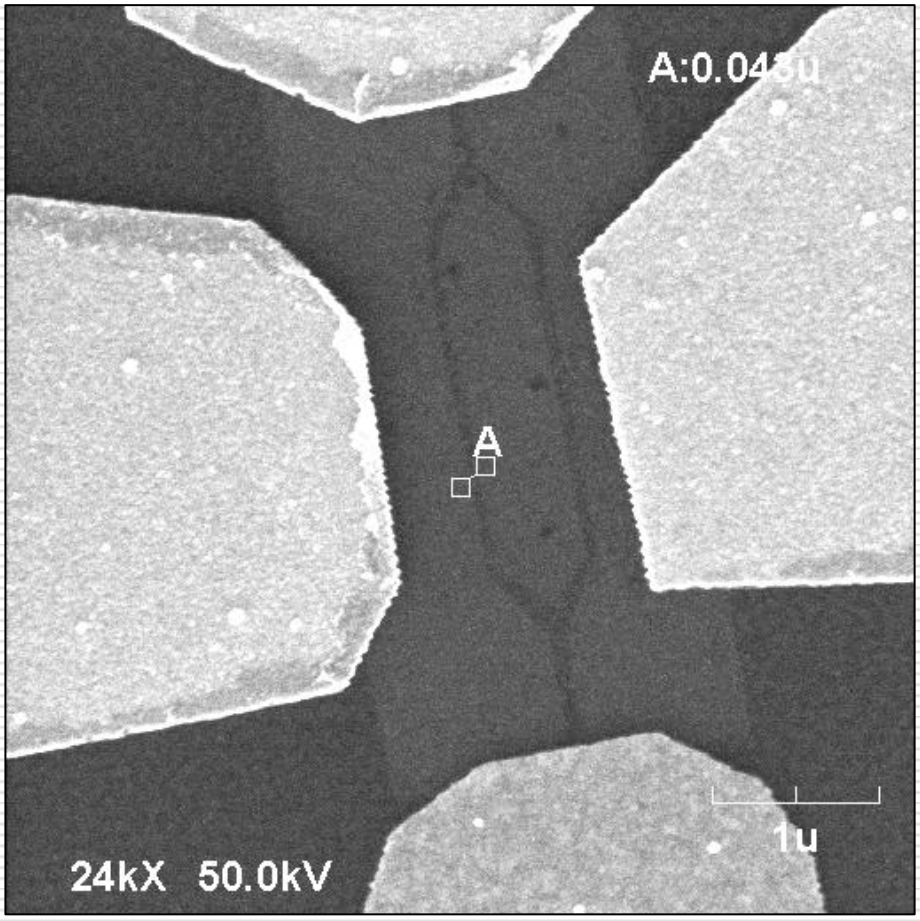


Increasing disorder: a) → b) → c) → d)

Transmission and I-V characteristics



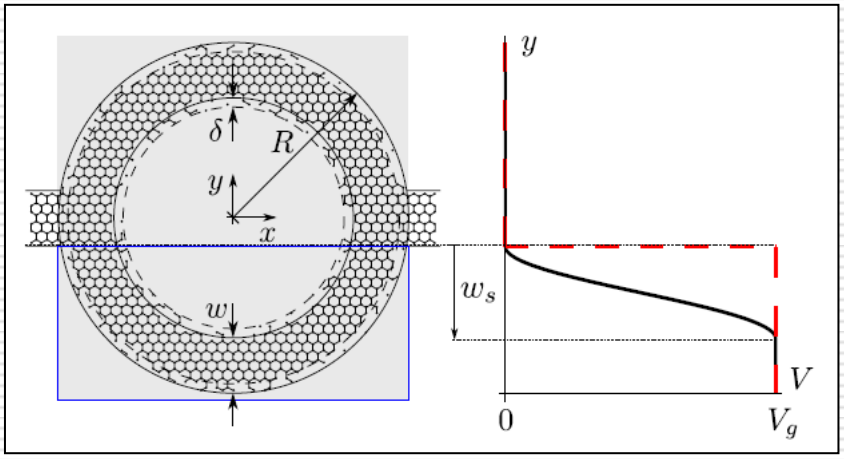
And the actual device…

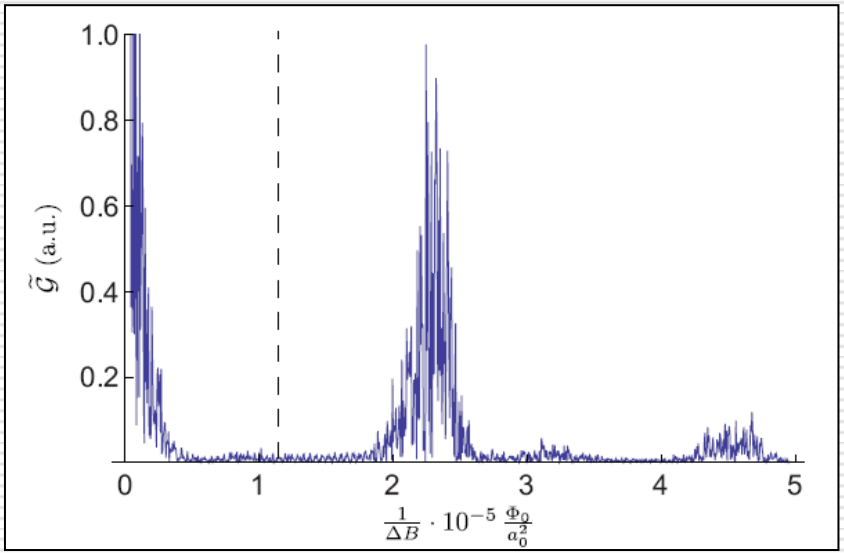


Courtesy of Cayetano Sánchez-Fabrés (U. Salamanca, Spain)

Thank you for your attention

Current control in graphene-based devices





Schelter *et al*., Phys. Rev. B **81**, 195441 (2010).

Transmission and I-V characteristics