# PN Junction Based Devices in Ultra-Clean Graphene

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**Abstract**

Encapsulated or suspended graphene offers a promising platform for **electron optical devices** due the ballistic nature of electron transport. In graphene gapless **pn interfaces** can be formed by electrostatic gating, showing intriguing effects like a negative index of refraction and tunneling with perfect transmission (Klein tunneling). We have developed a versatile technology that allows to suspend graphene and complement it with arbitrary bottom and top-gate structures. Using current annealing we demonstrate **exceptional high nobilities** in monolayer graphene approaching $10^2$ $m^2$/Vs. These suspended devices are **ballistic over micrometer length scales** and display intriguing interference patterns in the electrical conductance when different gate potentials and magnetic fields are applied. Specifically, ballistic electric graphene pn-devices will be discussed, in which one can study **electric analogs** of a **mirror**, a **guiding fiber**, and **Fabry-Perot resonators**, well known in optics. There are great similarities between the propagation of light in a dielectric and electrons in graphene, but also differences. In particular, a negative refractive index is straightforward to realize in graphene, but hard in optics. The effect of a magnetic field on the electron states in ultraclean pn junctions will also be discussed, where one can monitor the evolution from zero-field cavity standing waves and low field cavity modes to the quasicalassical **snake-state** and quantum Hall edge state at higher fields. If time permits, we will also discuss recent results on thermoelctric effects and ground-state properties in **pn-junction based bilayer graphene**.

## References

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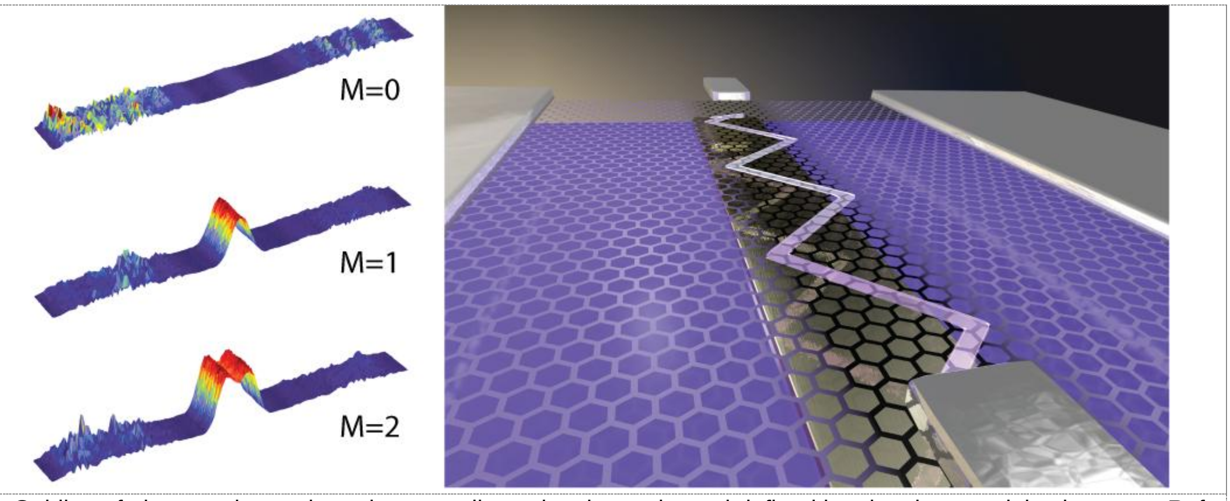


Guiding of electrons in graphene in a one-dimensional pnp channel defined by electric potentials alone, see Ref. [1]

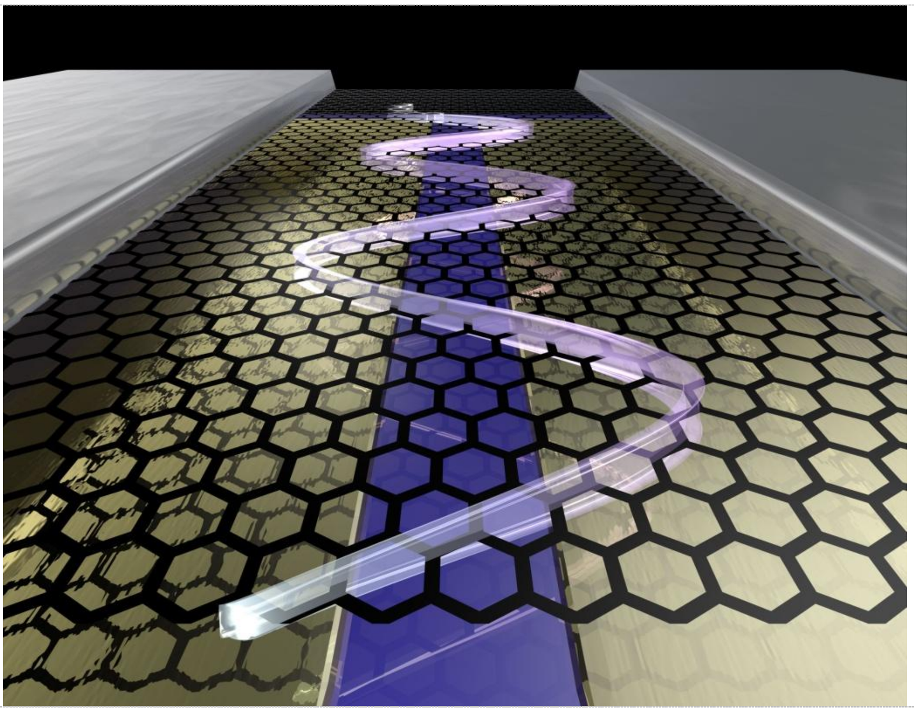

Illustration for snake state at a pn interface in graphene, see Ref. [2]