Valley dependent transport effects in strained graphene

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The low energy bandstructure of graphene allows for exploration of the novel concept of valleytronics where we seek to manipulate the valley degree of freedom in analogy to spin and charge in spintronics and electronics, respectively.
We study the concept of valley manipulation using strain engineering. This exploits that inhomogeneous deformations in graphene give rise to a pseudomagnetic field acting differently on the two valleys. Even tough time reversal symmetry is preserved when considering both valleys, it is broken in each valley independently.
In local deformations we obtain an intriguing combination of very strong and spatially varying fields. We show how the spatially varying strain-induced pseudomagnetic fields cause different trajectories for electrons in the two valleys. This difference leads to valley dependant scattering making the deformation act as a valley filter or splitter [1] (see Figure 1).
In a different regime, we discuss the possibilities to exploit a constant pseudomagnetic field in sample-wide deformations to demonstrate valley Hall effects showing distinct plateaus for each valley in the xy-conductivity (se Figure 2).

We employ novel valley projection techniques allowing us to address the valley degrees of freedom within a real space tight binding framework using effective methods based on the recursive Patched Green's function approach [2] and the Kernel Polynomial Method [3].

References

[1] M. Settnes *et al.* Phys. Rev. Lett. 117(2016), 276801
[2] M. Settnes *et al.* Phys. Rev. B 106(2015), 125408
[3] Jose H. Garcia *et al.* Phys. Rev. Lett. 114(2015), 6602

Figures

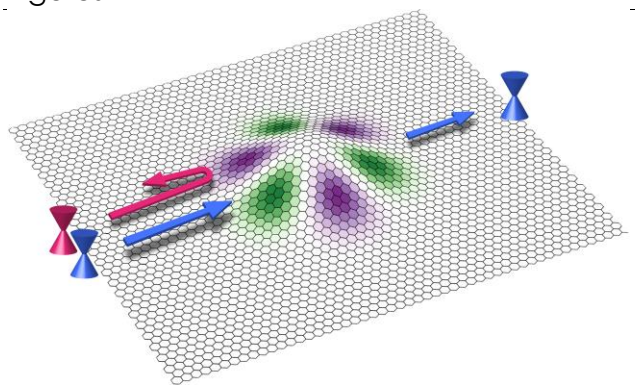

Figure 1: Local deformations in graphene create spatially varying pseudomagnetic fields scattering the two valleys differently. Here we show a Gaussian deformation giving rise to a threefold symmetric pseudomagnetic field (green and purple) acting as a valley filter due to different electron trajectories for K and K' electrons.

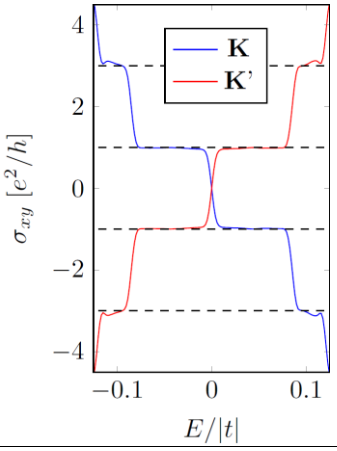

Figure 2: The valley Hall plateaus for each valley in graphene subjected to a strain-induced constant pseudomagnetic field.