A twist, a stretch, and a dislocation: deformations in graphene a few layer graphenes

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Deformations in materials are either perturbative or non-perturbative departures from the high symmetry crystal. Long wavelength ripples in a two-dimensional (2d) membranes belong to the former class, while recently imaged partial dislocations in bilayer graphene belong to the latter class. We will describe a theoretical approach [1] capable of treating both perturbative and non-perturbative deformations on an equal footing, and give examples of both in the form of partial dislocations, twist stacking faults, and deformations in single layer graphene.

In 2d systems non-perturbative deformations such as partial dislocations may qualitatively change the electronic structure and transport properties, for example in both bilayer graphene on SiC [2] and suspended bilayer graphene [3]. The latter case is particularly interesting as charge transport at the Dirac point exhibits two dramatically different transport states, insulating and metallic, that occur in apparently otherwise indistinguishable experimental samples [4]. We discuss how the existence of these two transport states has its origin in an interplay between evanescent modes, that dominate charge transport near the Dirac point, and disordered configurations of extended defects in the form of partial dislocations (Figure 1).

A mutual rotation between two layers of graphene is one of the richest examples of the connection between stacking and electronic properties. We present two examples of this through the small angle twist bilayer in out-of-plane electric and magnetic fields. In the latter case the field results in an ordered array of permanent current loops throughout the material, while in the former one finds that the electric field reconstructs the Fermiology to an almost perfect and controllable nesting geometry.

Finally, we will discuss deformations in single layer graphene based on a theory that includes a full treatment of both acoustic as well as optical deformation modes, finding a rich physics associated with the coupling of these modes in out-of-plane deformations.

References

[1] N. Ray *et al*. arXiv:1607.00920
[2] F. Kisslinger, C. Ott, C. Heide, E. Kampert, B. Butz, E. Spiecker, S. Shallcross, H. B. Weber, Nature Physics 11, 650 (2015).
[3] Sam Shallcross, Sangeeta Sharma, Heiko Weber Nature Communications 8 (1), 342 (2017)
[4] W. Bao et al. Proceedings of the National Academy of Sciences 109, 10802-10805 (2012)

Figures

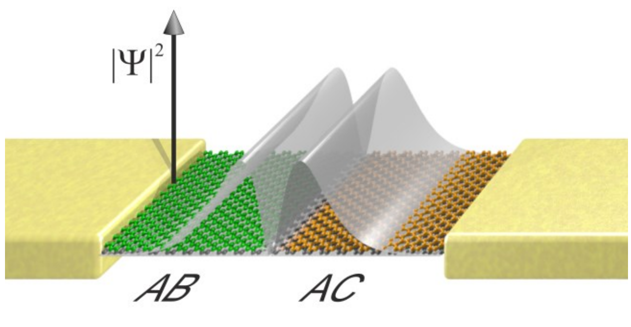

Figure 1: Interplay between partial dislocations and evanescent modes in graphene close to the Dirac point: each partial acts as a "pinning" centre for a evanescent wave.