Making and Using Beams of Electrons in Graphene

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As soon as graphene was isolated, researchers began dreaming about the remarkable electron optics they might expect, including Klein tunnelling and negative refraction. Until recently, these remained mostly out of reach, since electronic mean free paths were well below a micron. Some clever experiments tested[1,2] ballistic transport on very short length-scales, but with advances[3] in the past few years, mean free paths of tens of microns are now consistently achievable, opening up many new possibilities. In our quest to realize these possibilities and build electron optical elements in graphene, we face a formidable challenge: electrons in graphene cannot be readily confined by electrostatic gates. I will tell about our attractively simple, gate-free means of generating collimated electron beams[4] and how these beams can be used to directly probe angularly dependent phenomena, in particular Klein tunnelling. Further, I'll show how we use scanning gate microscopy to image how electrons can follow non-circular cyclotron motion[5] in graphene-based superlattices.

References:

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[3] CR Dean *et al,* Nat. Nano. **5** (2010), p. 722.
[4] AW Barnard *et al*, Nat. Comm. **8** (2017), p. 15418.
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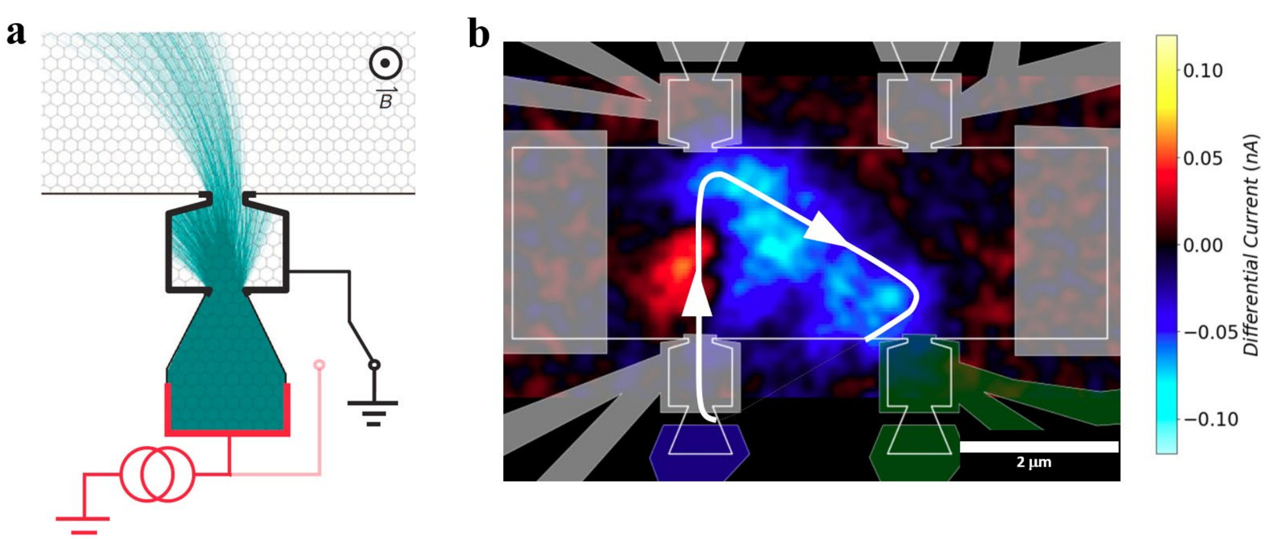

Figure 1. **a**) Schematic of an electron collimator source for controlling ballistic transport in graphene. **b**) Scanning gate microscopy image of non-circular cyclotron motion in a graphene-based superlattice device. White line indicates expected cyclotron orbit based on band structure calculations.