Gate-defined quantum point contact in high mobility graphene

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Since its discovery a decade ago, graphene has opened the field of 2D materials and is still of great importance for fundamental and applied physics. In particular, its gapless linear energy dispersion gives access to the new physics of Dirac fermions. However, the absence of gap is also detrimental to the engineering of advanced nanostructures. Indeed, nano-patterning in most two dimensional electron gases relies on electrostatic gating to taylor the electron gas, or the guiding of edge channels in the quantum Hall regime, by depleting the electron gas underneath them. In graphene, electrostatic gating only creates p-n junctions, that are highly transparent due to Klein tunneling. This impairs the development of devices, and especially of quantum point contacts, which are an important tool for many quantum transport studies (quantum Hall interferometry, shot noise experiment, etc...). Even in the quantum Hall regime, the fact that the N=0 Landau level is shared between electrons and holes prevents from getting quantized transport through a constriction. This limitation can however be overcome, by using high mobility heterostructures, where all degeneracies can be lifted with holes and electrons edge channels physically separated.

Here we present the magnetic field dependence of a gate-defined constriction in high mobility graphene heterostructures. At low magnetic field, transport is characterized by ballistic Fabry-Pérot resonances in the n-p-n cavity created by the top-gates and no quantization is observed. Specific graphene properties can be evidenced through the study of these oscillations, such as graphene Berry phase, evidenced by a typical phase shift. Upon increasing the magnetic field, Fabry-Pérot oscillations vanish and are replaced by Landau levels oscillations in the constricted region. In the quantum Hall regime, spin and valley degeneracies are lifted, and the transport happens through the constriction. In this regime, we demonstrate the gate-tunable selective transmission of integer and fractional quantum Hall edge channels through the quantum point contact, and the possibility to fully pinch-off the constriction [1]. This gate control of the edge channel transmission opens the door to quantum Hall interferometry and electron quantum optics experiments in graphene.

[1] Zimmermann et al., Nature Communications 8, 14983 (2017)