Tunnelling spectroscopy of the graphene quantum Hall topological insulator

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Charge neutral graphene develops a quantum Hall topological insulator phase when the Coulomb potential is screened by a high-k dielectric environment. This phase features spin-filtered helical edge channels and exhibits the quantum spin Hall effect [1], which are of high interest for spintronics and topological superconductivity. The topological gap that opens in the bulk of this quantum Hall topological insulator cannot, however, be quantitatively measured by transport measurements. In this work we present STM spectroscopy performed on high-mobility graphene devices with a home-made hybrid AFM-STM operating at 4 K and up to 14 T. Using $SrTiO_3$ high-k dielectric as a substrate, we screen the long-range Coulomb interaction to induce the quantum Hall topological insulator phase in the zeroth Landau level of graphene. We carry out high-resolution Landau level spectroscopy in the bulk graphene. Tuning the charge carrier density with a back-gate enables us to unveil the pinning of the Fermi level in the Landau levels, a key phenomenon in the quantum Hall physics that indicates the high quality of our sample. When the Fermi level fills the zeroth Landau level, we observe the opening of the spin gap at charge neutrality, resulting from the Stoner instability. This gap is found to be in good agreement with the Coulomb energy scale that takes into account the screening dielectric environment.

References

[1] L. Veyrat et al, *Helical quantum Hall phase in graphene on $SrTiO_3$*, arXiv:1907.02299 (2019).

Figures

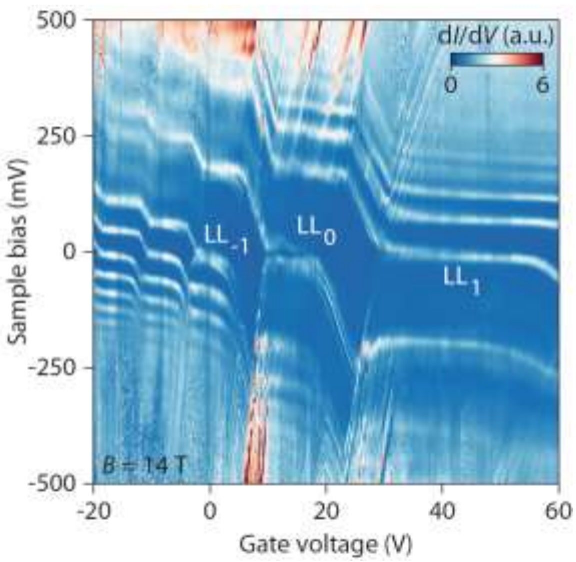

Figure 1: Gate map spectroscopy at 14 T showing the successive pinning of the Fermi energy inside the Landau levels of graphene.