Open-orbit induced extreme magnetoresistance and fractional Chern insulator signatures in low field graphene/h-BN superlattices

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We report on the previously unexplored low magnetic field regime in ultrahigh-quality graphene/h-BN superlattices where intrinsic band structure details appear to play a pivotal role. For magnetic fields as low as 0.1-1 Tesla, we uncover a pronounced extreme magnetoresistance pattern, attributed to the formation of open orbits at Lifshitz transitions through a real-space analysis of the current densities that reflects quantum effects. These measurements seminally provide a truly 2D experimental realization of the 2D theoretical models that are often used to model such orbits. We also observe a Landau level splitting near the secondary Dirac point in monolayer graphene, indicative of trigonal warping effects and the emergence of fractional Chern insulating behavior at low field. Based on semi-classical arguments we show that Fermi surfaces of overlapping minibands near saddle points naturally give rise to non-linear Landau level dispersions. Additionally, a transition from linear to parabolic Landau level dispersion is uncovered, a phenomenon we link to miniband overlap through a semiclassical analysis. Our combined theoretical-experimental study provides insights into the intricacies of the low-field fractal spectrum ahead of the quantum Hall regime.

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References

[1] Z. Wang *et al, arXiv:2312.07004, 2023*

Figures

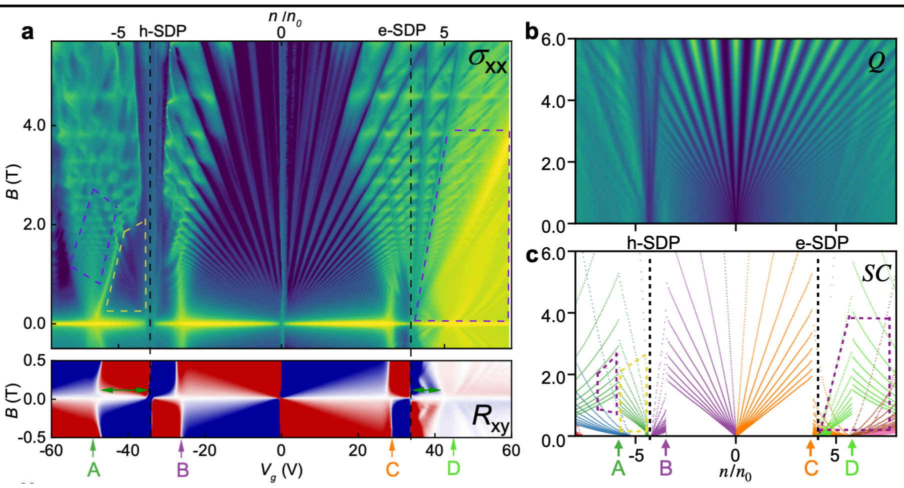

Figure 1: Comparison between experimental observations (a) and quantum (b) and semi-classical (c) predictions illustrating the different observables mentioned in the abstract.