Role of Lifshitz transitions and Berry curvature dipole on nonlinear Hall effect in low symmetry Bilayer graphene

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Abstract

The second harmonic (2ω) nonlinear Hall effect (NLHE) [1,2] can potentially bring a new paradigm in logic and energy-harvesting technologies by replacing the age-old interface-based devices with their bulk crystal-based counterparts [3]. On the other hand, NLHE is extremely sensitive to the geometry of the Fermi surface. NHLE can provide rich information on the locations of saddle points [4] and flat bands and directly probes topological phase transitions in atomically thin Chern insulators [5]. Obtaining such information on electronic properties is crucial in the case of heterostructures of atomically thin quantum materials, where structural symmetry engineering and thermo-dynamically tunable complex quasiparticle bands coexist. In this work, we experimentally study NLHE on inversion symmetry broken high-quality bilayer graphene (BLG) as a function of doping (n) dielectric displacement filed (D) and temperature (T). Our results reveal an unforeseen duopoly of extrinsic scattering and interfacial strain-induced intrinsic Berry curvature dipole (BCD), whose sign and magnitude can be tuned by n and/or D near the low energy band edge of BLG. Away from the band edge, the NLHE is observed to be dominated by the extrinsic scattering. The second harmonic generation efficiency $V_{XX(Y)}^{2\omega}/V_{XX}^{\omega\ 2}$ in BLG is ~ 50 V^{-1}, highest among all scalable materials. Moreover, n − D dispersion of the sign change of $V_{XX(Y)}^{2\omega}$ traces out the topologically relevant Lifshitz transitions in BLG. Our work establishes BLG as a highly tunable platform to generate NLHE, which in turn probes the fascinating low-energy electronic structure in Bilayer graphene.

References

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Figures

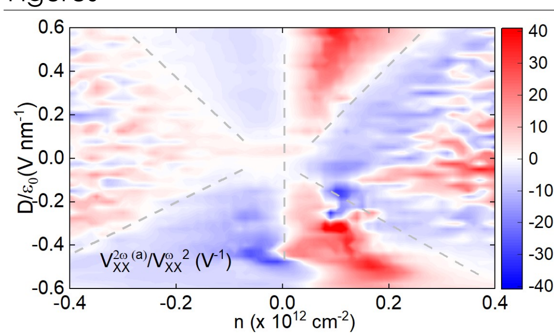

Figure 1: n-D phase space of $V_{XX}^{2\omega}/V_{XX}^{\omega\ 2}$ collected from one of our samples. The dashed lines indicate sign changes at charge neutrality and at Lifshitz transitions.