

Nonlinear quantum Hall effect from a bulk Chern–Simons theory

Habib Rostami¹

¹University Of Bath, Bath, United Kingdom

Recent experiments have reported quantized plateaus in nonlinear currents induced by a low-frequency drive in a magnetic-field-induced insulating regime of graphene [1]. These observations have primarily been interpreted in terms of edge-state transport. In contrast, we have recently shown [2] that quantized plateaus in the nonlinear conductivity can also arise from a purely bulk description in an extended two-dimensional quantum Hall system with broken inversion symmetry.

We develop a quantum field-theoretic description of the nonlinear quantum Hall effect by extending the Ginzburg–Landau–Chern–Simons action to include the leading nonlinear couplings in a time-reversal-symmetric, two-valley tilted-Dirac system that lacks inversion and rotational symmetries. This framework captures the role of intrinsic quantum geometry in the second-order Hall response. In the quantum Hall regime, for drive frequencies well below the Landau-level spacing, we predict that the second-order Hall current exhibits quantized integer and fractional plateaus that scale with Landau-level filling through the Chern–Simons coefficient. Applied to an experimentally relevant tilted Dirac model (as in 1T′–WTe₂), we find that these nonlinear plateaus are robust against both tilt and finite drive frequency, providing clear experimental fingerprints. Our results establish nonlinear spectroscopy as a direct bulk probe of quantization in nonlinear quantum Hall transport.

References:

[1] P. He, H. Isobe, G. K. W. Koon et al., *Nat.Nanotechnol.*19, 1460–1465 (2024).

[2] L. Pimlott, P. Reiser, T. H. Hansson, H. Rostami, manuscript in preparation (to be submitted).