Real-Space Approach to Light-Induced Hall Transport in Disordered Materials

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We present a linear-scaling real-space methodology for computing time-resolved electrical responses in far-from-equilibrium materials, treating energy relaxation and disorder non-perturbatively on equal footing. Applied to AB-stacked bilayer graphene under circularly polarized optical driving, this reveals a dynamical Hall conductivity, previously observed and predicted in graphene [1,2] that oscillates at twice the driving frequency and persists post-pulse before thermalizing, Figure 1. Remarkably robust against realistic disorder, this response suggests disorder and relaxation as tunable design parameters for nonequilibrium topological transport. Our framework enables exploration of light-driven electrical phenomena in complex disordered quantum materials, opening pathways to ultrafast optoelectronic devices.

References

[1] T. Oka and H. Aoki, Physical Review B 79, 081406 (2009)

[2] J. W. McIver, B. Schulte, F.-U. Stein, T. Matsuyama, G. Jotzu, G. Meier, and A. Cavalleri, Nature Physics 16, 38 (2020)

Figures

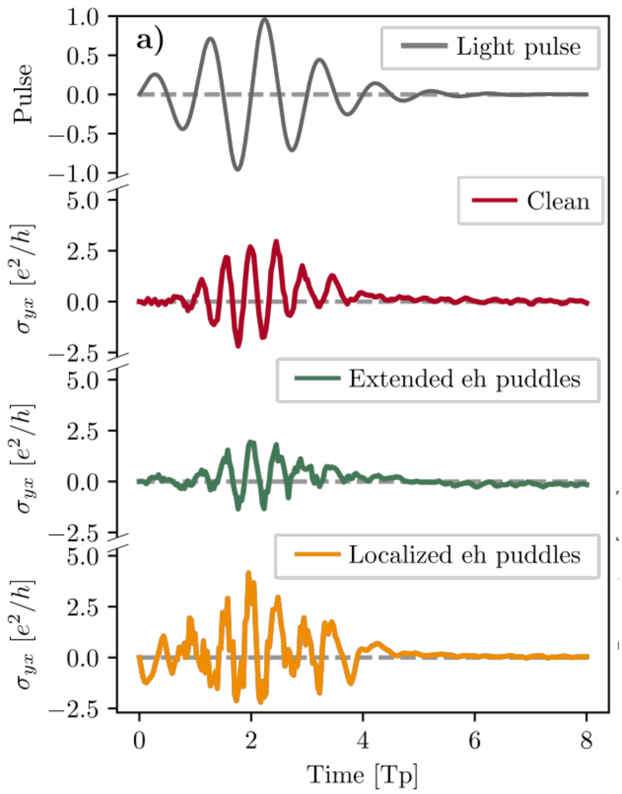

Figure 1: Time dependence of the applied light pulse in gray, and the Hall conductivity in red, green, and yellow for the clean system, extended electron-hole puddles, and localized electron-hole puddles, respectively, at μ = 0 eV.