Imaging the Local Band Topology and Chern Mosaic in Magic-Angle Graphene

Eli Zeldov

Department of Condensed Matter Physics, Weizmann Institute of Science, Rehovot, Israel

Topology is a key element governing the electronic and magnetic properties of 2D moiré materials. The topological electronic bands are classified by their Chern number C, which is considered to be a global topological invariant. The Chern number is governed by the Berry curvature that leads to orbital magnetization. Utilizing a scanning superconducting quantum interference device on a tip (SQUID-on-tip), we image the Berry-curvature-induced equilibrium orbital magnetization in magic-angle graphene, thus providing new means to resolve the local band topology on the nanoscale [1]. At integer filling $\nu=1$, we observe a zero-field Chern insulator, which rather than being described by a global topologically invariant C, forms a Chern mosaic of microscopic patches of C= -1, 0, or 1, the boundaries of which carry chiral edge states. Upon further filling, we find a first-order phase transition due to recondensation of electrons from valley K to K', leading to irreversible flips of the local Chern number and magnetization, and to the formation of valley domain walls giving rise to hysteretic anomalous Hall resistance. The findings shed new light on the structure and dynamics of topological phases in moiré devices.

[1] S. Grover, M. Bocarsly, A. Uri, P. Stepanov, G. Di Battista, I. Roy, J. Xiao, A. Y. Meltzer, Y. Myasoedov, K. Pareek, K. Watanabe, T. Taniguchi, B. Yan, A. Stern, E. Berg, D. K. Efetov, and E. Zeldov, Nature Physics **18**, 885 (2022).