Integer and Fractional Quantum Anomalous Hall Effects in Crystalline Graphene

L. Ju[1], T. Han[1], Z. Lu[1], Y. Yao[1], A.P. Reddy[1], J. Yang[1], J. Seo[1], G. Scuri[2,3], J. Sung[2,3], J. Wang[2,3], T. Han[1], C. Yoon[4], K. Watanabe[5], T. Taniguchi[6], H. Park[2,3], F. Zhang[4], L. Fu[1]

[1]*Department of Physics, Massachusetts Institute of Technology, Cambridge, MA, USA*
[2]*Department of Chemistry and Chemical Biology, Harvard University, Cambridge, MA, USA*
[3]*Department of Physics, Harvard University, Cambridge, MA, USA*
[4]*Department of Physics, The University of Texas at Dallas, Richardson, TX, USA*
[5]*Research Center for Electronic and Optical Materials, National Institute for Materials Science, Tsukuba, Japan*
[6]*Research Center for Materials Nanoarchitectonics, National Institute for Materials Science, Tsukuba, Japan*
longju@mit.edu

The fractional quantum anomalous Hall effect (FQAHE), the analog of the fractional quantum Hall effect at zero magnetic field, is predicted to exist in topological flat bands under spontaneous time-reversal-symmetry breaking. The demonstration of FQAHE could lead to non-Abelian anyons which form the basis of topological quantum computation. In this talk, I will first report the observation of a QAH state with Chern number C=5 in rhombohedral pentalayer graphene/WS_2. The underlying mechanism is distinct from magnetic topological insulator and 2D moiré superlattice materials, but similar to the Haldane model. Then I will report the observation of integer and fractional QAH effects in a rhombohedral pentalayer graphene/hBN moiré superlattice. At zero magnetic field, we observed plateaus of quantized Hall resistance at filling factors v = 1, 2/3, 3/5, 4/7, 4/9, 3/7 and 2/5 of the moiré superlattice. Our graphene system provides an ideal platform for exploring charge fractionalization and (non-Abelian) anyonic braiding at zero magnetic field, especially considering a lateral junction between FQAHE and superconducting regions in the same device.

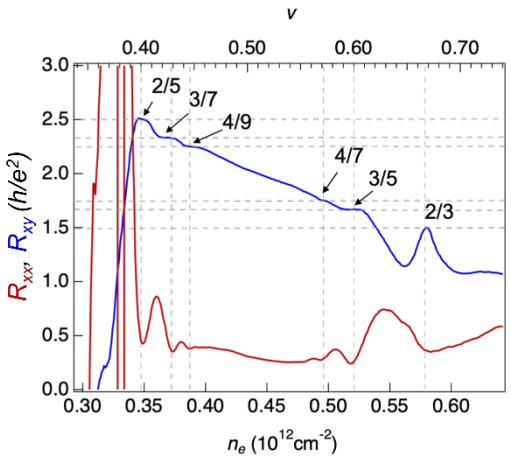

Figure 1. R_{xx} and R_{xy} of rhombohedral pentalayer graphene as function of the charge density n_e and moiré filling factor ν, featuring plateaus of R_{xy} at 6 fractional filling factors and corresponding dips in R_{xx}.

References

[1] Han, T., Lu, Z., Scuri, G. et al. Nat. Nanotechnol. 19, 181–187 (2024).
[2] Han, T., Lu, Z., Scuri, G. et al. Nature 623, 41–47 (2023).
[3] Han, T., Lu, Z., Yao, Y. et al. Science in press. arXiv preprint arXiv:2310.17483 (2023).
[4] Lu, Z., Han, T., Yao, Y. et al. Nature 626, 759–764 (2024).