Energy dissipation on magic angle twisted bilayer graphene

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Understanding nanoscale energy dissipation is nowadays among few priorities particularly in quantum systems. While traditional Joule dissipation omnipresent in today's electronic devices is well understood, the energy loss of the strongly interacting electron systems remains largely unexplored. Twisted bilayer graphene (tBLG) is a host of interaction-driven correlated insulating phases, when the relative rotation is close to the magic angle (1.08°) [1]. Here, we report on low temperature (5K) nanomechanical energy dissipation of tBLG measured by sharp tip of the pendulum atomic force microscope (pAFM). Ultrasensitive cantilever tip acting as an oscillating gate over the quantum device shows dissipation peaks attributed to different fractional filling of the flat energy bands. While conventional transport methods provide quantitative information on correlated insulating states in tBLG, they lack spacial resolution. pAFM, on the other hand, provides exquisite spatial resolution and thus allows to determine the twist angle distribution of tBLG. It does it without literally touching the sample surface and the tBLG correlated phases are all accessed through the cantilever dynamics without involving any electrical current detection. Application of magnetic fields provoked strong oscillations of the dissipation signal at 3/4 band filling, which we identified as familiar to Aharonov-Bohm oscillations arising from wavefunction interference present between domains of different doping. The work demonstrates that nano-mechanical energy dissipation provides a rich source of information on the dissipative nature of the correlated electronic system of tBLG, with implications for coupling a mechanical oscillator to the quantum devices.

[1] Y. Cao, V. Fatemi, K. Watanabe, T. Tanaguchi, E. Kaxiras, and P. Jarillo-Herrero, Nature **556**, 43 (2018)