Local Measurements of Interacting Electronic Matter in Magic Angle Graphene

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Magic angle twisted bilayer graphene is emerging as a powerful laboratory for studying exotic phases of electronic matter. Since its discovery, this system revealed a large variety of correlated insulating, magnetic, and superconducting phases, many of which are still poorly understood. In this talk, I will describe our recent experiments that use an ultrasensitive nanotube-based scanning single-electron-transistor to image the thermodynamic properties of this system on local scales. By measuring the electronic compressibility we reveal[1] that the population of this system with carriers is highly unusual, occurring via a sequence of phase transitions. These transitions reflect the emergence of a new flavor-symmetry broken state (spin/valley), which forms the parent quantum state, out of which the previously-observed correlated insulating and superconducting states emerge. We also measure the electronic entropy directly[2], and find that magic angle graphene displays an electronic analogue of the Pomeranchuk effect in ^{3}He. In ^{3}He, the liquid can solidify upon heating due to excess nuclear spin entropy in the solid. In magic angle graphene, we observe a similar transition, between a Fermi liquid and a puzzling new correlated state with giant excess entropy. Both observations have key implications for the physics of correlated electrons in magic angle graphene.

[1] U. Zondiner *et al.*, Nature 582, 203 (2020).
[2] A. Rozen *et al.*, arXiv 2009.01836.