Radiofrequency reflectometry measurement of superfluid stiffness in magic-angle twisted trilayer graphene

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Superfluid stiffness measurements are a primary means of characterizing the pairing symmetries of superconductors. While penetration depth experiments can be used to extract superfluid stiffness in bulk materials, alternative methods are required for two-dimensional materials with small sample volumes such as the intensely studied twisted graphene superconductors, the nature of which is still not understood. In this talk, we discuss our radiofrequency reflectometry technique for measuring superconducting kinetic inductance, and in turn superfluid stiffness in magic-angle twisted trilayer graphene superconductors. We study the superfluid stiffness as a function of carrier density and temperature and provide interpretations for possible pairing symmetries. The prevalent linear in temperature behaviors across different dopings and different samples suggest the nodal nature of the superconducting gap. We also explore the current bias dependence of the superfluid stiffness, which also shows linear dependence, further proving the nodal gap structure. We show that the combination of current bias and temperature provides more detailed insights into pairing symmetries and allows subtle distinctions between anisotropic gaps, nodal gaps, and disorder-induced behavior. We show how the base-temperature superfluid stiffness evolves as a function of doping and relates to the critical temperature and normal-state resistance in twisted multilayer graphene, revealing its unusual superconducting nature. Our experiments reveal a nodal superconducting phase in most of the superconducting dome, with an interesting distinction between the underdoped and overdoped regimes of the superconducting dome tuned by moire superlattice filling.