Direct Imaging of Electronic Symmetries in Twisted Double-Bilayer Graphene

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When two graphene bilayers are twisted relative to one another at about one degree, the resulting system has been shown to host correlated insulating and superconducting states. Unlike in the case of simple twisted bilayer, the insulating states in the magic double bilayer are enhanced under parallel magnetic field, suggesting that electronic correlations may be mediated by ferromagnetic order. We directly image the local density of states in twisted double bilayer graphene using scanning tunneling microscopy and spectroscopy and observe the evolution of electronic wave functions within the moiré unit cell as a function of carrier density and applied electric field. In addition to corroborating theoretical band structure calculations via point spectroscopy, our observations of symmetry-broken states across a range of dopings and long-range order persisting across hundreds of nanometers offer insights into the complex charge and spin order that exists in magic angle twisted double bilayer graphene.