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Universal moiré nematic phase in twisted graphitic systems

Graphene moiré superlattices display electronic flat bands. At integer fillings of these flat bands, energy gaps due to strong electron-electron interactions are generally observed. However, the presence of other correlation-driven phases in twisted graphitic systems at non-integer fillings is unclear. Here, we report scanning tunneling microscopy (STM) measurements that reveal the existence of threefold rotational (C3) symmetry breaking in twisted double bilayer graphene (tDBG). Using spectroscopic imaging over large and uniform areas to characterize the direction and degree of C3 symmetry breaking, we find it to be prominent only at energies corresponding to the flat bands and nearly absent in the remote bands. We demonstrate that the C3 symmetry breaking cannot be explained by heterostrain or the displacement field, and is instead a manifestation of an interaction-driven electronic nematic phase, which emerges even away from integer fillings. Comparing our experimental data with a combination of microscopic and phenomenological modeling, we show that the nematic instability is not associated with the local scale of the graphene lattice, but is an emergent phenomenon at the scale of the moiré lattice, pointing to the universal character of this ordered state in flat band moiré materials.