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Spectroscopy of Twisted Bilayer Graphene

The electronic properties of heterostructures of atomically-thin van der Waals (vdW) crystals can be modified substantially by Moiré superlattice potentials arising from an interlayer twist between crystals. Moiré-tuning of the band structure has led to the recent discovery of superconductivity and correlated insulating5 phases in twisted bilayer graphene (TBLG) near the so-called "magic angle" of ~1.1°, with a phase diagram reminiscent of high Tc superconductors. However, lack of detailed understanding of the electronic spectrum and the atomic-scale influence of the Moiré pattern has so far precluded a coherent theoretical understanding of the correlated states. I will describe the atomic-scale structural and electronic properties of TBLG near the magic angle using scanning tunneling microscopy and spectroscopy (STM/STS). We observe two distinct van Hove singularities (vHs) in the LDOS which decrease in separation monotonically through 1.1° with the bandwidth (t) of each vHs minimized near the magic angle. When doped near half Moiré band filling, the conduction vHs shifts to the fermi level and an additional correlation-induced gap splits the vHs with a maximum size of 7.5 meV. We also find that three-fold (C3) rotational symmetry of the LDOS is broken in doped TBLG with a maximum symmetry breaking observed for states near the Fermi level, suggestive of nematic electronic interactions. The main features of our doping and angle dependent spectroscopy are captured by a tight-binding model with on-site (U) and nearest neighbor Coulomb interactions. We find that the ratio U/t is of order unity, indicating that electron correlations are significant in magic angle TBLG. Superconductivity arises in TBLG at angles where the ratio U/t, rather than the density of states, is largest, suggesting a pairing mechanism based on electron-electron interactions.

References

[1] Kerelsky et al, arXiv:1812.08776

Figures

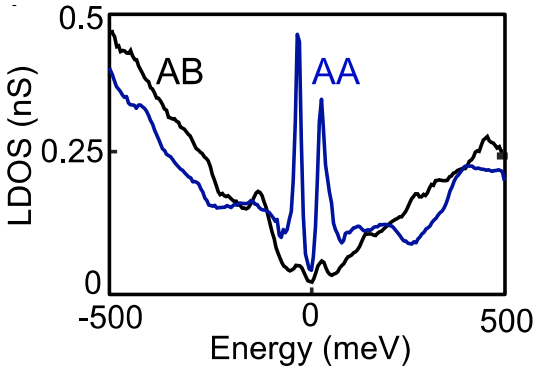

Figure 1: STM spectrum of magic-angle graphene.