Gate-dependent electronic structure of twisted monolayer-bilayer graphene revealed by μARPES

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Since reports of superconductivity [1] and Mott-like insulator states [2] in magic angle twisted bilayer graphene (MATBG) in 2018, there has been huge interest in exploring 2D twistronic systems in the hopes of finding further exotic states and increasing our understanding of correlated phenomena. For MATBG, the moiré periodicity produced by the 1.1° twist between layers results in a flat band near the Fermi energy, whose filling can be controlled electrostatically by gate electrodes to give rise to the reported correlated states. These phenomena are not unique to twisted graphene bilayers, but also present in other twisted 'multilayer' graphene systems [3,4] such as twisted monolayer-on-bilayer graphene (TMBG). In this system, the flat bands exist over a wider range of twist angles [5] than in MATBG. With a wealth of transport data and modelling, there is a pressing need for electronic structure measurements to test the theoretically predicted changes in electronic structure that underpin these twistronic effects.

We use angle-resolved photoemission spectroscopy with micrometre-scale spatial-resolution (μARPES) to directly study the band structure of TMBG over a range of different twist angles. Experiments were performed at the I05 beamline of Diamond Light Source, using capillary mirror optics to gain spatial resolution alongside high energy and angular resolution, with control over the photon energy and polarization. The strength of the interlayer interactions can be discerned through measurement of the size of the gaps formed at avoided band crossings, which inform and constrain theoretical modelling. By *in situ* electrostatic gating, we can control the carrier density within the TMBG layers, changing between n- and p-type doping, and look for gate-dependent changes of the band structure. The results demonstrate the importance of considering the field across the layers as well as the change in carrier concentration when a back gate voltage is applied.

References

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