Quantum critical behaviour in magic-angle twisted bilayer graphene

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The flat bands of magic-angle twisted bilayer graphene (MATBG) host strongly-correlated electronic phases such as correlated insulators [1,2], superconductors [3] and a 'strange metal' state [4]. The latter state, believed to hold the key to a deeper understanding of the electronic properties of MATBG, is obscured by the abundance of phase transitions; so far, this state could not be unequivocally differentiated from a metal undergoing frequent electron-phonon collisions [5]. We report on transport measurements in superconducting (SC) MATBG in which the correlated insulator states were suppressed by screening [6]. The uninterrupted metallic ground state features a T-linear resistivity extending over three decades in temperature, from 40 mK to 20 K, spanning a broad range of doping including those where a correlation-driven Fermi surface reconstruction occurs [7]. This 'strange-metal' behaviour is distinguished by Planckian scattering rates and a linear magneto-resistivity. To the contrary, near charge neutrality or a fully-filled flat band, as well as for devices twisted away from the magic angle, the archetypal Fermi liquid behaviour is recovered. Our measurements demonstrate the existence of a quantum-critical phase whose fluctuations dominate the metallic ground state. Further, a transition to the 'strange metal' is observed upon suppression of the SC order, which suggests an intimate relationship between quantum fluctuations and superconductivity in MATBG.

References

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Figure

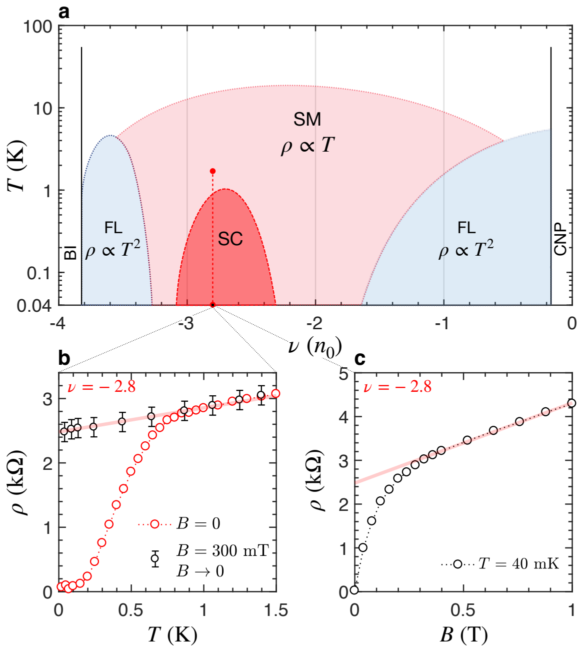

Figure 1: Quantum critical behaviour. A Schematic representation of the (ν,T) phase diagram of hole-doped MATBG. The superconducting dome is enclosed in a 'strange' metal region which is dominated by quantum fluctuations. The canonical Fermi liquid behaviour is recovered near the boundary of the flat-band region. **b** Temperature dependence of the resistivity for *B = 0* across the SC phase transition (ν=-2.8) and the in-field corrected resistivity for the critical field 300 mT. After suppression of the SC order, the uncovered metallic state is a 'strange' metal. **c** Evolution of the resistivity at ν = -2.8 and 40 mK vs. B. The suppression of the SC order leads to a sharp increase of the resistivity, and is followed by a linear MR up to *B* = 1 T. The linear MR is highlighted by a solid red line.