Gate-defined Josephson junctions in magic-angle twisted bilayer graphene

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Magic-angle twisted bilayer graphene has emerged as a uniquely versatile experimental platform that combines metallic, superconducting, magnetic and insulating phases in a single crystal [1,2]. In particular the ability to tune the superconducting state with a gate voltage opened up intriguing prospects for novel device functionality. We present the first demonstration of a device based on the interplay between two distinct phases in adjustable regions of a single magic-angle twisted bilayer graphene crystal [3,4]. We electrostatically define the superconducting and insulating regions of a Josephson junction and observe tunable DC and AC Josephson effects (see Figure 1). We show that superconductivity is induced in different electronic bands and describe the junction behaviour in terms of these bands, taking in consideration interface effects as well. Shapiro steps, a hallmark of the AC Josephson effect and therefore the formation of a Josephson junction, are observed. This work is an initial step towards devices where separate gate-defined correlated states are connected in single-crystal nanostructures. We envision applications in superconducting electronics and quantum information technology as well as in studies exploring the nature of the superconducting state in magic-angle twisted bilayer graphene.

REFERENCES

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FIGURES

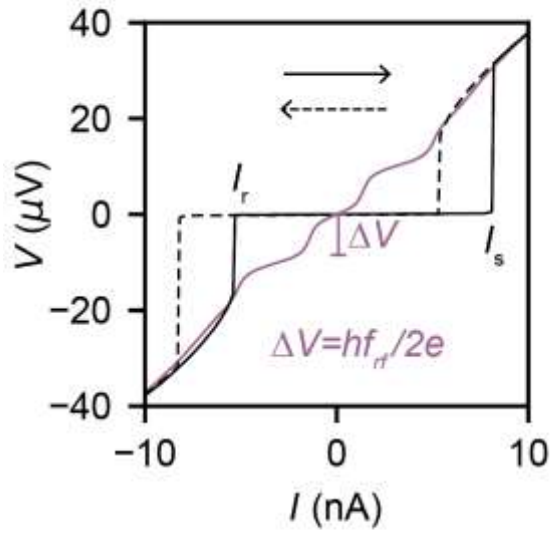

Figure 1: Current (I) versus voltage (V) linetraces showing the AC (magenta) and DC (black) Josephson effects. The solid and dashed arrows indicate the sweep direction of the current.