Magnetic Josephson Junctions and Superconducting Diodes in Magic Angle Twisted Bilayer Graphene

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The gate-tuneability of magic angle twisted bilayer graphene (MATBG) as well as its superconducting (SC), magnetic and topological states [1], allow for the creation of Josephson junctions (JJ) in a single device [2-4]. Here we report on the creation of gate-defined, magnetic JJ in MATBG, where the weak link is gate-tuned close to the correlated state at a moiré filling factor of ν=−2. A highly unconventional Fraunhofer pattern emerges, which is asymmetric with respect to the current and magnetic field directions, and shows a pronounced magnetic hysteresis. We find that these features are explained by a valley polarized ν=−2 state. Finally, we demonstrate how the switching of current, induced in this state by magnetization, enables us to realize a programmable zero field superconducting diode, which represents a major building block for a new generation of superconducting quantum electronics.

Figures

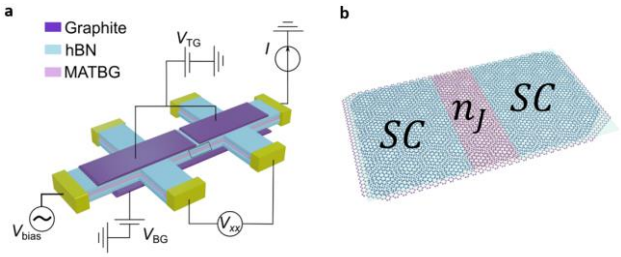

Figure 1: Scheme of the device (a), where the three gates are used to keep the sides in the SC state and to gate-tune the central region (b), creating a JJ.

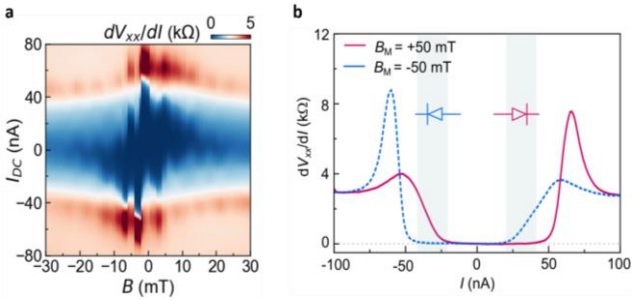

Figure 2: When the weak link of the JJ is set close to ν=−2, the oscillations of the resulting Fraunhofer pattern are asymmetric with respect to current and field (a). By reversing the magnetization of this state, we can switch the current direction of a superconducting diode at zero field (b).

References

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[4] Rodan-Legrain, D. *et al.*, Nature Nanotechnology 16, 769–775 (2021).