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

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Abstract

The simultaneous co-existence and tunability of the superconducting[1], magnetic[2] and topological orders[3] in magic angle twisted bilayer graphene (MATBG) open up new possibilities for the creation of complex hybrid Josephson junctions. Here we report on the creation of gate-defined magnetic Josephson junctions in MATBG, where the weak link is gate tuned closed to the correlated state at a moiré filling factor of $\nu = -2$. A highly unconventional Fraunhofer pattern emerges, which is phase-shifted and asymmetric with respect to the current and magnetic field directions, and shows a pronounced magnetic hysteresis. The combination of magnetization and its currents induced switching allows us to realize a programmable zero field superconducting diode, a major building block for a new generation of superconducting electronics.

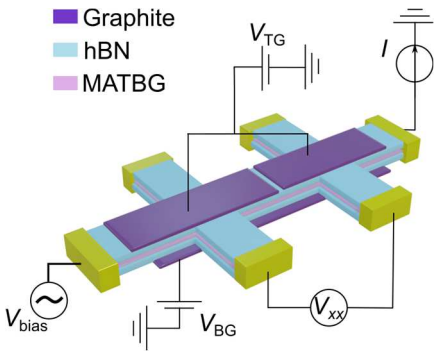

Figure 1. Device schematic and measuring circuit. The combination of the graphite back gate and split top gates allow us to realize a gate tunable Josephson junction in the MATBG.

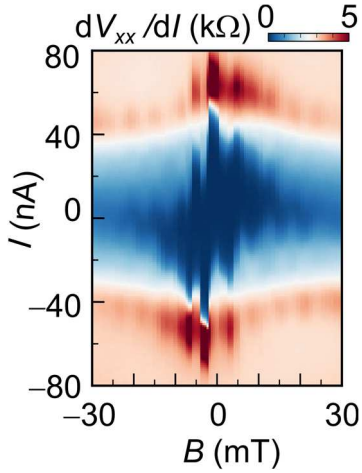

Figure 2. Fraunhofer pattern of the Josephson junction with the weak link set closed to $\nu = -2$. The pattern displays a shift from the zero-field value, and is asymmetric with respect to both the current and magnetic field directions.

References

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[3] Nuckolls, K. P. *et al. Nature* **588**, 610-615 (2020)