Evidence for chiral supercurrent in quantum Hall Josephson junctions

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We present evidence that ultra-narrow Josephson junctions defined in encapsulated graphene nanoribbons exhibit a chiral supercurrent, visible up to 8 T, and carried by the spin-degenerate QH edge channel. $2\Phi_0$ periodic oscillation of the supercurrent emerge at constant filling factor that is when the area of the loop formed by the QH edge channel is constant. By varying the junction geometry, we show that reducing the superconductor/normal interface length is pivotal to obtain a measurable supercurrent on QH plateaus, in agreement with theories predicting dephasing along the superconducting interface. Our findings mark a critical milestone along the path to explore correlated and fractional QH-based superconducting devices that should host non-Abelian Majorana and parafermion zero modes.

References

[1] Vignaud, H., Perconte, D., Yang, W. et al. Evidence for chiral supercurrent in quantum Hall Josephson junctions. Nature 624, 545–550 (2023). https://doi.org/10.1038/s41586-023-06764-4

Figures

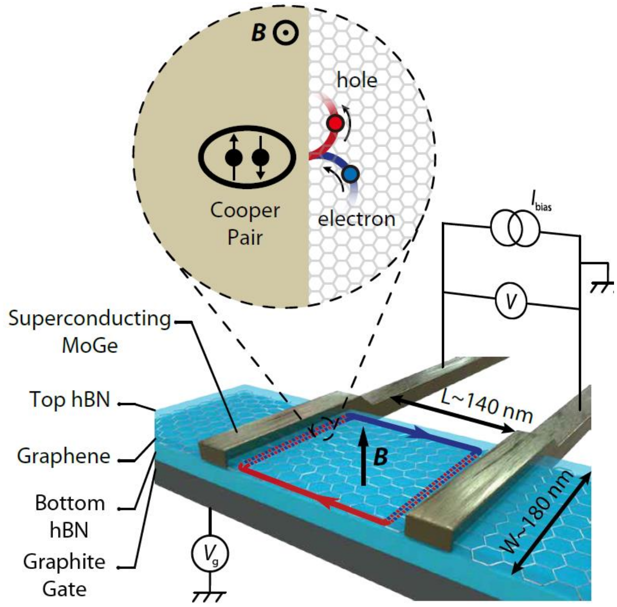

Figure 1: Schematics of the Josephson junction consisting of a graphene nanoribbon encapsulated in hexagonal boron nitride (hBN) resting atop a graphite back-gate electrode. Edge contacts are made of superconducting MoGe electrodes. Under magnetic field, charge carriers of the QH edge channel undergo successive Andreev reflections along the superconducting electrode, which convert incident quasi-electrons (blue channel) into quasi-holes (red channel) and vice-versa, as illustrated with semi-classical cyclotron trajectories in the insert. This electron-hole mixture forms a CAES (dashed blue-red channel) along the interface.