The "Quantum Pokéball": Even–Odd Josephson Diode and Vortex Fusion on a Topological Insulator

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Realizing non-Abelian statistics is a crucial milestone for topological quantum computing. In this talk, I present our recent advancements in controlling Josephson vortices on the pristine surface of a bulk-insulating 3D topological insulator (3DTI), exploring new pathways toward Majorana braiding.

First, I will highlight our observation of an even–odd Josephson diode effect (JDE) in 3DTI Corbino junctions [1]. We find the diode polarity alternates sign depending on the parity of the enclosed vortex number. Absent in non-topological and linear control devices, this polarity-tunable JDE is consistent with theoretical models of alternating periodic boundary conditions [2], suggesting a link to the underlying Andreev bound state topology.

Building upon this, we introduce the "Quantum Pokéball"—a Corbino-Josephson trijunction hybrid [3]. This architecture forms an annular track enabling *in situ* switching between fusion-inactive and fusion-active vortex dynamics. Probed via the inverse ac Josephson effect and Ginzburg-Landau simulations, this control over vortex creation, annihilation, and exchange provides a promising experimental platform to explore the braiding of Majorana bound states in future parity-sensitive measurements.

References

[1] J. Y. Park†,*, T. Werkmeister†,*, J. Zauberman†, …, P. Kim*, arXiv:2601.14384

[2] O. Lesser, J. Y. Park, …, Y. Oreg*, arXiv:2601.14364

[3] J. Zauberman†, T. Werkmeister†, …, P. Kim*, J. Y. Park*, in preparation

Figures

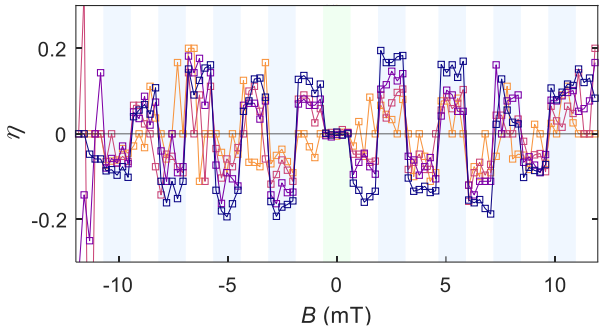

Figure 1: Vortex-parity-controlled diode effect observed in a Corbino-geometry Josephson junction on a topological insulator surface

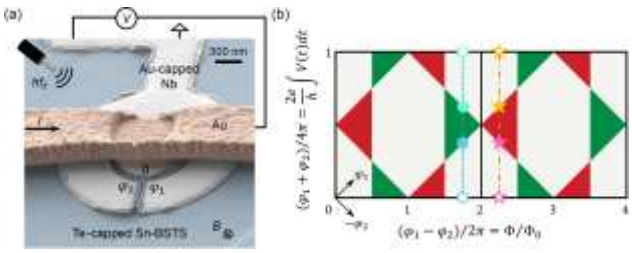

Figure 2: (a) Device geometry and (b) phase diagram for the Cobino-Josephson trijunction hybrid. Trajectories crossing red (green) regions correspond to fusion-active (inactive) vortex dynamics.