RobustSuperQ – Postdoc position

Helical Andreev Qubits

The position aims to investigate the dynamical properties of helical Andreev qubits, i.e. qubits based on two level systems made from the ground and excited Andreev levels of a Josephson junction built with 1D helical states. Helical states are spin-momentum locked, meaning that their spin orientation is given by the propagation direction. They are found at the edges of 2D topological insulators or at the hinges of 3D second-order topological insulators. Our past research has demonstrated that crystalline bismuth is a second order topological insulator, possessing 1D states that conduct ballistically even in high magnetic fields [1-4]. We have also recently found ballistic 1D conduction in WTe_2 [5] as well as in Bi_4Br_4 [6].

In addition to spin-momentum locking, the narrow spatial extension and long parity lifetime of these states endow them with a unique robustness, prompting their investigation as possible topologically protected qubits. The postdoctoral researcher will, in collaboration with a PhD student and the members of the group, develop a high frequency probe of these helical Andreev states. To this end, an ac-SQUID with the helical conductor as the weak link will be coupled to a resonator, probed with high frequency techniques such as second tone spectroscopy and time-resolved techniques to demonstrate coherent manipulation of these helical Andreev states.

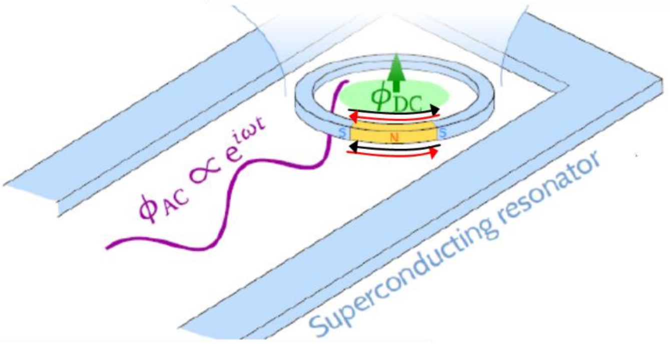

Figure1 Sketch of an ac SQUID with as the weak link a Higher Order Topological Insulator with helical states at its hinges, coupled to a superconducting resonator.

[1] Bernard, A et al., Long-lived Andreev states as evidence for protected hinge modes in a bismuth nanoring Josephson junction. Nature Physics, 19: 358 (2023).

[2] Murani, A et al;, Microwave Signature of Topological Andreev level Crossings in a Bismuth-based Josephson Junction. Physical Review Letters, 122(7): 076802 (2019).

[3] Schindler, F, et al., Higher-order topology in bismuth. Nature Physics, 14(9): 918–924 (2018).

[4] Murani, A, et al., Ballistic edge states in Bismuth nanowires revealed by SQUID interferometry. Nature Communications, 8: 15941 (2017).

[5] Xavier Ballu et al, Probing the topological protection of edge states in multilayer tungsten ditelluride with the superconducting proximity effect, arXiv:2504.12791v1

[6] J. Lefevure et al., Quantum Coherent Transport of 1D ballistic states in the second order topological insulator Bi4Br4, arXiv:2502.13837

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https://equipes2.lps.u-psud.fr/meso/

Starting date: After September 1, 2025

The candidate must have a PhD in Physics, and preferably experience with mesoscopic physics, superconductivity, low noise, low temperature and high frequency measurements

To apply, contact Sophie Gueron, sophie.gueron@universite-paris-saclay.fr

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