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Supersymmetry and Decoherence in the Phase Diagram of an Unconventional Superconducting Device

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Supersymmetry (SUSY) is a theoretical framework relating bosonic and fermionic space-time degrees of freedom extensively scrutinized in particle physics as an extension of the Standard Model. However, despite having the virtue of taming ultraviolet divergences and tackling hierarchy problems, no experimental evidence for SUSY partners has been found, suggesting that SUSY, if present in the space-time, must be realized only at very high energy scales. On the other hand, SUSY is not tied to space-time and can be realized and experimentally tested at low energy in condensed matter physics constructing unconventional quantum devices marking some relevant properties which emerge from the corresponding energy spectrum.

Here I present a novel device comprising two twisted cuprate Josephson junctions integrated in a Superconducting Quantum Interference Device (SQuID) loop and threaded by an external magnetic flux. The high-tunability of the device allows to explore various regimes with difference coherence properties hosting respectively: a symmetric, "twist-based", double-well potential, a "plasmonic"potential, and a "flux-biased"double-well potential. The possibility of realizing such an extensive phase diagram is related to the d-wave nature of the order parameter allowing peculiar symmetries on the Hamiltonian. They can be used to encode and significantly tune a topologically protected qubit called *flowermon* in the "twist-based"regime. Moreover, the emergence of a second non-trivial, "flux-biased", regime is granted by the opportunity of concretely realizing SUSY in the superconducting phase. SUSY shapes the energy spectrum with one non-degenerate ground-state and all other states degenerate in pairs and triggers sharp modifications in the system coupling to external noise fluctuations and, consequently, in the decoherence mechanisms.

Title

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