Submicrometric ferromagnetic tunnel Josephson junctions for superconducting quantum architectures

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Recently, hybrid paradigms have emerged that enable alternative qubit frequency tuning by integrating JJs with unconventional barriers. A promising approach is based on superconductor/insulator/superconductor/ferromagnet/superconductor (SISFS) tunnel magnetic Josephson junctions (MJJs), which, once integrated into a transmon architecture, allow qubit-frequency tuning via magnetic-field pulses [1].
In this work, we report on the first generation of submicrometric SISFS tunnel junctions, specifically designed within the energy range of transmon qubits [2]. Low-frequency measurements confirm that our junctions operate in the quantum phase diffusion limit, consistent with conventional tunnel JJs with similar characteristic energies implemented in state-of-the-art transmons [3].
Therefore, the proposed junction architecture represents the building block for an alternative control of quantum hardware and for mitigation of quantum phase fluctuations.

References

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Figures

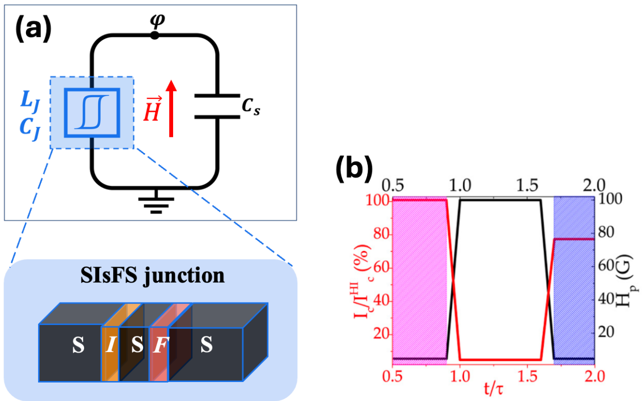

Figure 1: (a) Implementation of an SISFS ferromagnetic tunnel Josephson junction in a transmon platform, with an in-plane external magnetic field **H** applied to the junction. **(b)** Example of a magnetic field pulse sequence $\mathbf{H_p}$ and the corresponding maximum digital tuning of the critical current $\mathbf{I_c/I^{HI}}$, where $\mathbf{I^{HI}}$ is the maximum critical current at zero magnetic field. Adapted from [1].

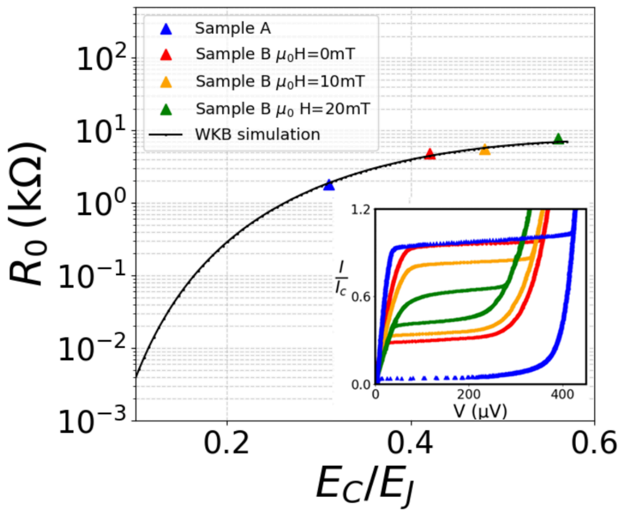

Figure 2: Evidence of a resistive branch in the current-voltage characteristic of submicrometric MJJs (inset). The resistance $\mathbf{R_0}$ has been simulated using the Wentzel–Kramers–Brillouin (WKB) approximation as a function of the ratio between Josephson energy $\mathbf{E_J}$ and charging energy $\mathbf{E_C}$ (black line in the main figure). Adapted from [2].