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TUNABLE FLUX QUBITS FOR SCALABLE QUANTUM PROCESSORS

Superconducting flux qubits are often considered as a leading potential candidate for the physical realization of quantum computers. In the last years, improvements of flux qubit architectures have led to an impressive increase of their coherence times [1-3]. Yet, the control of their transition frequency is insufficient. In this project we study a promising design towards the realization of a scalable quantum processor: a tunable superconducting flux qubit.

The tunable flux qubit consists of a micron-size superconducting aluminum loop intersected by five Josephson junctions. Two of these junctions form a small asymmetric SQUID (See Figure). It can be shown that such a circuit behaves as a two-level system when the flux threading the loop is close to half a flux quantum. Each level is characterized by the direction of the macroscopic permanent current I_P flowing in the large loop of the qubit. At the so-called optimal point – at precisely half flux quantum, the two levels are degenerate, hybridize and give rise to an energy splitting Δ, which is called the flux qubit gap. The application of a small magnetic field in the SQUID loop allows to control Δ.

Previous reports have shown that adding a symmetric SQUID indeed allows to tune the gap of a flux qubit over a large range [4]. However, the reported decoherence rates were shown to be large even at the optimal point. We believe that the origin of these large decoherence rates is due to flux noise which affects the SQUID and therefore the gap value. In this project, we will try to circumvent this problem by using an asymmetric SQUID [5].

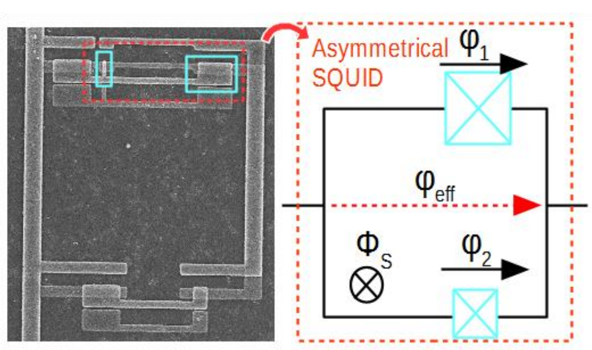

FIG.: SEM micrograph of a flux qubit including a small asymmetric SQUID shown by the dashed red line and the equivalent electrical diagram of the SQUID

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