Coupling 3-Josephson junctions flux qubits for Quantum Computation

María Hita-Pérez
Gabriel Jaumà, Manuel Pino, Juan José García-Ripoll

Instituto de Física Fundamenta IFF-CSIC, Calle Serrano 113b, 28006, Madrid, Spain

hitaperezmaria@gmail.com

Many platforms have been proposed to implement Quantum Simulations, from superconducting circuits to trap ions. Nevertheless, it is still not clear how to obtain general and fully tunable multi-qubits dynamics in any of those platforms. General enough qubit-qubit interactions would allow, for instance, to simulate novel quantum materials or to reproduce the dynamics of non-stoquastic Hamiltonians, the ones for which classical Monte-Carlo methods fail.
In this talk, we analyse the coupling between two 3-Josephson junctions flux qubits and present the effective Hamiltonian that controls the dynamics of the system when the two qubits are coupled via a capacitor and/or via a Josephson junction [3]. We show that those two elements allow engineering a fairly large family of qubit Hamiltonians with XX, YY and ZZ, including non-stoquastic interactions and ultrastrong coupled ones.
In addition, we discuss the capacitive coupling between a flux qubit and an LC-resonator [4], showing ultrastrong coupling in a direction perpendicular to that of the commonly studied inductive coupling.

References

[1] M. Hita-Pérez, G. Jaumà, M. Pino and J.J. García-Ripoll, "3-Josephson junctions flux qubit couplings", in preparation.
[2] M. Hita-Pérez, G. Jaumà, M. Pino and J.J. García-Ripoll, "Ultrastrong capacitive coupling of flux qubits" (2021), arXiv:2108.02549 [quant-ph].

Figures

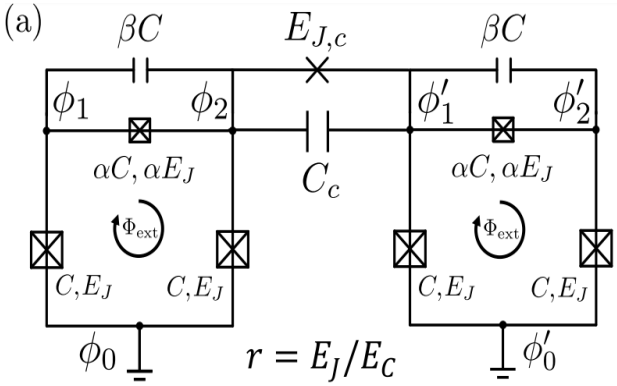

Figure 1: Example of circuit architecture for the couplings considered on the talk: two identical c-shunted 3-Josephson junctions flux qubits with ground in nodes 0 and 0' coupled through a capacitor and a Josephson junction connecting nodes 2 and 1'.