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Coupling 3-Josephson junctions flux qubits for Non-stoquastic Adiabatic Quantum Computation

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Many platforms have been proposed to implement Adiabatic Quantum Computation, 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 reproduce the dynamics of non-stoquastic Hamiltonians, the ones for which classical Monte-Carlo methods fail, opening the way to Universal Adiabatic Quantum Computation.

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 [1]. We show that those two elements allow engineering a fairly large family of qubit Hamiltonians with XX, YY and ZZ, including fully non-stoquastic interactions and ultrastrong coupled ones. In addition, we discuss the capacitive coupling between a flux qubit and an LC-resonator [2] and show ultrastrong coupling in a direction perpendicular to that of the commonly studied inductive coupling, leaving the door open to the simulations of quantum optics models unexplored up to date.

[1] M. Hita-Pérez, G. Jaumà, M. Pino, and J.J. García-Ripoll, Appl. Phys. Lett. **119**, 222601 (2021).
[2] M. Hita-Pérez, G. Jaumà, M. Pino, and J.J. García-Ripoll, Phys. Rev. Appl. **17**, 014028 (2022).