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Engineering Quantum Annealing Architectures Beyond the Transverse-Field Ising Model

The first generation of quantum annealers based on Josephson junction technology successfully represent arrays of spins in the quantum transverse-field Ising model. However, to date, no annealing architecture has emulated the more sophisticated non-stoquastic Hamiltonians of interest for next generation quantum annealing. Here, we present our recent results for tunable ZZ- and XX-coupling between high coherence superconducting flux qubits, as well as robust simulations of future coupled qubit systems. We consider the capabilities and limitations of annealing architectures based on these two-qubit building blocks, and we address specifically our efforts to engineer strong XX-coupling in the absence of local qubit fields, an inherent limitation of all existing flux qubit-based annealing systems. This research was funded by the Office of the Director of National Intelligence (ODNI), Intelligence Advanced Research Projects Activity (IARPA) and by the Assistant Secretary of Defense for Research & Engineering under Air Force Contract No. FA8721-05-C-0002. The views and conclusions contained herein are those of the authors and should not be interpreted as necessarily representing the official policies or endorsements, either expressed or implied, of ODNI, IARPA, or the US Government.