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High-fidelity two-qubit gates using a tunable coupler

High-fidelity two-qubit gates at scale are a key requirement to realize the full promise of quantum computation and simulation. The advent and use of coupler elements to tunably control two-qubit interactions has improved operational fidelity in many-qubit systems by reducing parasitic coupling and frequency crowding issues. Nonetheless, two-qubit gate errors still limit the capability of near-term quantum applications. The reason, in part, is the existing framework for tunable couplers based on the dispersive approximation does not fully incorporate three-body multi-level dynamics, which is essential for addressing coherent leakage to the coupler and parasitic longitudinal *ZZ* interactions during two-qubit gates. In this talk, we present a systematic approach that goes beyond the dispersive approximation to exploit the engineered level structure of the coupler and optimize its control. Using this method, we experimentally demonstrate CZ and *ZZ*-free iSWAP gates with two-qubit interaction fidelities approaching 99.7-99.8%, which are close to their T1 limits.