

Experimental observation of dynamical blockade between transmon qubits via ZZ interaction engineering

Aviv Glezer Moshe¹

M. Riccardi¹, G. Menichetti¹, R. Aiudi¹, C. Cosenza², A. Abedi¹, R. Menta^{1,3}, H. G. Ahmad², D. Nieri Orfatti¹, F. Cioni³, D. Massarotti⁴, F. Tafuri², V. Giovannetti^{1,3}, M. Polini^{1,5}, F. Caravelli¹, and D. Szombati¹

¹Planckian, I-56127 Pisa, Italy

²Dipartimento di Fisica, Università di Napoli "Federico II", Via Claudio, I-80125 Napoli, Italy

³NEST, Scuola Normale Superiore, Piazza dei Cavalieri 7, I-56127 Pisa, Italy

⁴Dipartimento di Ingegneria Elettrica e delle Tecnologie per l'Informazione, Università di Napoli "Federico II", Via Claudio, I-80126 Napoli, Italy

⁵Dipartimento di Fisica, Università di Pisa, Largo Bruno Pontecorvo 3, I-56127 Pisa, Italy

agmoshe@planckian.co

Abstract

We report [1] the experimental realization of strong longitudinal (ZZ) coupling between two superconducting transmon qubits Q1 and Q2, achieved solely through capacitive coupling engineering. By systematically varying the qubit frequency detuning, we measure cross-Kerr inter-qubit interaction strengths $\zeta/(2\pi)$ ranging from 10 MHz up to 350 MHz (Fig. 1). This is more than an order of magnitude larger than previously observed in similar capacitively coupled systems. In this configuration, the qubits enter a strong-interaction regime in which the excitation of one qubit inhibits that of its neighbor, demonstrating a dynamical blockade mediated entirely by the engineered ZZ coupling. Circuit quantization simulations accurately reproduce the experimental results, while perturbative models confirm the theoretical origin of the energy shift as a hybridization between the computational states and higher-excitation manifolds. We establish a robust and scalable method to access interaction-dominated physics in superconducting circuits, providing a

pathway towards solid-state implementations of globally controlled quantum architectures [2-4] and cooperative many-body dynamics.

References

- [1] M. Riccardi, [A. Glezer Moshe](#), G. Menichetti, R. Aiudi, C. Cosenza, A. Abedi, R. Menta, H. G. Ahmad, D. Nieri Orfatti, F. Cioni, D. Massarotti, F. Tafuri, V. Giovannetti, M. Polini, F. Caravelli, and D. Szombati, arXiv:2601.11714 (2026).
- [2] R. Menta, F. Cioni, R. Aiudi, M. Polini, and V. Giovannetti, Phys. Rev. Research 7 (2025), L012065.
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Figures

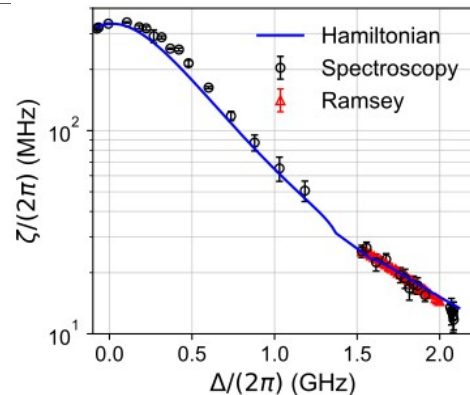


Figure 1: Measured ZZ interaction between capacitively coupled qubits Q1 and Q2 as a function of $\Delta/(2\pi)=f_1-f_2$, where f_1 (f_2) is the 01 transition of Q1 (Q2). The black circles mark the ZZ obtained from spectroscopy measurements, while the red triangles are obtained from Ramsey measurements on Q1 conditional on the state of Q2. Additionally, we show in blue the ZZ extracted from the circuit Hamiltonian.