Universal control of a bosonic mode via drive-activated native cubic interaction

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Abstract

Bosonic modes, thanks to their large Hilbert space, offer a hardware-efficient alternative for quantum information processing. However, to operate linear bosonic modes, some nonlinearity is still required, which is typically realized by an ancilla qubit. We present a bosonic mode consisting of a superconducting nonlinear asymmetric inductive element (SNAIL)-terminated planar resonator, which is controlled by microwave-activated nonlinearities in the SNAIL element. The Kerr nonlinearity is canceled by tuning the flux through the SNAIL to realize a close to linear mode when the system is idling. The off-resonant strong third order nonlinearity can be activated by applying a flux pulse at three times the frequency of the bosonic mode. Hence, the resulting tri-squeezing interaction promotes the more easily accessible Gaussian interactions to a universal gate set. By combining these interactions, we experimentally demonstrate Wigner-negative states such as the cubic phase state. Furthermore, the operation of these native squeezing and tri-squeezing interactions can be combined with standard ancilla qubit control and thereby boost the control capabilities.

References

[1] Eriksson, A. M. et al. Universal control of a bosonic mode via drive-activated native cubic interactions, arXiv:2308.15320, to appear in Nat. Commun.

[2] Frattini, N. E. et al. 3-wave mixing Josephson dipole element. Appl. Phys. Lett. 110, 222603 (2017)

Figures

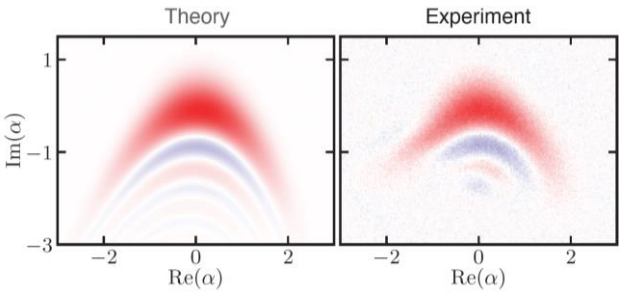

Figure 1: Wigner function of the experimentally generated cubic phase state (right) and corresponding theory prediction (left). Adapted from Ref. [1]