Closed-loop optimisation of quantum states in a high Q bosonic mode

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The generation of high-fidelity quantum states and multi-qubit gate operations is a fundamental requirement for quantum physics experiments. However, most experiments are guided by Hamiltonians containing terms that are either overlooked or imperfectly characterized. These imperfections are exacerbated by stochastic variations of the Hamiltonian or, more broadly, the instrument setup. Quantum optimal control methods offer a solution to mitigate these unwanted effects and achieve high-quality state preparation [1] and gate fidelities [2].
Closed-loop optimization for generating a quantum state necessitates measurements after each iteration. For bosonic modes, this can become prohibitively expensive, as it requires consideration of the entire phase space for state reconstruction. We demonstrate that full state reconstruction is not necessary to improve fidelity, provided that an appropriate figure of merit (FOM) and suitable measurements are chosen.
In our study, we utilize a high-Q Niobium cavity coupled to a superconducting transmon qubit to generate quantum states in a cavity mode. Employing a closed-loop optimization approach using the QuOCS library [3], we implement calibration techniques to maximize the fidelity of cat states (Fig. 1).

References

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Figures

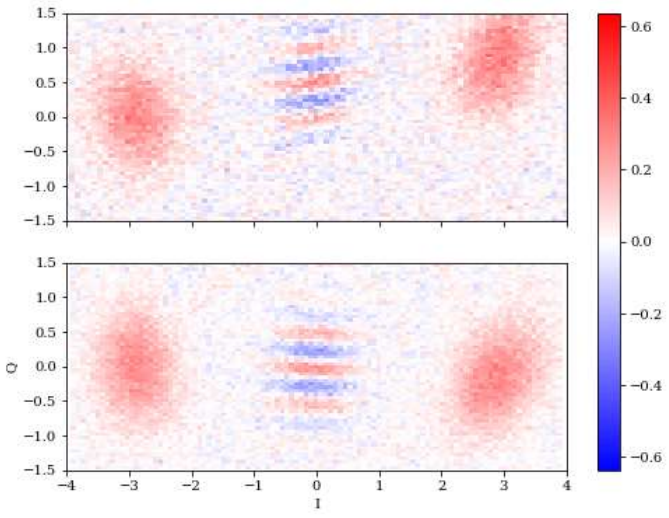

Figure 1: a = 3 cat before (top) and after (after) closed-loop optimization