High fidelity at high power in transmon qubit readout and suppression of measurement induced state transitions

C. Mori[1], F. D'Esposito[1], A. Petrescu[2], L. Ruela[1], V. Milchakov[1], S. Kumar[1], V. N. Suresh[1], W. Ardati,1 D. Nicolas,1, T. Ramos[3], Q. Ficheux[1], N. Roch[1], **O. Buisson[1]**

[1] Univ. Grenoble Alpes, CNRS, Grenoble INP, Institut Néel, 38000 Grenoble, France

[2] Laboratoire de Physique de l'Ecole Normale Supérieure, Inria, ENS, Mines ParisTech, Université PSL, Sorbonne Université, Paris, France

[3]Institute of Fundamental Physics IFF-CSIC, 28006 Madrid, Spain

olivier.buisson@neel.cnrs.fr

The field of superconducting qubits is constantly evolving with new types of circuit and designs but, when it comes to qubit readout, the use of simple transverse linear coupling is overwhelmingly prevalent. This type of coupling intrinsically limits the readout mode's dispersive shift and is known to cause Purcell effect. We propose here to overcome these limitations by engineering a non-linear coupling between the transmon qubit and a dedicated readout mode. This is based upon previous published work of Rémy Dassonneville [1] on qubit readout with a non-perturbative cross-Kerr coupling engineered by a transmon molecule circuit. A new sample with optimized design and parameters shows a readout fidelity of 99.21% measured using a parametric amplifier and a high Quantum Non-Demolition (QND) fidelity of 97%. Interestingly, these results have been achieved with 89 photons in the readout mode (Figure 1). These results display the promising quantum non-demolition (QND) robustness of the transmon molecule readout scheme in the presence of a large number of readout photons. In addition, we have studied measurement-induced state transitions (MIST) as function of the readout power. By working in the weak dispersive shift compare to readout output coupling, we perform multistate single-shot readout up to the fifth excited state and identify when the qubit leaves the computational subspace. The measurements indicate that the onset of MIST happens at high power when readout photon number exceeds about 400. This is corroborated by Floquet simulations and branch analyses, showing that the non-linear coupling is very robust to readout photons compared to the usual transverse coupling.

References

[1] R. Dassonneville, T. Ramos, V. Milchakov, L. Planat, *et al.*, Phys. Rev. X **10**, 011045 (2020).

Figure

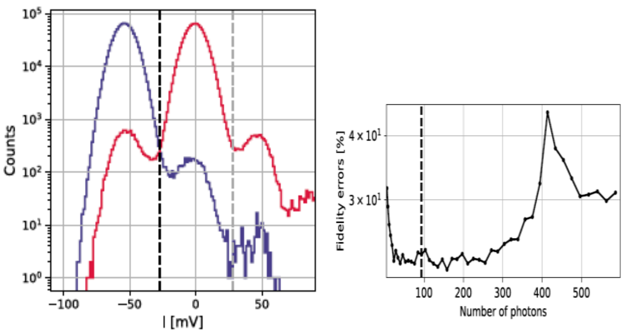

Figure 1: Left) Histograms of integrated readout signals of amplitude 89 photons over a duration of 400 ns for transmon states |0> (blue) and |1> (red). Right) Fidelity errors of the readout as a function of readout power.