Approaching the thermodynamic limit of a first-order dissipative quantum phase transition in zero dimension

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Abstract

In this work, we show a detailed experimental study of the photon blockade breakdown (PBB) process as a dissipative first order quantum phase transition (QPT) in a circuit QED system containing a single transmon qubit and a single cavity mode. Here, we show the key feature of such a QPT – coexistence of two states of the system [1] with a time domain bistable signal, similar to the one observed in a previous work [2]. However, it is also necessary that the two states – dim and bright – in such an observable be macroscopically distinct from each other. In our work we show such a regime, the “thermodynamic limit”, where both the timescale and the amplitude of the bistable signal [Figure 1], as also predicted theoretically [3], approaches infinity, resulting in long-lived and macroscopically distinct dim and bright phases. We approach this thermodynamic limit of infinite coupling strength (g→infty) by controlling the cavity linewidth (κ) in situ, hence increasing the ratio of coupling versus resonator loss. For the smallest κ value, the blinking timescale reaches 6 seconds, which is at least four orders of magnitude higher than the slowest timescale of the system. Also, we show experimental phase diagram [Figure 2] in the drive detuning (Δ) - drive strength (η) plane for the first time for the PBB phase transition.

References

[1] H. J. Carmichael, Phys. Rev. X 5, 031028 (2015).

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Figures

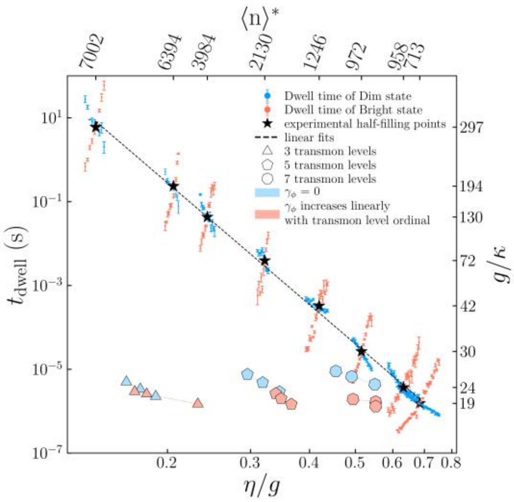

Figure 1: Measured dwell times and the mean intracavity photon numbers at different g/ κ values, being compared with the numerical simulations for 3,5 and 7 transmon levels at lowest three g/ κ cases.

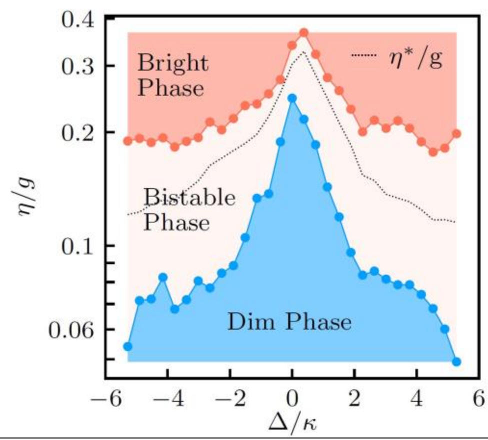

Figure 2: Experimentally obtained phase diagram.