Implementation of critical qubit readout

Master project

General Information

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Motivation

Critical phenomena are often studied in many-body systems within the thermodynamic limit, where the number of components becomes infinitely large. However, quantum phase transitions can also be engineered in finite systems by rescaling parameters to simulate an effective thermodynamic limit. We have demonstrated that these transitions can be achieved using a parametrically pumped superconducting microwave resonator [1]. Similar to thermal phase transitions, quantum phase transitions in open systems are critical phenomena where the system's steady state or an observable (like the order parameter) undergoes a non-analytical change with an infinitesimal variation in a control parameter. This characteristic makes them particularly valuable for sensing applications.

Critical Quantum Sensing (CQS) is an innovative technique that aims at exploited the increased sensitivity of quantum systems near phase transitions to enhance measurement precision. By utilizing the nonclassical features that emerge at critical points, CQS aims to achieve quantum-enhanced sensing and reach Heisenberg precision in practical applications [2].

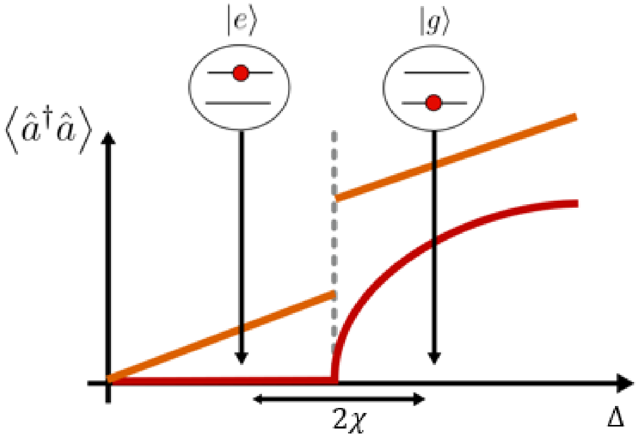

Fig 1 Schematic of critical qubit readout

Description

In this project, you will implement and investigate critical quantum sensing for qubit readout. The system under consideration will be a transmon qubit coupled to a parametrically pumped superconducting microwave resonator, known to exhibit phase transitions. The main aims of the project are:

- Literature search
- Implement standard protocols to characterize the qubit.
- Realize and optimize the measurement protocol for critical qubit readout.
- Contribute to the design of the next generation of devices.

[1] Beaulieu, Observation of first- and second-order dissipative phase transitions in a two-photon driven Kerr resonator, arXiv preprint arXiv:2310.13636 (2023)
[2] R. Di Candia, Critical parametric quantum sensing, npj Quantum Inf. 9, 23 (2023).