Detection of persistent current correlation in cavity-QED

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Recent technological developments in circuit quantum electrodynamics (cQED) offers superconducting microwave resonators operating in the range of GHz. This technique has been applied to studies charge, spin and current dynamics in various nanodevices: single spins in doped crystals, quantum dot systems, superconducting qubits, nanomechanical oscillators or magnonic nanostructures [1].

Here, we want to show how cQED can be applied to measure correlations of the persistent current in the metallic ring (shown in the figure). We simulated the radiative response of the cavity quantum electrodynamics (QED) inductively coupled to the ring pierced by magnetic flux and analyzed its spectral dependence to get insight into persistent current dynamics. Current fluctuations in the ring induce changes in the microwave resonator: shifting the resonant frequency and changing its damping. We use the linear response theory and calculate the current response function by means of the Green function technique. Our model contains two quantum dots which divide the ring into two branches with different electron transfers. There are two opposite (symmetric and asymmetric) components of the persistent current, which interplay can be observed the response functions. We observe a nonmonotonic dependence of the local current response function on the Aharovov-Bohm phase ϕ. Its shape depends on transmission asymmetry between the left and the right branch. The resonator reflectance shows characteristic shifts in the dispersive regime and avoided crossings at the resonance points. The competition of two opposite persistent currents is also quite pronounced. In the region around $\phi = \pi$ the asymmetric component of the persistent current is dominant which leads to a negative resonant frequency shift, a negative damping ratio and signal amplification. Outside this region fluctuations of the symmetric persistent current component are relevant.

References:

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