# Detecting propagating microwave photons with quantum nondemolition transport measurements

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**Abstract**: Nondemolition detection of microwave photons is crucial for advancing quantum technologies. We propose a quantum dot–cavity system to achieve such detection via transport measurements, where the microwave photon is monitored through the quantum dot current.

Nondemolition detection of microwave photons enables a variety of applications within quantum computing and sensing, including the preservation of quantum information or repeated measurements for error correction. While various optical readout schemes have been explored [1,2], achieving nondemolition detection in the microwave regime remains challenging. We propose a nanoscale quantum device that detects microwave photons via non-equilibrium transport measurements in a quantum dot (QD) – cavity system.

Our system consists of a QD coupled to a microwave cavity in the dispersive regime, with the QD also connected to source and drain electrodes. The relevant observable is the current through the QD, which is perturbed by the presence of a microwave photon. To capture the propagating nature of the microwave photon, we model the dynamics of the system within a cascaded master equation approach, which fully accounts for quantum coherences between the cavity and transmission line.

The detection principle is as follows: An incoming photon is absorbed into the cavity [see Fig. 1(a)], where it interacts with the QD system. This interaction perturbs the QD current from its stationary state, enabling photon detection without destroying the photon. We benchmark our measurement protocol for experimentally feasible parameters and discuss limitations as well as potential improvements. We consider possible routes to enhance the sensitivity of the photon detector by leveraging quantum coherence effects considering in alternative QD setups [3].

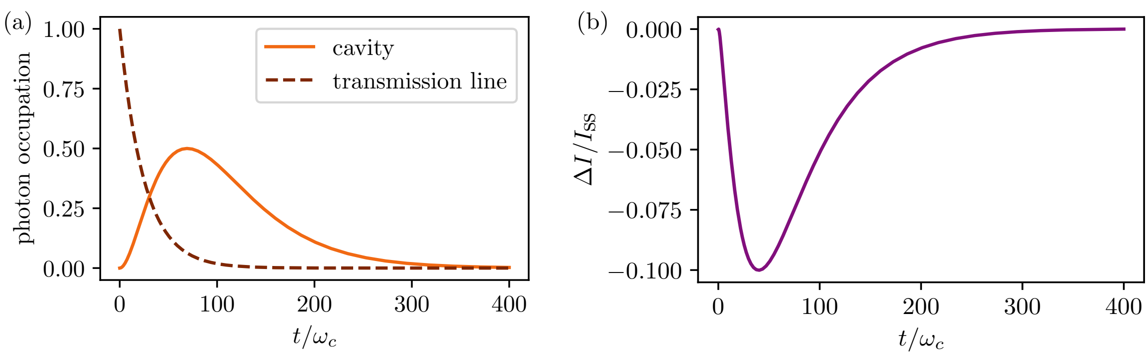


**Fig. 1** (a) Photon occupation of the cavity and transmission line: An incoming photon gets absorbed into the cavity and reemitted after a while, $\omega_c$ is the resonance frequency of the cavity. (b) Change in the transient current I(t) through the QD due to a photon present in the cavity [$\Delta I(t) = I(t) - I_{ss}$, with the stationary state current $I_{ss}$].

## References

[1] S. R. Sathyamoorthy et al., "Quantum Nondemolition Detection of a Propagating Microwave Photon" Phys. Rev. Lett. **112**, 093601 (2014).

[2] R. Leascanne et al., “Irreversible Qubit – Photon Coupling for the Detection of Itinerant Microwave Photons”, Phys. Rev. X **10**, 021038 (2020).

[3] S. Matern, K. Macieszczak, S. Wozny, M. Leijnse, “Metastability and quantum coherence-assisted sensing in interacting parallel quantum dots”, Phys. Rev. B **107**, 125424 (2023).