Physics Institute – Solid State Physics – Microwave Team Tübingen

Bachelor/Master thesis available!

Non-classical states in low-frequency LC circuits using microwave photon-pressure

Photon-pressure coupling is a novel interaction between two superconducting circuits [1, 2], a schematic of such a platform is shown in Fig. 1. The basis of the interaction is that one of the circuits – typically a low-frequency (LF) circuit with a resonance frequency in the 100 MHz regime – changes the resonance frequency of the second when it is oscillating. The second circuit is typically a microwave high-frequency (HF) LC resonator with an integrated superconducting quantum interference device (SQUID) and a resonance frequency in the GHz regime.

The photon-pressure interaction allows to use the HF circuit for low-frequency photon sensing with quantum-limited sensitivity and to mani-pulate the state of the LF circuit by e.g. sideband-cooling and squeezing control schemes. Several milestone experiments have been reported in the recent years, such as the observation of dynamical backaction, reaching the strong-coupling regime and sideband-cooling into the quantum ground state [3, 4].

As next steps, we want to explore non-classicality in the LF circuit and realize quantum-squeezed and entangled MHz-photon states, which have potential applications for quantum radar, in dark matter axion detectors and in signal processing technologies for quantum information science with superconducting circuits.

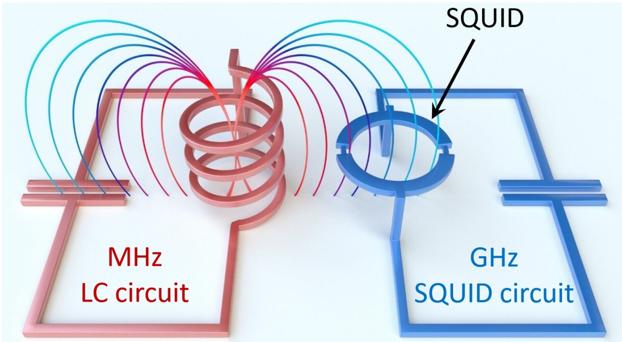

Figure 1: *Schematic of two superconducting circuits coupled to each other via a photon-pressure interaction. The magnetic field generated in the inductance of the MHz circuit is coupling into the SQUID loop of the GHz circuit, herewith modulating its resonance frequency.*

If you got excited now and want to contribute to the forefront of superconducting microwave quantum circuits with your Bachelor and/or Master end project, get in touch with us! We are looking forward to meet you and tell you more about our research and your possible part in it!

<u>The main tasks and challenges during the thesis project will be:</u>

- Design and simulation of superconducting photon-pressure circuits
- Advanced nano-fabrication using lithography and thin film deposition techniques
- Characterization of circuits in cryogenic environments using microwave spectroscopy
- Data analysis and measurement scripting using python

<u>References:</u>
[1] J. R. Johannson *et al.*, Phys. Rev. A **90**, 053833 (2014)
[2] C. Eichler and J. R. Petta, Phys. Rev. Lett. **120**, 227702 (2018)
[3] D. Bothner*, I. C. Rodrigues*, and G. A. Steele, Nature Physics **17**, 85-91 (2021)
[4] I. C. Rodrigues*, D. Bothner*, and G. A. Steele, Science Advances **7**, eabg6653 (2021)

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