Physics Institute – Solid State Physics – Prof. R. Kleiner, Prof. D. Kölle

# Bachelor/Master thesis available!

## Development of niobium-based superconducting quantum interference microwave circuits

Superconducting quantum interference devices (SQUIDs) are fascinating and extremely useful electronic components. They are amongst the world's most sensitive sensors for magnetic flux, they are used in nowdays quantum information processors and they allow for high-resolution imaging techniques.

Incorporated into a superconducting LC resonant circuit, these SQUIDs allow for microwave-based, quantum-limited detection and manipulation of mechanical oscillators, of single photons in low-frequency LC circuits and of magnetic systems such a spin ensembles and micromagnets [1, 2]. An example for such a microwave SQUID cavity made of Aluminum is shown in Fig. 1.

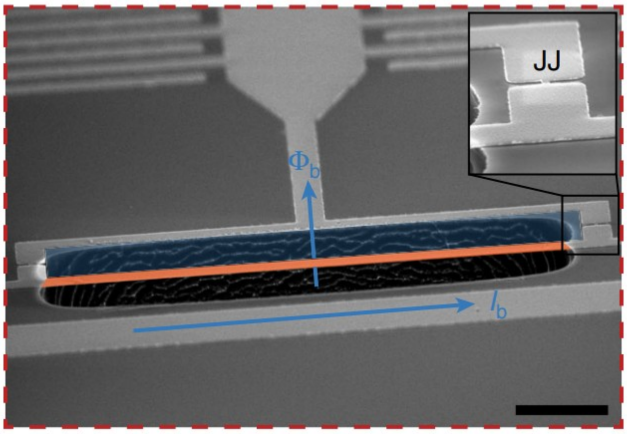


***Figure 1***: *Scanning electron microscope image of a superconducting quantum interference resonator. Visible is the rectangular SQUID in the center (part of the loop is suspended here, shown in orange) and a finger capacitor in the background. The magnetic flux through the SQUID loop $\Phi_b$ can be changed with a current $I_b$ through the bias line in the front. Scale bar is 1 $\mu$m. Inset shows zoom into the constriction-type Josephson junction (JJ). From [1].*

The goal of this thesis is the development of similar, but enhanced microwave quantum interference circuits based on niobium, a superconducting material with larger critical temperature and larger critical field than the so far implemented aluminum devices. The succesful development of these niobium-based microwave quantum interference circuits will allow for the next generation of experiments with mechanical and magnetic oscillators in so far unaccessible parameter regimes.

The main tasks and challenges will be:

- Design and simulation of microwave resonators and SQUIDs
- Advanced nano-fabrication using lithography and focussed ion beam techniques
- Characterizaton of the SQUIDs by means of electrical transport measurements
- Characterization of the resonant circuits using microwave spectroscopy
- Data analysis and measurement scripting using python

This thesis is integrated into a bigger team effort within the PIT II and if you are interested in the topic and motivated to contribute to the next generation of advanced superconducting microwave experiments in Tübingen within your thesis don't hesitate to contact us.

References:
[1] I.C. Rodrigues*, D. Bothner*, and G. A. Steele, Nature Commun. **10**, 5359 (2019)
[2] D. Bothner*, I.C. Rodrigues*, and G. A. Steele, arXiv:1911.01262v2

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