Department of Microtechnology and Nanoscience (MC2)
Quantum Technology Lab, Wieczorek Group

Master Thesis Project(s)

Levitated superconducting particles for macroscopic quantum experiments

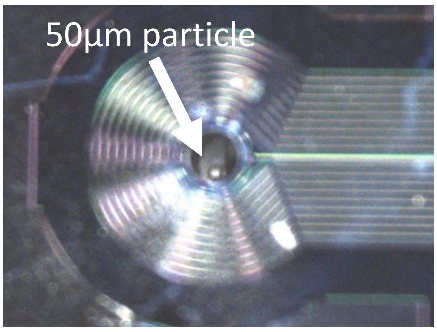

Figure 1 Chip-based magnetic trap for levitating a 50μm diameter superconducting particle.

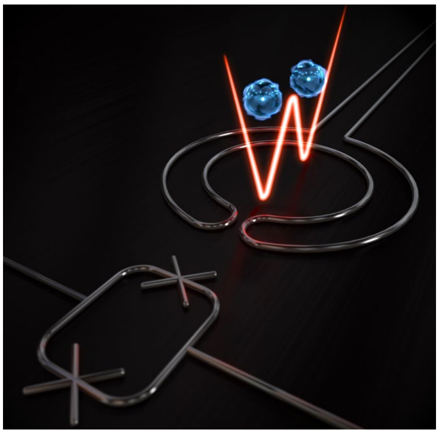

Figure 2 The vision of the experiment is to generate a macroscopic superposition state.

Magnetic levitation has been proposed as a novel platform to greatly decouple the center-of-mass motion of a levitated superconducting particle from its environment. As a result, this experimental platform will enable novel, ultra-sensitive force and acceleration sensors, as well as quantum experiments with macroscopic objects of 10^{13} atomic mass units. The latter could shed new light on the transition from quantum to classical behavior via, e.g., proposed unconventional decoherence mechanisms outside the formalism of quantum mechanics.

In our experiments, we employ chip-based magnetic traps to levitate superconducting microparticles (see Figure 1). The motion of the particle is detected by coupling it to a superconducting quantum interference device (SQUID), which allows for real-time feedback control of the mechanical position of the levitated particle. Our near-term goal is to couple the levitated particle to superconducting quantum circuits, in particular, flux-tunable superconducting resonators, to perform quantum control of the particle's center-of-mass motion (see Figure 2).

Potential thesis projects:

- Real-time feedback cooling of levitated particle motion by use of a SQUID and signal processing via FPGA logic (implemented with red pitaya), or
- Design, simulation and fabrication of miniaturized chip-based flip-chip trap architectures to push trap frequencies to the kHz regime, or
- Proof-of-principle coupling of the center-of-mass motion of the levitated particle to a flux-tunable superconducting microwave resonator

What you will learn:

- the physics of superconducting levitation and its relation to quantum experiments,
- to design, simulate and fabricate superconducting devices at MC2's cleanroom,
- to perform levitation experiments at mK temperatures in a dry dilution refrigerator,
- team-work in a stimulating research environment

For more information: wieczorek-lab.com

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