Design, simulation and optimization of a phononically shielded sample holder for chip-based magnetic traps

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Introduction

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 [1]. As a result, the experimental platform we develop 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 behaviour via, e.g. proposed unconventional decoherence mechanisms outside the established formalism of quantum mechanics [2].

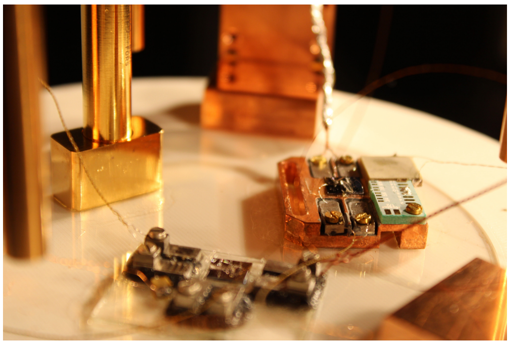

Figure 1: The trap chips inside the cryostat, mounted on glass and copper sample holders.

In our experiments [3], we employ chip-based magnetic traps to levitate superconducting microparticles (see Figure 1). The traps are operated inside a dilution refrigerator, which unfortunately transfers vibrations onto the particle during its operation. To isolate from this, we propose developing a subwavelength phononically shielded sample holder creating a bandgap at the resonant frequency of the particle, hindering the transmission of vibrations from the cryostat. Phononical shields are an established technique for limiting transmission of vibartions in nanomechanical resonators, producing bandgaps like in Figure 2.

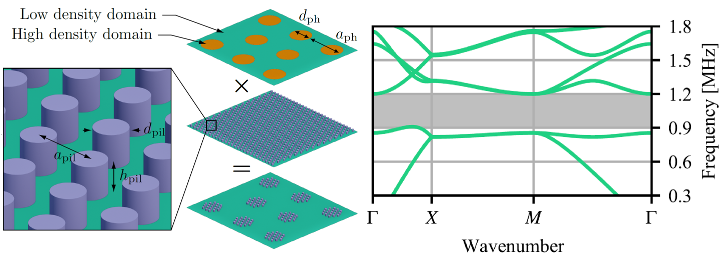

Figure 2: A phononic crystal strucure and corresponding band structure. Images from [4].

The project

You will initially perform a literature study to learn about the principles of phononic crystals. You will then design and simulate in FEM software a sample holder with a crystal structure incorporating what you learned. The sample holder will be manufactured by the MC2 workshop and tested with the goal of incorporating it into the vibration isolation system of our cryostat.

What we offer you

- Learn about phononic crystals and use the knowledge in a novel application
- Perform FEM simulations and apply optimization strategies to phononic crystal designs
- Team-work in a stimulating research environment

What you offer us

We expect you to take own initiatives to drive your project forward. You should be aware that the main focus of the project is on design and simulation, with a component of testing. Knowledge in solid state physics and good grasp of programming are important skills for the project.

Contact

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References

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[4] D. Høj *et al.*, "Ultra-coherent nanomechanical resonators based on density phononic crystal engineering," *arXiv: 2207.06703*, 2022.

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