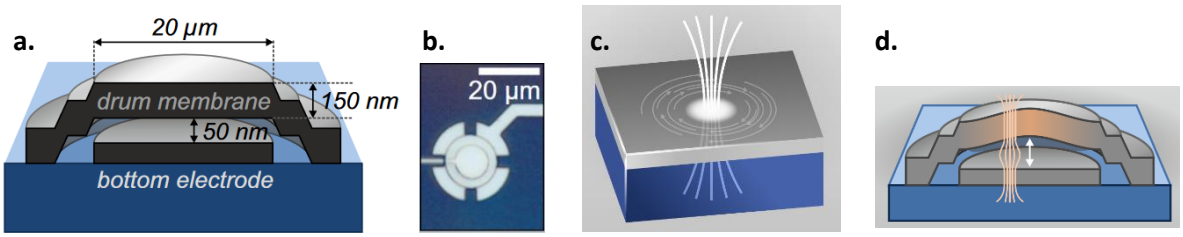
Summer project call 2024 - QNOF group

Nanomechanical oscillators allow to realize very sensitive force measurements. The QNOF group is aiming to use **oscillating aluminium drum membranes** to measure small forces occurring in superconducting structures, among which, the force applied by superconducting vortices.



a. *Schematic cut of a drum membrane.* ***b.*** *Microscope image of a drum membrane.* ***c.*** *Schematic representation of a vortex.* ***d.*** *Schematic representation of a vortex in a drum membrane.*

Aluminium is a rather well understood superconductor. It is a type-I superconductor, which means that it entirely repels magnetic fields. This contrasts with type-II superconductors which can, in some conditions, allow magnetic flux through "one quantum at a time" along singular lines, giving rise to so-called superconducting vortices.

However, in our experiments, we are using aluminium **thin films**. Superconducting thin films behave differently than bulk superconductors and can allow for vortices, even if they are made of a type-I material. Eventually, whether vortices exist depends on the material, its purity, and on the geometry (in particular, the thickness) of the film. **Drum membranes** have a rather particular geometry, where two thin films of aluminum are separated by a vacuum gap. The group would like to investigate the conditions in which vortices may appear in these devices.

In this project, you will use a **simulation engine** (time-domain Ginzburg-Landau simulation) that we have already built in the group in **COMSOL** to simulate vortices in thin films and in various geometries. Although we are particularly interested in the drum membrane geometry, this will be the opportunity to study other geometries relevant in quantum technologies.

This project is suitable for undergraduate students of all levels, Master students, and can be extended and adapted to be a part of a Master thesis if necessary. No previous knowledge about superconductivity or COMSOL is required. If you have not studied these yet, then the project will be the opportunity to learn without pressure. If you wish, over the summer, you can also help the team build the experiment that will eventually allow to make optical images of superconducting vortices in a cryostat equipped with optical windows.

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