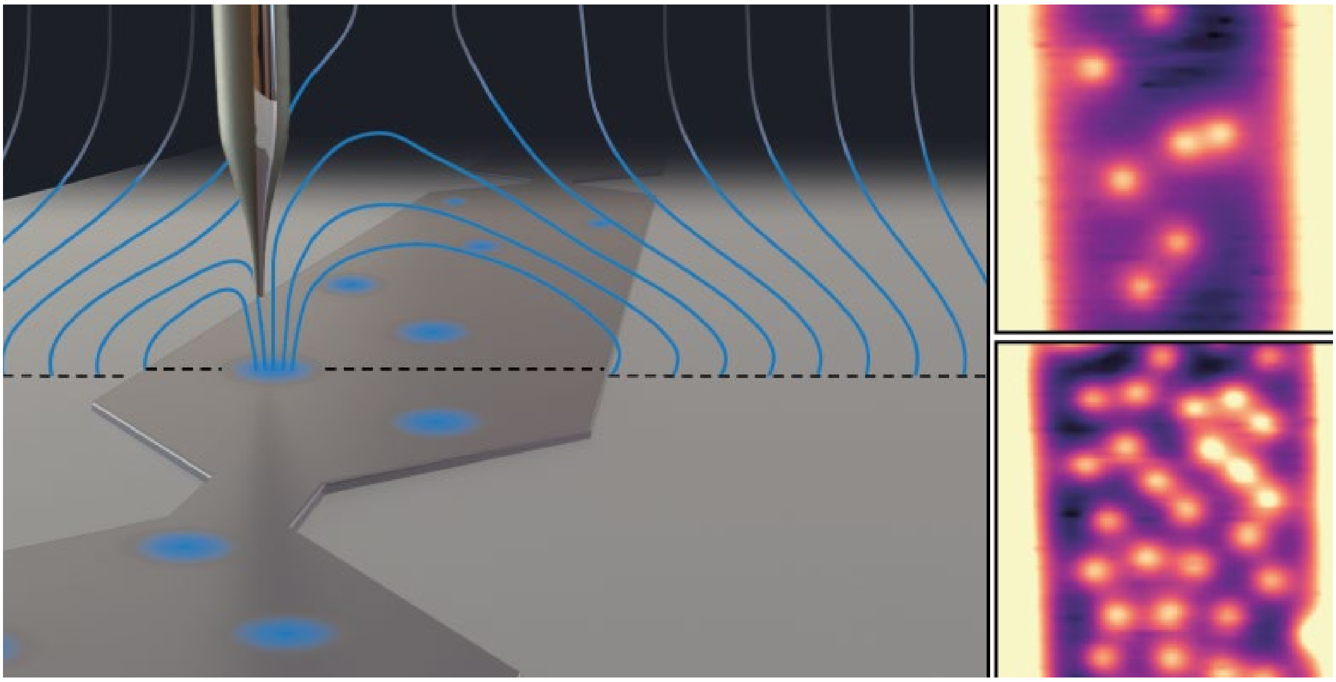
# Detailed information about vortices

## Imaging of ultra-thin superconductors delivers key information

In 2019, Argovia Professor Martino Poggio from the Department of Physics at the University of Basel continued his research into nanowires, including a more intensive study of thin molybdenum silicide (MoSi) films. At very low temperatures, these amorphous films have superconducting properties, but it is possible to manipulate these properties locally with the help of individual photons. The MoSi films are of considerable interest to scientists because the absorption of individual photons produces a clear signal – and the films can therefore be used as sensitive photon detectors. Superconducting vortices are responsible for this phenomenon. The Poggio Lab has imaged and examined vortices of this kind in MoSi for the first time and described the results in Physical Review B. The method allows the optimization of materials for a wide range of applications.

Lorenzo Ceccarelli and Martino Poggio study superconducting vortices.



The Poggio team succeeded in imaging vortices in MoSi for the first time using a newly developed, highly sensitive superconducting quantum interference device at the end of a tiny scanning probe. (Image: L. Ceccarelli, Department of Physics, University of Basel)

**Sensitive photosensors**

Molybdenum silicide (MoSi) is an amorphous material used as a thin film for the production of nanowire photon detectors. Normally, MoSi has superconducting properties at very low temperatures – that is, it conducts electricity without resistance. But when individual photons collide with the material, they cause localized changes in resistance and the MoSi film behaves like a normal electrical conductor. Accordingly, the material can be used to produce nanowires for the detection of individual photons. These superconducting nanowire single-photon detectors (SNSPDs) are fast, sensitive and efficient and lend themselves to numerous applications.

Within the NCCR QSIT, such MoSi films were produced in a collaboration with the group of Professor Richard Warburton and the company ID Quantique in the laboratory of Professor Christian Schönenberger and are now already in commercial use.

**Vortices influence properties**

Some experts in this field attribute the change in conducting properties to superconducting vortices. However, since the vortices in thin, amorphous MoSi are very weak, it has not yet been possible to image them or to gain a better understanding of the causes of this phenomenon.

In 2019, PhD student Lorenzo Ceccarelli from the Poggio team succeeded in imaging vortices in MoSi for the first time using a newly developed, highly sensitive superconducting quantum interference device at the end of a tiny scanning probe.

To do this, he began by applying magnetic fields, from below, which also lead to the formation of vortices in the amorphous MoSi films. The microscopic images allowed precise determination of the superconducting properties of the material and provided information about the conditions in which the vortices are formed. They also provide a direct visualization of the vortices, which have a central non-superconducting core.

Moreover, it was possible to map exactly how the vortices move and how they get caught on defects known as "pinning centers" in the material. This work suggests that the density and thickness of these pinning centers has a decisive influence on the quality of superconducting single photon detectors made of amorphous thin films.

**Further applications of the method will follow**

In further experiments in cooperation with scientists from the KTH Royal Institute of Technology in Stockholm, the scientists in Basel will investigate other commercially available superconducting nanowire photodetectors. Once the method has been refined, they also plan to study vortices generated by single photons.

Based on this research, the Poggio team has also embarked upon a collaboration with Professor Andreas Wallraff of ETH Zurich in order to study vortex motion in superconducting circuits used as qubits in quantum computers. As the errors seen there are often caused by vortices, the analyses carried out at the Poggio Lab can be used to record the specific effects of changes in materials.