Master thesis in Forschungszentrum Jülich - Institute for Microstructure Research (PGI-5)

**Scanning probe microscopy using nanoscale superconducting quantum interference devices (nano-SQUIDs)**

Background:

Scanning superconducting quantum interference devices (SQUIDs) can be used to provide images of magnetic fields produced by magnetic materials or currents in electronic devices, as well as for the evaluation of defects in materials and magnetization states in spintronics devices. As a result of their high sensitivity and negligible infuence on the object, SQUIDs can potentially be used for the non-destructive readout of the final states of superconducting flux qubits after their protection by sufficiently high potential barriers. Nanometer-sized SQUIDs (nano-SQUIDs) have demonstrated an unprecedented spin sensitivity of 0.38 μB/Hz and a spatial resolution of 20 nm (Anahory et al., *Nano Lett*. **14**, 6481, 2014). The implementation of electrically-tunable multi-terminal nanoSQUID configurations (Uri et al., *Nano Lett.* **16**, 6910, 2016) has provided optimal flux bias conditions by the direct injection of flux modulation and a feedback current into the SQUID loop. It is planned to develop a nano-SQUID measurement system for the study of magnetic effects in samples on the nanometer scale as a technique that is complementary to measurements perfomed using electron holography in the transmission electron microscope.

Project description:

This work will be embedded in an international team in the Institute for Microstructure Research (PGI-5) and the Ernst Ruska-Centre in Forschungszentrum Jülich. The candidate will use a SQUID microscope system to investigate the magnetic fields of room temperature objects and participate in the development of a nano-SQUID microscope system that will be based on low-temperature high-precision ultra-large-scan-range piezo stages from the company “Attocube”, as well as a nano-SQUID as a sensitive detector of magnetic fields at liquid helium temperature with sub-micrometer spatial resolution. The project may involve the development of electronics for low noise operation of nano-SQUIDs and the construction and assembly of fine mechanical parts, including piezo scanning stages, cryogenics, vacuum technology, magnetic shielding, semiconducting and superconducting electronic components and system control and readout software. The nano-SQUID microscope system will be used for imaging the magnetic fields of nanoscale objects that are of interest for the rapidly evolving research fields of topological materials, spintronics, quantum computation and artificial intelligence.

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