

SQUID-on-lever scanning probe for magnetic imaging with sub-100-nm spatial resolution

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Scanning superconducting quantum interference device (SQUID) microscopy is a magnetic imaging technique combining high field sensitivity with nanometer-scale spatial resolution. We demonstrate a scanning probe that combines the magnetic and thermal imaging with the tip-sample distance control and topographic contrast of a non-contact atomic force microscope. [1] We pattern the nanometer-scale SQUID, including its weak-link Josephson junctions, via neon or helium focused ion beam milling on a niobium coated cantilever. These SQUID-on-lever probes overcome many of the limitations of existing devices, achieving spatial resolution better than 100 nm, magnetic flux sensitivity of $0.3 \mu\Phi_0/\sqrt{\text{Hz}}$, operation in magnetic fields up to about 0.5 T and the incorporation of a third Josephson junction for shifting its phase. Its advanced functionality, high spatial resolution, and the ease of use of a cantilever-based scanning probe, extends the applicability of scanning SQUID microscopy to a wide range of magnetic, superconducting, and quantum Hall systems. We demonstrate magnetic imaging of skyrmions at the

surface of bulk Cu_2OSeO_3 and image modulated magnetization patterns with a period of 65 nm. [2]

References

- [1] Wyss, M. et al. Phys. Rev. Applied **17.3** (2022).
- [2] Weber, T., Jetter, D. et al. Phys. Rev. Applied **24.5** (2025).

Figures

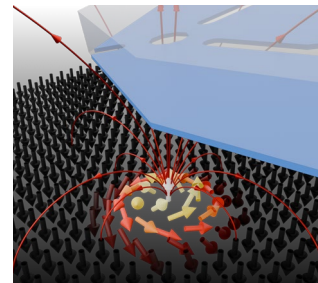


Figure 1: Schematic of the SQUID-on-lever scanning probe above a skyrmion field-profile.

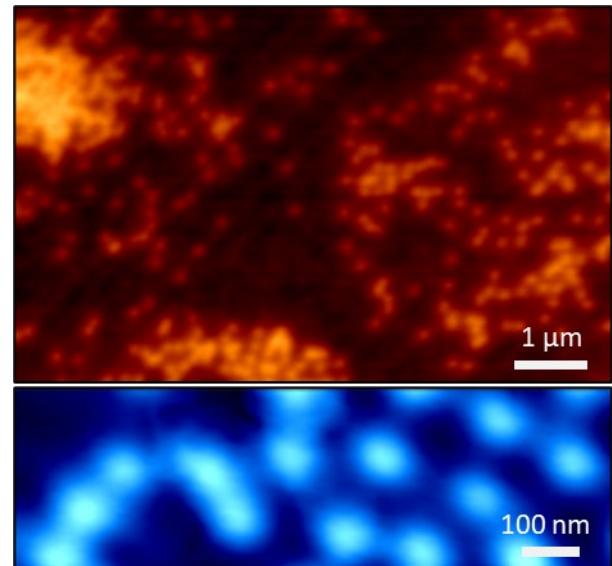


Figure 2: Out-of-plane magnetic field B_z (top) and out-of-plane magnetic field gradient dB_z/dz (bottom) maps of the low-temperature skyrmion phase in Cu_2OSeO_3 . [2]