

Scanning Spin Noise Microscope: Probing Local Monopole Dynamics

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Recently, the search for emergent magnetic monopoles in quantum materials has focused on spin-ice compounds, which host quasiparticles with magnetic monopole characteristics [1]. Indeed, studies of Dy₂Ti₂O₇ (DTO) and Ho₂Ti₂O₇ (HTO) using Superconducting Quantum Interference Devices (SQUIDs) reveal a magnetic signal characteristic of the generation-recombination noise of magnetic monopoles, as well as the presence of dynamical heterogeneities [2-4]. These findings motivate the development of local measurement instruments.

To study the local nature of monopole dynamics, we are developing a Scanning Spin Noise Microscope (SSNM) that combines the atomic resolution of a Scanning Tunnelling Microscope (STM) with the high magnetic sensitivity of a SQUID at cryogenic temperatures (10 mK). The magnetic tip, made of soft magnetic material, acts as a flux guide to transfer the local monopole field to the SQUID. The instrument is built on a low-temperature vibration isolator to minimize mechanical vibrations from the cryogen-free dilution refrigerator.

The latest development steps will be presented, including the first atomic-resolution topography scan at 10 mK, as well as the flux guide characterization using a mutual inductance apparatus. Characterization of the tip demonstrates that

the flux guide effectively transmits signals within the full SQUID bandwidth with a sensitivity threshold higher than the theoretically predicted local monopole field.

References

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