Probing Vortex Dynamics in 2D Superconductors with Scanning Quantum Microscopy

Sreehari Jayaram
Malik Lenger, Dong Zhao, Lucas Pupim, Ruoming Peng, Rainer Stoehr, Mathias Scheurer, Jurgen Smet, Joerg Wrachtrup

*3rd Institute of Physics, University of Stuttgart, Allmandring 13, Stuttgart, 70569, Baden-**Wuerttemberg**, Germany*

s.jayaram@pi3.uni-stuttgart.de

Visualization of nanoscale magnetic responses in two-dimensional superconducting materials offers a powerful approach to unravelling underlying supercurrent behaviours and investigating critical phenomena at reduced dimensions[1]. In this study, we utilize scanning quantum microscopy based on nitrogen-vacancy (NV) centers in diamond[2] to explore the local magnetic responses of the 2D superconductor 2H-$NbSe_2$. We notice that vortex arrangements are strongly influenced by 2D confinement, with expanding vortex size. Meanwhile, the vortex can be locally kinetic due to the thermal excitation and clear melting of vortex solids is identified as approaching the critical temperature, resulting in distinct vortex configurations
on different cooling conditions. Furthermore, our approach allows for the probing of vortex fluctuations via spin Hahn-echo measurements, where persistent spin decoherence is observed even well below the critical temperature.

References

[1] Saito, Y., Nojima, T. & Iwasa, Y. Highly crystalline 2d superconductors. Nature Reviews Materials 2, 1–18 (2016)
[2] Balasubramanian, G. et al. Nanoscale imaging magnetometry with diamond spins under ambient conditions. Nature 455, 648–651 (2008)

Figures

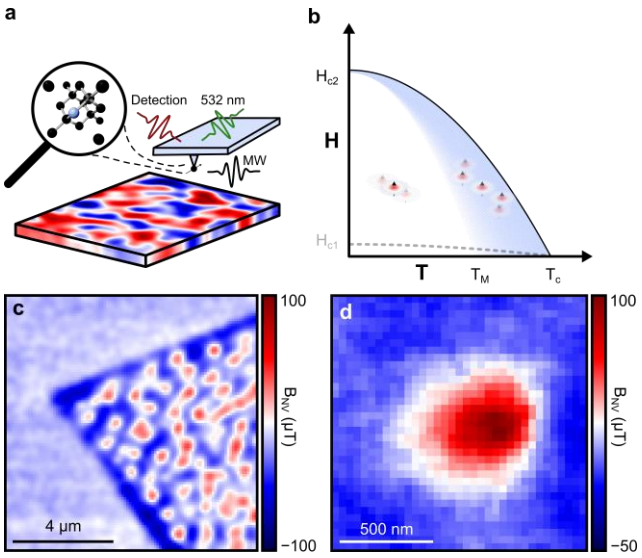

Figure 1: (a) Illustration of the scanning quantum microscope used to probe the local magnetic response. (b) Optical image (c) Magnetic field mapping of 5.5 nm thick NbSe2 flake (d) High-resolution scan of a single vortex in NbSe2.

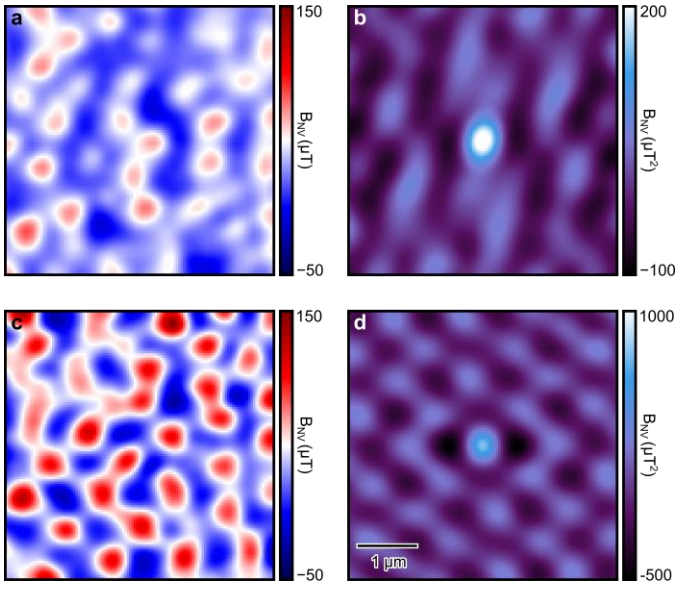

Figure 2: (a, b) Magnetic field mapping and corresponding autocorrelation of a thin-layer (5.5 nm) NbSe2 on oxide substrate and encapsulated with hBN, (c, d) thick-layer (12nm) NbSe2 sample doubly encapsulated with hBN.