Static and Dynamic Properties of a 2D Superconductor Investigated by NV Center SPM

Sreehari Jayaram[1]
Malik Lenger[1], Ruoming Peng[1], Dong Zhao[2], Jurgen Smet[2], Jörg Wrachtrup[1]

[1]*3rd Institute of Physics, University of Stuttgart,* [2]*Allmandring 13, Stuttgart 70569, Germany*

Max-Planck-Institute for Solid State Research, Heisenbergstrasse 1, Stuttgart, 70569, Germany

s.jayaram@pi3.uni-stuttgart.de

Visualization of nanoscale dynamics in superconducting materials provides a pathway to unravel the pairing mechanisms of interacting electrons [1]. Here, we have employed the state-of-the-art scanning NV probe [2] technique to explore the local magnetic response of the 2D superconductor, 2H-$NbSe_2$, in which we demonstrate full dynamic sensing of vortices with high sensitivity and spatial resolution (fig. 1). Utilizing this quantum probe, we present the first spatio-temporal dynamics of vortices in a 10 nm thin exfoliated 2H-$NbSe_2$, where the arrangement of the vortices shows a strong correlation with the geometric confinement (fig. 2). Notably, we have observed the melting of vortex solids near critical temperature allowing the re-arrangement of the vortices that is governed by the cooling rate. Additionally, our study delves into the dynamics of vortex cores, superconducting-insulator edge dynamics, and phase transitions, all unveiled through spatio-temporal noise spectroscopy with the NV probe.

References

[1] Chatterjee, S. et al., Phys. Rev. Research, 4, (2022), L012001
[2] Casola, F., van der Sar, T. & Yacoby, A., Nat Rev Mater, 3, (2018), 17088

Figures

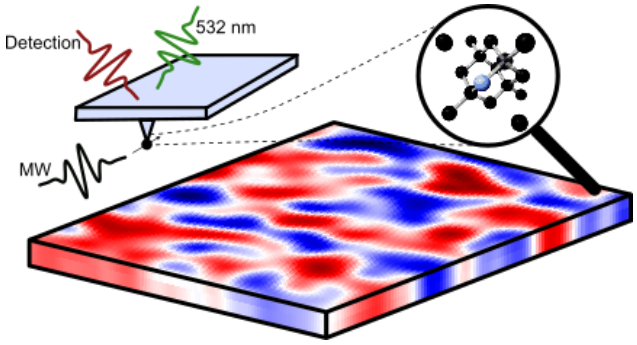

Figure 1: Illustration of the 2D superconductor and NV SPM system. A monolithic diamond probe is brought near a magnetic sample. The single NV center at the apex of the probe is interrogated using various optical and MW pulses to read out the Zeeman shifted spin state

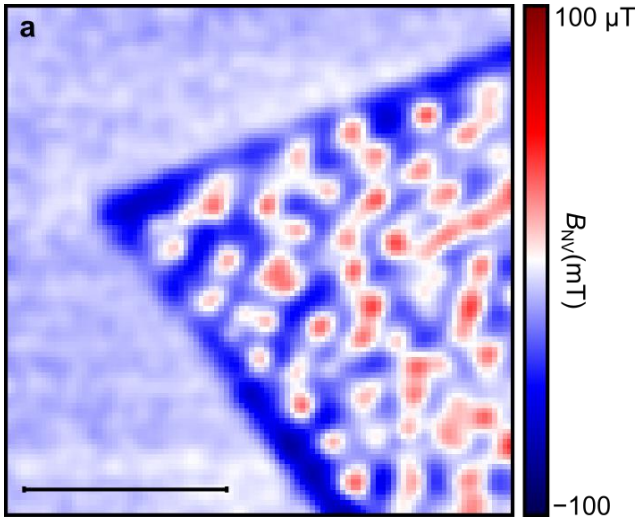

Figure 2: Magnetometry of a 2H-$NbSe_2$ flake showing a weakly ordered vortex arrangement with strong geometric confinement effects. Scan performed at 2.5 K and 6 mT field applied out of plane. Scale bar is 4 μm.