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Dynamics of few-trapped vortices in niobium at microwave frequencies

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Trapped vortices in superconductors introduce residual resistance in superconducting radio-frequency (SRF) cavities and disrupt the operation of superconducting quantum and digital electronic circuits. Understanding the detailed dynamics of trapped vortices under oscillating magnetic fields is essential for advancing these technologies. We have developed a near-field magnetic microwave microscope to study the dynamics of a limited number of trapped vortices under the probe when stimulated by a localized rf magnetic field.† By measuring the local second-harmonic response (P_2f) at sub-femto-Watt levels, we isolate signals exclusively arising from trapped vortices, excluding contributions from surface defects and Meissner screening currents. Toy models of Niobium superconductor hosting vortex pinning sites are introduced and studied with Time-Dependent Ginzburg-Landau (TDGL) simulations‡ of probe/sample interaction to better understand the measured second-harmonic response. The simulation results demonstrate that the second-harmonic response of trapped vortex motion under a localized rf magnetic field shares key features with the experimental data. This measurement technique provides access to vortex dynamics at the micron scale, such as depinning events and spatially-resolved pinning properties, as demonstrated in measurements on a Niobium film with an antidot flux pinning array.

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Yes

Footnotes

† C.-Y. Wang, S. M. Anlage, "Microwave Microscope Studies of Trapped Vortex Dynamics in Superconductors,"https://arxiv.org/abs/2503.02811.
‡ B. Oripov, S. M. Anlage, Phys. Rev. E 101, 033306 (2020).

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Author: Dr WANG, Chung-Yang (University of Maryland, College Park)

Co-author: Prof. ANLAGE, Steven (University of Maryland, College Park)

Presenter: Prof. ANLAGE, Steven (University of Maryland, College Park)

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