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RF and DC vortices in superconductors studied with time-dependent Ginzburg-Landau theory

Thursday 25 September 2025 14:30 (3 hours)

Time-dependent Ginzburg-Landau (TDGL) numerical simulations can capture vortex nucleation and motion, as well as proximity effects, at high frequencies in superconductors.† We use TDGL to study the nucleation of RF semi-loop vortices in Niobium in the presence of surface defects when the material is subjected to an intense RF magnetic field arising from a near-field microwave frequency dipole source.‡ We also simulate the case of trapped dc magnetic vortices near the surface of a superconductor being stimulated by the nearby microwave magnetic dipole.§ These simulations also yield the second- and third-harmonic signal responses produced by the superconductor and captured by the near-field microwave probe. The results of such simulations are in good agreement with data and provide an excellent "digital twin"of our near-field microwave microscope. This combined simulation and 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. We use these validated TDGL simulations to address "what-if"questions about the response of superconducting surfaces and vortices to intense RF magnetic fields under a variety of conditions, and some of these results will be presented.

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Yes

Footnotes

† B. Oripov, S. M. Anlage, Phys. Rev. E 101, 033306 (2020).
‡ C.-Y. Wang, C. Pereira, S. Leith, G. Rosaz, S. M. Anlage, Phys. Rev. Applied 22, 054010 (2024).
§ C.-Y. Wang, S. M. Anlage, arxiv:2503.02811.

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