Modeling of Magnetization and Intrinsic Properties of Ideal Type-II Superconductors in an External Magnetic Field

O. Chevtchenko[1], J. Smit[1], D. de Vries[2], F. de Pont[2]

[1]Delft University of Technology, Delft, Netherlands
[2]COMSOL BV, Zoetermeer, Netherlands

Abstract

The two dimensional, time dependent Ginzburg-Landau (GL) equations for vortex dynamics in ideal type II super conductors were solved with the approach of Sorensen [1]. Using the PDE interfaces of COMSOL Multiphysics® software, coupled magnetic vector potential $\bar{A}$ and order parameter Ψ fields were solved on a finite domain subjected to an external perpendicular magnetic field. After reproducing the results on vortex dynamics from [1] for GL parameter κ=2, this approach showed significant drawbacks for more realistic values (κ~50). Simulations were time consuming, unstable and mesh sensitive.

To overcome these drawbacks, the evolution of a single vortex was modeled in a scalable hexagonal unit cell with periodic conditions on all external boundaries (Abrikosov lattice). Within the unit cell, a single flux quantum (fluxon) is excited using a small pinhole with radius much smaller than the GL coherence length ($r \ll \chi$) at the center of the unit cell. Using the virial theorem, the applied magnetic field and the magnetization are determined for each given unit cell size.

The model is validated by comparing the computed magnetization to that of Brandt and Pogosov [2, 4]. At κ=50, excellent agreement throughout the whole range of applied magnetic fields is found. Additionally, the scalable hexagon approach proved to be fully compliant with analytical theory[3] for extreme unit cell radius ($R \gg \chi$).

The new model approach was used to illustrate the effect of pinning on magnetization for a simple case of a periodic array of cylindrical pinning centers.

Reference

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