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# THE ROLE OF MATERIAL PARAMETERS, EXTERNAL FIELD AND GEOMETRY ON THE ARRANGEMENT OF VORTICES IN SUPERCONDUCTING STRUCTURES

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The Ginzburg-Landau (GL) theory provides a phenomenological description of type II superconductors. It allows to describe the processes of nucleation and ordering of magnetic field vortices in the mixed state. In confined geometries, the induction of vortices and their arrangement depend not only on the material parameters of the superconductor (e.g. the correlation length, which determines the size of the vortices) and the external field (which determines the distances between the vortices), but also on its shape and dimensions.

In this study, we simulate the mixed state in a superconducting wire of infinite length, with the external field applied along its axis. We study how the shape of the wire cross section and its size affect the arrangement of the vortices for different values of correlation length and external field. We also study how these geometric factors affect the nucleation of vortices and how they impact the first critical filed.

We solved the time-dependent GL equations numerically using the finite element method. We implemented the GL equations in Comsol Multiphysics using a 2D model. Our studies were supplemented by 3D calculations of the wires of finite length. For both the 2D and 3D models, we studied a two-domain system where the superconducting domain of compact shape is embedded in a large non-magnetic and non-conducting surrounding. The presence of this surrounding is of particular importance for the proper description of the stray field produced by the superconductor, which, in turn, is crucial for the formation and ordering of the magnetic vortices.

Our future research aims to expand our exploration to ferromagnetic-superconductor heterostructures, investigating how vortices affect magnetization dynamics and magnetic domain behavior in the ferromagnetic layer. The presence of vortices can cause significant alterations in local magnetic fields and interactions, potentially reshaping ferromagnetic properties, spin textures, and magnetic ordering at the ferromagnetic material.

This investigation aims to enhance our understanding of vortex behavior, with the promise of improving superconducting materials for a wide range of technological applications. Insights from this research facilitate the development of improved superconducting devices, advanced energy transmission technologies, and potential breakthroughs in manipulating magnetic interactions at the nanoscale.

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