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Simulation of the field enhancement effect in type II superconductors for SRF applications

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Modern SRF applications require precise control of a wide range of material properties, from microscopic material parameters to macroscopic surface structures. Historically, Nb has been the primary superconducting material in SRF cavities. The past decade has seen increasing amounts of research into the development of cavities using next generation materials, such as Nb3Sn. These materials have great promise for improving SRF performance, but their small coherence lengths require even greater control of surface and material defects. Mesoscopic simulation of superconductors has proven itself to be a powerful tool in SRF development, connecting the results of ab initio/quantum calculations to the mesoscopic structures of the material, allowing for investigation of many phenomena which are difficult to probe experimentally. One particular phenomenon of concern is the field enhancement effect, which causes increased magnetic field near rough surface features, potentially leading to vortex nucleation or other dissipative processes. We outline a two-domain finite element framework of the Time-Dependent Ginzburg-Landau equations which allows for the simulation of magnetic field enhancement due to supercurrent screening near rough surface features. We apply this framework to several different candidate surface structures which may occur in Nb3Sn, and determine their impact on dissipation and vortex nucleation. We discuss the implications of these results for SRF cavity design.

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Footnotes

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