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Time-Dependent Ginzburg Landau simulations to guide Nb3Sn SRF cavity development

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Interest in Nb3Sn as a material for SRF cavities is driven by its potential to operate at higher temperatures with higher quality factors and accelerating fields. In practice, performance is limited by magnetic flux that is nucleated at defects and inhomogeneities on the scale of the superconducting coherence length. Because Nb3Sn has a small coherence length, it presents many fundamental material engineering challenges. To relate observed performance to ab initio material calculations and better guide development protocols, we use time-dependent Ginzburg-Landau simulations to understand the role specific types of inhomogeneities play in vortex nucleation and dissipation. We use a finite-element formulation that incorporates a variety of material-specific parameters that can vary both spatially and temporally. Our simulations mimic experimentally observed defects and inhomogenties in real Nb3Sn cavities, such as grain boundaries with and without Sn-segregation and Sn-depleted islands. We also explore temporal effects including flux expulsion during cooling and metastability at extremely high frequencies. I discuss the implications for Nb3Sn cavity development and performance.

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