Magnetic flux penetration in superconducting films with border defects

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Defects can have a large impact on the magnetic response of superconducting thin films by forcing changes in the path of the induced electrical currents. When the magnetic flux creep exponent is high, the associated perturbation is typically damped over a distance that can largely exceed the size of the defects. The current flow is then reorganized in large domains with different orientations of the electrical current density, separated by narrow domain walls. In the critical state limit with an infinite creep exponent, the domain walls degenerate into discontinuity lines, or d-lines. In this talk, I consider the penetration of magnetic flux perpendicularly to a Nb superconducting film containing edge indentations and/or defects. It has recently been shown, by means of magneto-optical imaging and numerical simulations, that the detailed shape of the d-lines generated by lithographically-defined micro-indentations carry information about their size and shape, and vary with temperature [1]. In this talk, I examine macroscopic models, constructed over length scales of many vortices, which can be used to describe the d-lines. I discuss the effects of temperature, demagnetization, and flux creep, as well as the influence of a field-dependent critical current density on the distribution of the magnetic field. The models are applied to both indentations and defects arising from inhomogeneous properties of the film. A comparison between the model predictions and the experimental data points to the importance of a lowered surface barrier in the presence of the defects. It is argued that indentations and defects help in releasing the magnetic flux pressure, and, thereby, help in avoiding thermomagnetic instabilities.

References

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