Condensed Matter / Biophysics Seminar

Controlling Superconducting Vortices at the Nanoscale

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Thursday

February 26

4:00 P.M.

Rm 184 NSH

Vortices, each containing a single quantum of flux surrounded by circulating supercurrents, control the electromagnetic behavior of all applied superconductors. Their motion dissipates energy and limits the potential applications of superconductors. One of the major goals in present superconductor research is to 'pin' the vortices via induced defects, to enhance their current carrying capacity. Recent advances in nanofabrication technologies have made it possible to create tailored defect patterns at the nanoscale, providing us with a unique platform to explore vortex dynamics.

This talk will present a variety of methods to control the motion of vortices to enhance the critical current in superconducting films. The first method focuses on nanoscale 'holes' which serve as artificial vortex pinning centers with both controllable pinning potential and spatial distribution. We find that the critical current over a wide range of magnetic fields can be enhanced by tailoring the spatial distribution of local density of pinning sites (LDOPS). The second method employs magnetic nanostructures to attract and localize the vortices. Here, I will present how to achieve continuous in-situ tunable critical currents utilizing these magnetic nano-structures. Finally, I will present our most recent discovery where the superconducting critical current is enhanced by applying an in-plane magnetic field parallel to the applied current direction.