Condensed Matter Seminar

The Vortex Physics of High Performance Superconductors

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Thursday, February 21 ❖ 4:00 P.M. ❖ 184 NSH

The search for an isotropic high temperature superconductor (HTS) with high current carrying capacity (critical current, Jc) is one of the grand challenges in basic superconductivity research. Currently, the best HTS wires carry only 20 to 25% of their theoretical 'depairing' current. The critical current of high temperature superconductors also varies with applied magnetic field orientation. This anisotropy is a critical impediment to many potential applications. An *isotropic* high temperature superconductor would vastly increase the effectiveness of superconducting wires for electricity transmission and could be used in rotating machinery, such as electric motors and wind turbines. The main factor limiting the current carrying capacity of superconductors is the motion of vortices – nanoscale magnetic flux tubes, each containing a single quantum of magnetic flux – in the presence of a high enough magnetic field. Vortices have cores of normal electrons and therefore dissipate energy when driven under the influence of the Lorentz force induced by an applied current.

I will present a brief review of the current progress in enhancing the critical current and reducing the anisotropy of state-of-the-art 2nd generation HTS coated conductors and describe our recent success in breaking the 25% critical current 'glass ceiling'. In addition, I will discuss our research into the possibility that recently discovered ironbased pnictide superconductors can be tailored to act as isotropic, high temperature superconductors. Using controlled particle irradiation, we introduce vortex pinning defects into these iron-based superconductors so as to enhance their critical currents and decrease their anisotropy. Although the superconducting transition temperatures of the iron pnictides are not as high as those of the more familiar cuprate HTS, their high critical current and low anisotropy make them desirable for many superconducting applications such as SMES, MRI, and superconducting generators and motors.

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