Advanced Instrumentation Seminars

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1:30 PM
Kavli 3rd, B48

Resistance is Not Futile: Pinning Down Elusive Vortices in Superconductors

Guest Speaker –
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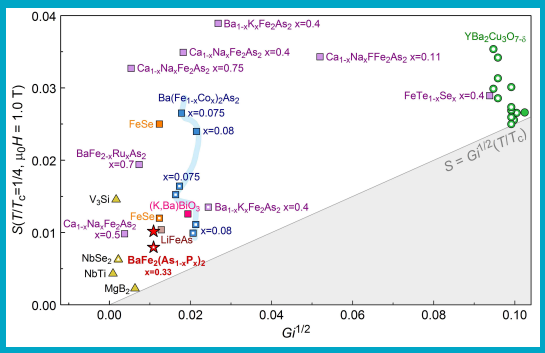

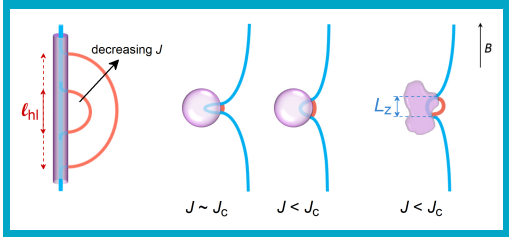

Though superconductors are revered for their ability to carry dissipation-free supercurrents below a material-dependent critical current (J_c), the seemingly inconspicuous action of vortices can introduce dissipation even for currents well below J_c. In type II superconductors (including high-T_c cuprates, iron-based superconductors, and MgB_2) immersed in high enough magnetic fields, vortices are formed by the penetration of magnetic flux and can be moved by current-induced forces and thermal energy. Vortex motion can be disruptive: it limits the current-carrying capacity in wires, can cause losses in microwave circuits, and, more generally, can induce phase transitions. Understanding vortex dynamics is a formidable challenge because of the complex interplay between moving vortices, material disorder (defining pinning sites) that can counteract vortex motion, and thermal energy that can cause vortices to escape from these pinning sites. In particular, we cannot precisely predict the rate of thermally activated vortex motion (creep) in a given sample, and tuning the creep rate by modifying the microstructure is typically achieved by means of trial and error. Furthermore, common techniques to enhance J_c by adjusting the disorder landscape (e.g., irradiation or incorporation of non-superconducting inclusions) are often accompanied by unfavorable increases in the creep rate. In this talk, I will discuss the importance of minimizing creep and efforts at Los Alamos National Laboratory to better understand vortex creep. I will cover results from studies of a wide variety of materials, including iron-based superconductors, films with different defect structures (e.g., varying densities of point defects, nanoparticles, columnar defects), and commercially available YBa2Cu3O7-δ tapes. I will end by discussing a recent result in which we propose the existence of a universal minimum realizable creep rate that depends on material parameters. This limitation is of both fundamental and technological significance: it provides new clues about the interplay between material parameters and vortex dynamics and about how to engineer materials with slow creep. This hard constraint, applicable at low temperatures and fields, has two important implications: first, the creep problem in high-T_c superconductors cannot be fully eliminated and there is a limit to how much it can be ameliorated; and second, we can predict that any yet-to-be-discovered high-T_c superconductors will have fast creep.

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