Impact of non-local electrodynamics on vortex matter in single crystal YNi_2B_2C: equilibrium magnetization

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The presence of non-local electrodynamics can strongly affect the properties of clean superconductors, where the electronic mean free path is large compared with the coherence length. The borocarbides, especially the nonmagnetic compounds YNi_2B_2C and $LuNi_2B_2C$, are a particularly good system for observing these effects. Non-locality modifies the vortex-vortex interaction and makes it anisotropic, even in cubic materials (e.g., V_3Si) or in tetragonal crystals with the magnetic field directed perpendicular to the square basal plane. In the latter case, nonlocal effects produce the observed hexagonal-to-square phase transitions in the vortex lattice, as observed previously by neutron scattering and STM. We show that the same anisotropic vortex interaction modifies the equilibrium magnetization and changes its dependence on magnetic field from the simple local London relation $M \sim \ln(H)$ to a more complex dependence. The experimental results are well described by Kogan's generalized London theory that introduces a third length scale, the non-locality radius, in addition to the usual coherence length and penetration depth. In studies with the magnetic field directed within the square basal plane, we have observed a four-fold oscillation of the magnetization that cannot be accounted for by the usual mass anisotropy (a second rank tensor). Further analysis of basal plane data reveals well-behaved values for all superconductive parameters. In addition to these non-local effects, a further consequence of a long mean free path should be a distinct temperature dependence in the Ginzburg-Landau parameters $\hat{e}_i$, which we indeed observe in studies based both on the heat capacity and magnetization. Finally, all of these non-local phenomena (both reversible *and* associated irreversible effects) become "washed out" at higher temperatures, as qualitatively expected when the coherence length increases and becomes comparable with the mean free path.

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