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Abstract

PSEUDO-REVERSIBLE MAGNETIZATION OF Nb *

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ABSTRACT

One of the striking features of the magnetization of bulk samples of defect-saturated, second-group superconductors is a quasi-perfect diamagnetism for certain regimes of the flux penetration. This effect is seen, typically, in the magnetization of a long cylinder in a uniform, axially parallel magnetic field after "flux jumps" and on changing the sign of the field rate of rise for an already penetrated specimen. The effect is also seen when the sample is cooled in the field. In the case of zero cooling field, there is a small, reversible penetration to the point where the applied field reaches some value which we associate with the lower critical field of the Ginzburg-Landau-Abrikosov-Gor'kov (GLAG) theory; above this value the irreversible, almost quadratic penetration predicted by the Bean theory commences.

We have measured the reversible flux penetration in specimens of Nb in the above geometry as a function of the cooling field, temperature, and degree of cold work. The measurement was made by integrating dB/dt from a coil surrounding the sample, and the apparatus was sufficiently sensitive to resolve a change in penetration of 3×10^3 quanta. Designating the field for the onset of irreversibility as H_{irr} and the cooling field as H_{cool}, we have $-4\pi M = H_{irr} - H_{cool}$.

The locus of these points, when plotted in the $4\pi MH$ plane, reveals a magnetization characteristic of the negative-surface free-energy theories superposed on a symmetric (diamagnetic-paramagnetic) magnetization expected for the defect structure. The net diamagnetic area enclosed by this pseudo-reversible curve is

equal to the free energy of condensation. The upper and lower critical-field values defined by these measurements are in qualitative accord with the result anticipated for Nb, namely, a decrease in the electronic mean free path associated with an increase in the intensity of the defect structure.

This result suggests that the relation of the GLAG structure to the defect-flux structure, in terms of an "effective" free energy, is one of simple superposition, and that the two coexist in this regime of penetration.

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