Driving Vortices in Weak-pinning V_3Si at High Currents and Fields While in Liquid Helium

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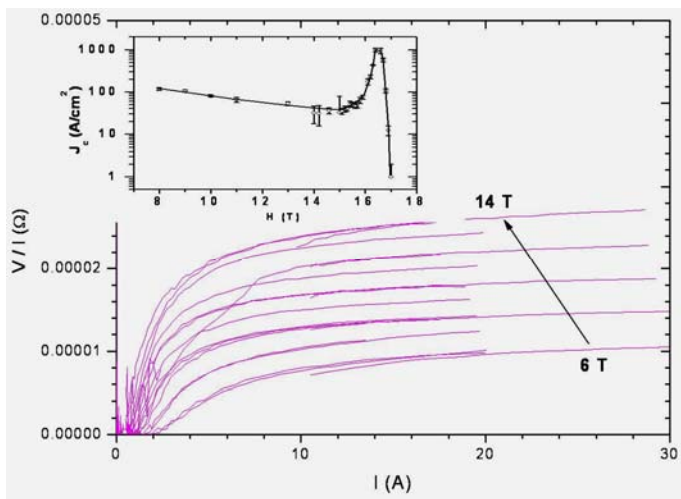
Introduction

The extent of energy dissipation due to the motion of superconducting magnetic flux quanta – so-called vortices – reveals details about their dynamics. Of particular interest is the so-called Bardeen Stephen flux flow (BSFF) phase, in which vortices move in an orderly fashion and follow a distinctive *linear* dependence with respect to field [1]. To access this phase, a sample with very weak vortex pinning potential was used, made of material with sufficiently low T_c to minimize thermal fluctuations. As such, this also opened up the possibility of observing the non-monotonic field dependence or "peak effect" of critical current density J_c just before reaching upper critical field, wherein the elasticity of the vortex medium is overcome by pinning, and which is not normally seen except in weak-pinning systems where J_c levels are sufficiently low. The experiment sought to map this effect, and also to ascertain the current levels necessary to approach the BSFF phase, both at liquid helium temperature.

Experimental

The need for a weakly pinned system was the reason for choosing a single crystal of the A15 superconductor V_3Si. ρ_f and J_c were determined by measuring *V(I)* curves at currents up to 30 A. To minimize heating due to such high currents, current leads were ultrasonically soldered, current was pulsed in 17-ms bursts, and the sample was kept in a liquid helium bath. The J_c levels expected at this temperature required fields of up to 20 T; therefore the experiments were conducted in the 25-T resistive magnet system in Cell 6 of the DC user facility at NHMFL.



Results and Discussion

The peak effect of J_c was clearly seen (inset in figure shown), consistent with previous results at other temperatures [2]. The *V(I)* curves at fields from 6 T to 14 T reveal an *approach* towards a clearly field-dependent ρ_f, here manifested as a saturation in dissipation *V/I* occurring at different levels for different fields and thus producing parallel *V/I* curves at highest currents. Also consistent with previous studies, this approach is seen only at fields *below* 14 T, above which the non-monotonic 'peak' of J_c is manifested. Since the peak effect indicates locally increased pinning, this strongly supports the assertion that the field-dependent ρ_f is a manifestation of an approach towards flux flow that is less viscous and more free or ordered. The field dependence of ρ_f, however, indicates that much higher currents are required for BSFF to be fully realized at this temperature.

Conclusions

These results have prompted plans to seek BSFF at higher current levels or at higher temperatures. A long-term goal is to study a predicted second-order *deviation* from the linear field dependence of ρ_f, due to the finite size of the vortex *cores* [3].

Acknowledgements

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References

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