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AC, DC and magnetic relaxation studies of cuprate and pnictide superconducting single crystals exhibiting a second magnetization peak

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We investigated the AC magnetic response of several $La_{2-x}Sr_xCuO_4$ and 122-type pnictide superconducting single crystals exhibiting a pronounced DC Second Magnetization Peak (SMP). It was found that in the case of small demagnetization effects (LSCO samples) the AC magnetic signal across the SMP remains in the linear regime, with no detectable distortions in the SMP range, which indicates reduced values of the Campbell penetration depth.

The nonlinear AC Bean regime far below the Irreversibility Line has been observed in plate-like 122-type pnictide specimens in perpendicular magnetic fields with strong demagnetization effects. The origin of SMP in superconducting single crystals with fourfold symmetric inter-vortex interactions (such as $La_{2-x}Sr_xCuO_4$ and the 122-type iron pnictides) has been directly related to the structural rhomb-to-square vortex-phase transition (ST). At the same time, for various superconducting systems, the SMP was attributed to a pinning-induced disordering of the quasi-ordered vortex solid, the proliferation of dislocations in the vortex system leading to a better accommodation of vortices to the pinning centres.

We discuss the relevance of these two models for the SMP in fourfold symmetric superconductors, by investigating the isothermal DC magnetic hysteresis curves $m(H)$, the DC magnetization relaxation, and the AC magnetic response of overdoped $BaFe_2(As_{1-x}P_x)_2$ single crystal, where both the SMP and the ST are expected to be present. It was found that the ST leads to a "shoulder" on the $m(H)$ curves, affecting the onset of the SMP. The enhancement of the $m(H)$ shoulder with decreasing temperature leads to the intersection of magnetic hysteresis curves, and, consequently, to a peak in the temperature variation of the critical current density. However, in AC magnetic measurements, when the vortex system is dynamically ordered in the ST range, there is no sign for such a peak at the structural transition temperature. This indicates that the $m(H)$ shoulder is generated by a precipitous pinning-induced proliferation of dislocations in the vortex system at the ST, where the "squash" vortex-lattice elastic modulus softens.

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