Interplay of weak collective and strong pinning regimes in iron based superconductors tuned by disorder

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Irreversible magnetization of almost all iron based superconductors exhibits ubiquitous magnetic field dependence commonly attributed to superposition of currents arising from distinct types of vortex pinning:

(1) Strong pinning regime giving rise to star shaped hysteresis loop with $1/\sqrt{B}$ variation of the critical current [1].

(2) Second peak at higher magnetic fields originating from weak collective pinning [2].

In exceptionally clean materials ($Ba(FeAs_{1-x}P_x)2$, $CaK(FeAs)_4$) second contribution may be small and hard to detect. Introduction of point defects by low temperature 2.5-MeV electron irradiation leads to increase of weak collective pinning contribution and emergence of second magnetization peak. Low temperature heavy ion irradiation producing correlated disorder leads to ultimately strong pinning and localisation of vortices in form of Bose-glass. To illustrate the effect of modification of pinning landscape, I will present a systematic study of pinning and creep measured on pristine and irradiated $Ba_{1-x}K_xFe_2As_2$ and $CaK(FeAs)_4$ crystals.

We found that weak collective and strong pinning are not simply additive contributions. The introduction of point disorder lowers not only critical temperature but reduces condensation energy and strong pinning by large defects. Magnetic relaxation was measured by miniature Hall sensor array on pristine and irradiated samples. Separation of pinning contributions based on the analysis of flux creep [3] was attempted. However, the sustainable currents accessed in real experiments on iron-based superconductors are close to ½ of J_c, far from regime of $J \ll J_c$ common in high T_c cuprates. This requires careful analysis of range of applicability of models developed for the later regime [4].

References

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