Vortex dynamics and necklace-like vortex pattern in iron based superconductors

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The iron based superconductors have a great potential for high power applications for its high upper critical field and low anisotropy. We carried out systematic studies on the vortex dynamics through measurements of magnetization relaxation. By measuring the dynamical and conventional magnetization relaxation of the $Ba_{0.64}K_{0.36}Fe_2As_2$ single crystals, we found strong second magnetization peak (SMP) effect on the magnetization hysteresis loops. It is found that there is a kink of magnetization at a field between the valley and maximum magnetization. Interestingly, the magnetization relaxation rate has a deep minimum at the field with the kink, indicating a diminished vortex creep. The relaxation rate at this field is clearly smaller than the so-called universal lower limit of the relaxation rate characterized by $S_0 \approx Gi^{1/2}(T/T_c)$. This diminished vortex creep is associated with the origin of the SMP effect and attributed to the strongly hindered flux motion when experiencing the transition from the quasi-ordered to disordered vortex phases [1]. By reducing the thickness of the single crystals, we found that the SMP effect eventually vanishes when the thickness comes to the scale of micro-meter. We believe this is induced by the cut-off of the vortex entanglement along the c-axis [2].

Due to the spatial confinement to the quasiparticles within a vortex, it was predicted in 1964 by Caroli, de Gennes and Matricon (CdGM) that bound states with energies of $E = \mu\Delta^2 / E_F$ (μ=±1/2, 3/2, 5/2,,,) should exist within the vortex core. These discrete energy levels have never been clearly observed. By doing STM measurements on the surface of $FeTe_{0.55}Se_{0.45,}$ we observed the long sought discrete CdGM bound states [3], which suggest BCS-BES scenario in IBS. Recently we observed a new-type necklace like vortex pattern in $KCa_2Fe_4As_4F_2$. We attribute this novel vortex pattern as a consequence of the self-interference of the vortex bound state with opposite angular momenta [4]. This illustrates a completely new type of vortex pattern.

References

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