

Disorder induced lowering of vortex dimension in Pnictide superconductor and precipitation of thermal melting of a dilute vortex solid phase

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Abstract body: Theoretically the vortex state is expected to melt at both, low and high magnetic fields at a fixed temperature [1,2]. While the high field melting has been extensively investigated in high T_c cuprates, the low field melting phenomena in presence of disorder hasn't been well explored. Using bulk magnetization measurements and high-sensitivity differential magneto-optical imaging technique we detect a low-field vortex melting phenomenon in a single crystal of Ba_{0.6}K_{0.4}Fe₂As₂ [3]. The low-field melting is accompanied with a significant change in local magnetization ~ 3 G, which decreases with increasing applied field. The observed vortex solid to liquid transformation phenomena is traced on a field temperature phase diagram and its behavior is shown to be partially obeying the theoretical Lindemann-criterion based low field vortex melting line equation. Our analysis shows a Lindemann number $c_L = 0.14$ associated with the low field melting. Imaging of low-field vortex melting features shows the process nucleates via formation of extended finger like projections which spread across the sample with increasing field or temperature, before entering into an interaction-dominated vortex solid phase regime. Magnetization scaling analysis reveals that the dimensionality of the vortices which melt, is close to one. Angular dependence studies of bulk magnetization hysteresis loop in the sample, shows the presence of extended defects. From our studies, we propose the sample contains a peculiar geometry of extended defects arranged in a plane in the sample, with these planes extending through the sample thickness. In the weak intervortex interaction limit, we argue that reduced vortex dimensionality due to pinning by these peculiar extended defect planes strongly enhances thermal fluctuations. Thus it is the effect of disorder, viz., the confining effect of extended defects planes in the crystal which lowers the vortex dimension, inturn triggering a low field melting in the pnictide superconductor [3].

References

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